Applying and Extending the Global Knowledge Base

Proceedings of the CIB Working Commission 070
Facilities Management and Maintenance
Global Symposium 2002

CIB Proceedings: Publication 277

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Published by:
CABER, Glasgow Caledonian University
for
CIB Working Commission 070 – Facilities Management and Maintenance
Co-ordinator: Danny Shiem-Shin Then

ISBN: 1-903661-33-1

September 2002

International Council for Research and Innovation in Building and Construction

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(as at 1st August 2002)

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The 2002 Glasgow CIBW070 Symposium

Exploring the global knowledge base on Asset Maintenance Management, Workplaces and Facilities Management.

Foreword

Danny Shiem-Shin Then
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Over its history since 1979, Working Commission has grown in both scope and breadth – from a narrow focus on social housing maintenance management systems to it current broad base focus on facilities management and asset maintenance. There are clearly challenges ahead for maintaining a multi-dimensional focus for this working commission. I am confident that the deliberation of this symposium will further enhance the links between *facilities management* and *asset maintenance management* which ultimately bear on the outcomes for the *workplaces*.

The bi-annual symposiums of CIBW070 have seen international exposure in the Far East (Tokyo –1994), in South East Asia (Singapore – 1990, 1998) and in Australia (Brisbane – 2000). The last time a CIBW070 symposium was held in UK was in Edinburgh in 1988. It gives me great pleasure, as Coordinator of W070, to welcome all delegates back to Scotland – this time in Glasgow – after an absence of 14 years.

The collection of papers presented here provided an excellent commentary on the state of art covering three main themes:

> **Facilities Management** – including developments in strategic FM; achieving and measuring best value; services procurement and management; health and safety; the internationalisation and standardisation of FM practices; and innovations and priorities in facilities management research and practice.
>
> **Workplaces** – achieving sustainability; workplace performance and the business; innovations in workplace design and management; strategic facilities planning; and workplace priorities.
>
> **Asset Maintenance Management** - strategic asset management; achieving sustainability; conservation and refurbishment; technologies and integrated systems for property management and maintenance; sustainability and waste minimisation; innovations and priorities in asset management research and practice.

Plenary sessions considered how best to consolidate, integrate, apply, and extend the existing global knowledge base, and a target for the event was to identify the priority issues and future agenda for cooperative research within the CIB W70 membership.

I would like to express my sincere thanks to Professor John Hinks and his team at CABER, Emma Dryburgh and Stuart Buchanan, for their splendid efforts in organizing and hosting the 2002 CIBW070 Symposium.

I wish all participants a fruitful time in networking and intellectual exchanges. I remain hopeful that the interactions between academics and practitioners will lead to new insights and innovations into processes that build understanding and add value to businesses.

Dr. Danny Then
September 2002

Introduction

The 2002 CIB W70 Symposium on Facilities Management and Asset Maintenance took place in Glasgow on 18th-20th September 2002. The theme for the symposium was exploring the global knowledge base on Facilities Management, Workplaces, and Asset Maintenance Management. The collection of papers presented here provide an excellent international commentary on the state of art and priority themes in these fields, and the breadth of perspectives covered here explore the themes which lie at the heart of CIB W70.

Professor Bob Grimshaw's opening keynote paper, *FM: Exploring the Professional Interface*, discusses how the worldwide growth of facilities management institutions with ambitions to become recognised as professional gatekeepers raises issues about the claim of Facilities Management to be a profession. Bob explores whether FM practice and conduct merit this designation, and discusses the context and the factors that influence each side of this professional interface and the implications for the development of a successful FM profession in contemporary society. He raises the challenge of achieving the difficult balance between developing the recognized characteristics of a traditional profession whilst pioneering a professional ethos that responds to the new environment of business. He finishes by noting that FM must embrace change and allow diversity in the way it defines and manages practice. The levers for change and the gap between the existing and understood knowledge and the research priorities required to support this are discussed thoroughout these proceedings:

The **Facilities Management** track presents papers which demonstrate clearly the growth in the strategic dimensions to FM research priorities (for example Jim Smith's paper on briefing lessons for strategic FM). The papers also indicate the increasing convergence of FM research and business research perspectives (refer, for example, to Clive Warren's paper on Public Sector Strategy). There is a strong theme of performance measurement research reported across the symposium (see the papers by Dilanthi Amaratunga, Igal Shohet and Russell Kenley), and encouraging indications that research to support the academic underpinning required to integrate such performance measurement with management processes is developing well and on several different fronts (see David Baldry's paper, too).

It is therefore useful to have these issues discussed in the same arena as whole life performance (David Rutter), and incorporating environmental issues in the life cycle (Jon Robinson). Note also the discussion of FM in the context of strategic briefing, flexibility (Arto Saari), handover, conservation (Derek Worthing and David Lawrence), plus renewal and adaptation (Mike Pitt), and also user needs (So Young Lee). Geert Vijverberg also considers the renovation dimensions. This range of perspectives is critical to supporting the rounded approach that whole life performance deserves. Therefore the inclusion of research on multiple decision making issues is timely too! (by Arturas Kaklauskas).

An FM track sub-theme on healthcare facilities management emerges strongly from the symposium, too, and the key issues of managing risk (see Peter Gombera's paper, also refer to Denny McGeorge's entry on risk management), measuring performance in the healthcare context, and combining operational and organisation decision making in the healthcare FM context are all discussed (Mike Okorah).

The inclusion of papers on consolidating FM knowledge (Hilaire Graham), achieving feedforward (Keith Alexander), the development of standards (Roode Liias), and the prioritising of FM research (David Baldry) bode well for the development of the research base that the FM professions and the industry need to achieve their aspirations that Bob Grimshaw discusses.

Workplaces overlaps noticeably with FM and Asset Maintenance Management – with themes emerging on safety management and achieving better value (Brian Neale, Charles Egbu, and Iain Cameron), POE, also flexibility and value (Frank Becker), plus quantifying adaptivity (Mike Riley and If Price - see also If's other paper on the impact of facilities on student choice of university). Consider also the context of virtual operations (Ghasson Shabha and Keith Cattell), also the evaluation of performance (see the paper by Jan Brochner and Paul Dettwiler).

The Asset Maintenance Management track shows the marriage between strategic and operational management dimensions – for example in the context of healthcare facilities (Martti Hekkanen); on managing change in the built cultural heritage (Derek Worthing), and also on sustainability in construction and operation (Anne Aikivuori). The issues of managing maintenance operationally and strategically are discussed using a collection of case-based papers (for example, Linariza Haron) and the application of management systems (for example, Takashi Saito's paper on TRAM2), combined with Michael Garvin's paper on prospects and challenges for decision support systems and David Johnston's analysis of the Property Standard Index, issues which overlap into Workplace perspectives. Note also a review of a web-enabled management technology (see Gerard Cesar Gabriel). The challenge of optimising the technical and operational practices that underpin these management decisions and processes are well addressed by a suite of papers on material performance (see the contributions by Kenji Motohashi, Teruo Kondo, and Masato Kobayashi). Note also the strategic management papers such as Martti Hekkanen's commentary on maintenance planning in Oulu, and Elzbieta Trocka-Leszczynska's review of cooperative buildings maintenance in Poland. In the UK context, Keith Jones tackles the issue of handling attitudes to prefabrication.

In the round, the papers presented at this symposium represent a bubbling of increasingly integrative issues, and the convergence between Asset Maintenance Management, Workplace and Facilities Management themes occurs over. These proceedings show clearly a suite of priority issues and hot topics for the future agenda for cooperative research within the CIB W70 membership. Hence it was only appropriate that the plenary sessions considered how best to consolidate, integrate, apply, and extend this existing global knowledge base. The clear need for cooperative research activity, to garner synergies from existing research and expertise, consolidate the knowledgebase and coordinate the international research faculty with the leaders in the industry and professions is a key issue that CIB W70 is well placed to lead forward, and the symposium finished with a debate on how to best underpin and achieve this.

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Table of Contents

Facilities Management

FM: Exploring the Professional Interface

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Abstract
The worldwide growth of facilities management institutions with ambition to become recognised as professional gatekeepers raises issues about the claim of Facilities Management to be a profession. Does FM practice and conduct merit this designation? Using Nutt's resource based approach to FM with its four 'trails to the future', the tensions that exist on the interface between the 'business trail' and the 'people' trail provide the context needed to discuss the nature of FM's professional credentials. This paper examines this context and the factors that influence each side of this professional interface and the implications for the development of a successful FM profession in contemporary society.

Keywords: facility management, professional development, business drivers, people drivers

Introduction

A CIB W70 Symposium, perhaps the only neutral global forum for the reporting of FM research, is the right forum in which to take stock of where FM stands after 20 years or so of development. The growing body of academic literature on the nature of FM practice, typified by Nutt (1999), Nutt and McLennan (2000), Green and Price (2000) and Grimshaw and Cairns (1999), has done little to dispel the impression that there is still wide diversity in FM practice; but FM, in whatever guise, continues to grow and the term 'FM' is recognised in all five continents. However, the lack of intellectual coherence within the core practice of FM presents particular difficulties for coherent onward development and for the establishment of a unified FM profession. This paper reviews the issues involved and 'takes stock' of the obstacles to progress.

Markus and Cameron (2002) in using discourse analysis as a tool to evaluate how we conceptualise the built environment, imply that the nature of any function can be revealed by the statements made about them. In this spirit FM could be characterised (and defended) by any of the following statements:-

1) FM is a technical function concerned with maintaining the practical utility of the physical infrastructure to ensure its supports the core activity of an organisation (OPERATIONAL MAINTENANCE)

2) FM is an economic function concerned with ensuring the efficient use of physical resources by controlling cost (FINANCIAL CONTROL)

3) FM is a strategic function concerned with the forward planning of physical infrastructure resources to support organisational development and reduce risk (CHANGE MANAGEMENT)

4) FM is a social function concerned with ensuring the physical infrastructure of work meets the legitimate needs of users within their organisational role (USER INTERFACING)

5) FM is a professional function with social responsibility for people in the workplace (ADVOCACY)

In many ways it is the tension between these different but overlapping positions that provides the dynamic for the onward development of FM – this remains a healthy debate providing the stated positions can be reconciled in some way and that none of the positions become too dominant. Duffy (2000), for example, expresses concerns about the growing dominance of cost control as the chief function of FM practice and this can be regarded as a clear wake-up call to ensure the other 'value added' aspects of FM practice are reinforced.

The reconciliation of the 5 statements (and other equally legitimate statements that could be made about FM) highlights the complexity of its development. Therefore, the advent of a new 'model' for FM is to be welcomed because it can act as a catalyst for raising issues and questions. Nutt's (2000) resource based approach with *its 'four generic 'trails' to the future*', based on a definition of FM as the *'management of facility resources and services in support of an organisation'* is of importance. The four 'trails' of Property, People, Business and Knowledge echo Adam Smiths basic capitalist framework of Land Labour and Capital but also remind us of the growing centrality of knowledge. As Mitchell (2000) states '*(g)oods and services flow in new ways in an electronically networked and mediated world, one in which the traditional generators of wealth – land , labour and capital – are joined and sometimes transcended by fast flowing information'.* Overall the model provides a useful framework to reflect on the global context of FM development and the forces that are influencing its development. Grimshaw (1999) has argued that FM can only be understood in the context of the global changes in organisational structures that are increasingly impacting on all social and political life.

Nutt's model highlights the fact that the relationships between the four foci of business infrastructure are changing. The capital investment that underpins the business trail is now framed within a global market that can switch investment very quickly and is not prone to influence by national governments (Bauman, 2000). This 'liquid' capital market relies on accessible and instant information to ensure its smooth operation (Castells, 2000). This integration of capital and knowledge is the basis for what is being called the network society – Castells argues that, although this is clearly a capitalist form of organisation, it is fundamentally different from the way early capitalist society was organised in that *'it is global and structured to a large extent around a network of financial flows'.* In respect of Nutt's model the clear message is that whilst business and knowledge have been elevated to a global level, people and physical facilities have not – they are remain in their national context and in a much weaker position. The relationship between a business, its people and its physical assets has fundamentally changed – this is the real context of FM development.

Nutt's model, outlined in Diagram 1, acts not only as a metaphor for the factors that are driving FM development but provides a framework for evaluating the issues in the tensions that occur at the six interfaces[1] between the four trails. The management of these interfaces to ensure that the tensions are creative rather than destructive defines the challenge that FM faces now and in the future. All the interfaces are worthy of further study but this paper is concerned with the professional development of FM. In these terms, the interface between the 'business trail' and the 'people trail' is useful in giving a clear focus for examination. It highlights the nature of the tensions between individual needs and organisational imperatives that is the territory of a professional discipline. In this respect it can be regarded as the 'professional interface'.

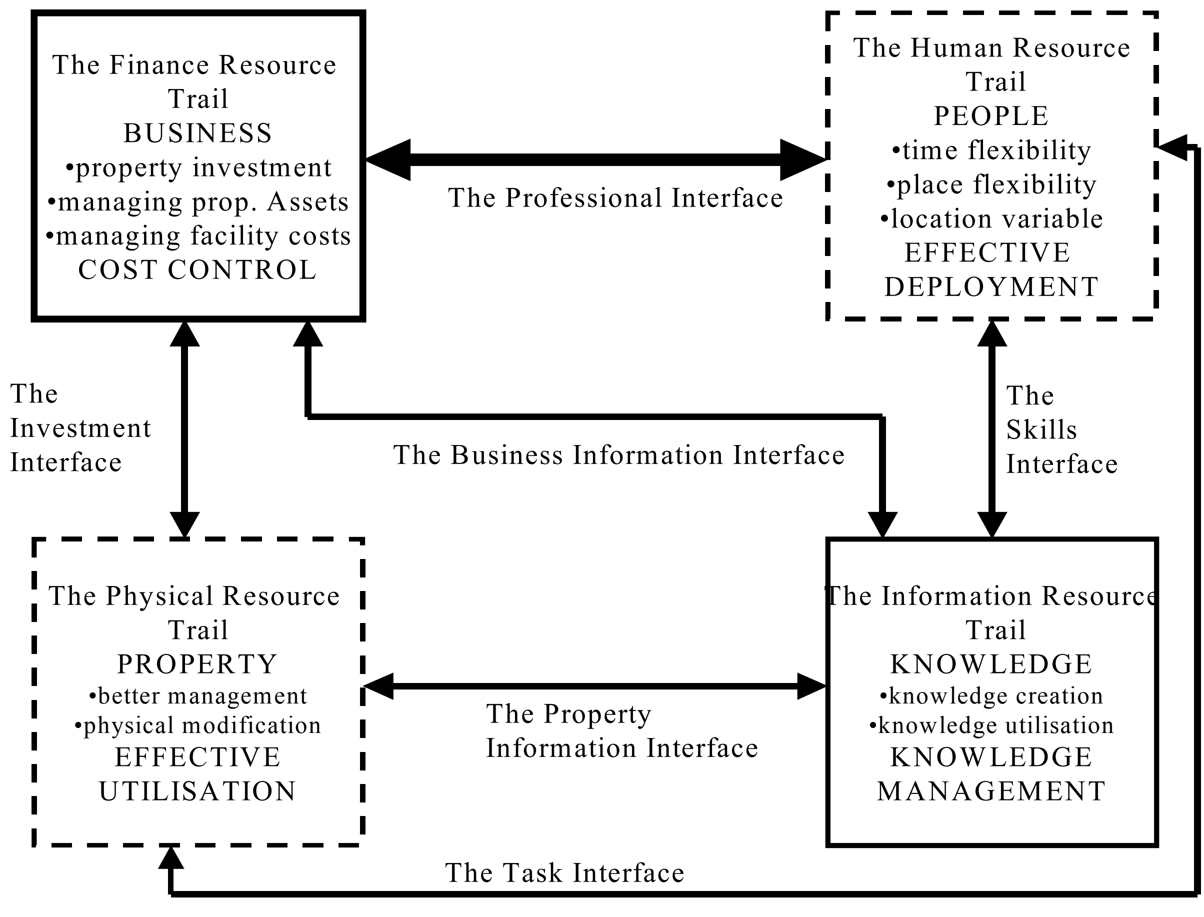

Diagram 1 : The Resource Model of Strategic FM (source: Nutt, 2000)

[1] Please note that the interfaces shown in diagram 1 were named by the author and do not appear in Nutt's original text.

The Business Trail

In the context of FM the focus of the ‘business trail’ is property as a capital investment and how to manage the asset to ensure that the return on investment (ROI) reflects the risks involved. As around 25% of corporate capital is still tied up in real estate the performance of real estate investment is significant for the performance of the whole organisation. The increasing uncertainty about the ability of long term capital investment in property to realise an adequate ROI has led to strategies that directly impact on FM practice – a greater emphasis on cost control, the emergence of more flexible working arrangements and the exporting of routine jobs. This has pushed FM practice into a cost control and outsourcing function in order to reduce servicing costs for the asset and to increase the return on investment (Duffy, 2000).

The current weakness of global technology organisations that started with the bursting of the dot.com bubble has reminded everyone of two salient facts: the possibility of using IT to do business in a different way are legion but that whatever the changes in organisational structure and operation the fundamental need to produce an return on capital still applies. Investors will only risk their capital if a return is forthcoming and the rate of return expected must reflect the risk involved. However, the short-term problems of e-commerce do not disguise the fact that electronic communication is transforming the way that business is being carried out and organisational forms are changing in response. There is a marked shift to looser networked structures held together by electronic information based links. Castells (1997) comments that ‘*dominant functions and processes in the information age are increasingly organised around networks. Networks constitute the new social morphology of our societies, and the diffusion of networking logic substantially modifies the operation and outcomes in processes of production, experience, power and culture’*. He identifies the drivers of this dash to networks as innovation, globalisation and decentralisation.

The impact of this move is reflected in the way global corporations are changing. Mitchell (2000) has identified significant changes in business practice in financial services, marketing, travel, stock markets, book selling, telecommunications, music distribution, and film distribution. Global business is spending a growing proportion of investment capital on electronic infrastructure rather the physical infrastructure. There is a significant trend towards outsourcing major and even core functions and a growth in flexible working arrangements. Caldwell (2002) reports that 28 million U.S. employees participate in some form of teleworking with more than a fifth working at home. Dot.com organisations like Amazon that do business over the Internet have a much lower property asset base than their conventional rivals. These developments are indicative of the transformation of the relationship between business and its property infrastructure with a consequent impact on employees.

What is driving much of this change in business process is the globalisation of the market for capital. The electronic links between the world's major stock markets has effectively created a single market and this has freed capital from its erstwhile national roots. The era of corporate nationalism (Reich, 1991) where as late as the 1970's nation states were sufficiently in control of capital and labour to steer industrial policy has ended. The integration of business, the unions and the government has been destroyed by the decoupling of capital (Bauman, 2000). Now capital can be transferred around the world very rapidly and it inevitably seeks out the best and quickest returns. This ‘electronic capitalism’ (Reich, 1991) is now a world-wide system for re-deploying financial assets to where they earn the highest returns. The freeing of capital from national constraints has enhanced the power of global organisations and investors and greatly reduced the power of both governments and labour to influence events. All the latter can do is ensure the conditions for inward investment are as favourable as possible (Harvey, 2000).

Organisations are increasingly turning to what Morello (2002) calls the ‘Resilient Virtual Organisation’ (RVO) with the network structure observed by Castells (1997, 2000) and reliant for operation on its electronic infrastructure. The impact on the workplace is illustrated in a major American report on workplace futures in 22 corporate settings published jointly by Gartner and MIT. The ‘Agile Workplace’ (2002) predicts that in the next five years changes to the workplace will be driven by the need to be more flexible, more people centric and more responsive. The workplace will transform form a ‘*collection of properties to a network of place and electronic connections’*.

The message is clear – the risk of investing in property will increase. Already the life expectancy of individual facilities has less and less to do with utility. Even substantial capital investments in industries like automotive engineering and steel making are being abandoned when more favourable conditions can be found elsewhere. Individual plants are increasingly being made to compete with similar plants in other countries for the right to develop new products and services. The jobs they support can be exported. This has major implications for the physical infrastructure and its cost. Workplaces are increasingly becoming transient nodes in network organisations that are linked electronically. This puts individual employees in a very different landscape – one that is neither linear nor predictable.

The People Trail

The focus of the ‘people trail’ is how to ensure the effective deployment of people as a business resource in this rapidly changing business context. Work in general is much more flexible both temporally and spatially as electronic communication and data handling transform the need for face to face location. Network organisations are creating a network society, where according to Castells (1997, 2000), ‘*social relationships between capital and labour are profoundly transformed. At its core capital is global and as a rule labour is local……labour is disaggregated in its performance, fragmented in its organisation, diversified in its existence and divided in its collective action’*.

Castells goes on to argue that labour is becoming increasingly individualised in its relationship to global business. Capital and labour are occupying different spaces and times – capital the ‘*space of flows’* and labour the ‘*space of places’.* Global capital depends less and less on specific labour and more and more on undifferentiated generic labour facilitated by a core of knowledge workers who inhabit virtual places in the networks (Bauman, 2000).

This split reflects Reich's (1991) typology of work categories suitable for the new capitalism of the global economy. On one side are knowledge workers, categorised as 'symbolic manipulators', and including all the professional, managerial and creative occupations that generate creativity and innovation. These 'knowledge workers' have high value added skills that are globally relevant and that can be transferred anywhere. There is a global market for their skills and a good working environment is an important element in their retention.

However, Reich also identifies a category of 'routine labour' covering semi-skilled assembly tasks or routine office work. Routine labour tasks, many of which have been generated in the UK by inward investment, are inherently insecure even though they might be in high tech sunrise industries. The liquidity of the capital that supports them makes them vulnerable to even minor changes in market condition. These workers are fixed in their national context whilst their jobs are eminently exportable. As a result the conditions under which the jobs are carried out are highly cost sensitive and result in what Baldry et al (1998) describe as 'neo-taylorist' working environments. At the extreme end some call centre jobs are highly regulated using electronic monitoring and control to reinforce an abusive management regime that is designed to keep productivity as high as possible (Rosenberg, 1999).

The two elements of Reich typology demand different physical responses – symbol-manipulators are high valued added employees and the provision of their workplace is not cost sensitive. Routine workers on the other hand can only have a workplace provision that is rigidly cost controlled unless there is a clear indication that their physical workspace adds value and contributes to higher productivity. This metric, which would be so useful, is sadly lacking reinforcing the view of FM as a cost control function. In these circumstances Becker's concept of workplaces which actively supports a better fit between the physical environment and employees' physical and psychological needs can apply only to the 'symbol manipulators' (Becker and Steele, 1995). This consideration will not extend to spaces occupied by routine workers.

Much of the recent debate in management theory revolves around how many people should be classified as knowledge workers. Senge (1997), Drucker (1997) and Bartlett and Ghosal (1995) argue in different ways for the need for organisations to be creative and innovative by encouraging as many employees as possible to be involved – their future competitiveness is dependent on creating and implementing new knowledge. On the other hand Ashkenas et al (1995) argues that the traditional hierarchical model of organisation is still the most appropriate with a small number of symbol-manipulators controlling a large number of routine workers.

Whilst the split between the two categories of job can be attributed to capital flows other factors relevant to FM are at work. The tenacity of the traditional 'command and control' culture should not be underestimated. Van Meel (2000) reports that national cultures are still visible in office designs across Europe in supposedly homogenous commercial organisations. Duffy (2000), the pioneer of new and supportive working environments, reports in 2000 that, due to entrenched cultural attitudes, little has changed in office design in the UK and USA in the last 20 years. He notes that offices are still designed as if they are required to support employees who work from 9-5 and do not move from their desks.

The only optimistic note for routine workers is sounded by Harvey (2000) who argues that if global organizations '*become increasingly sensitive to the spatially differentiated qualities of which the world's geography is composed then it is possible for the peoples and powers that command those spaces to alter them in such a way as to be more rather than less attractive to highly mobile capital'*. In these circumstances even small differences become increasingly significant.

The Professional Interface

i) The Professional Core

The interface between business and people is the territory of the FM profession. From the above it can be argued that the fundamental nature of many professions, including FM, is being re-shaped by these forces and that a new professional model is emerging. Before considering the nature of this new model it is necessary to examine the underlying core of professional structures. Freidson's (1994) review of the literature reveals a long history of debate, the way that debate has been shaped by context over time and the lack of any recognized definition for a profession. However, he makes some fundamental distinctions worthy of note. There is a major conceptual split between the Anglo-American model of a profession and the European model. The former is occupationally based and is dominated by autonomous institutions; the latter is educationally based and depends for status on the quality of education and not on the nature of the occupation. Within the Anglo-American model there is also a division between a general strand of middle class, educated occupations that are labeled 'professional' and the smaller number of exclusive institutionally led professions. Friedsen also distinguishes between the 'status' professions (the medieval learned professions of law and medicine) and the 'occupational' professions that developed in response to industrialization in the 19C.

The Anglo-American system is hierarchical in nature and inherently engenders a struggle to become recognized as high status. This is reflected most starkly in the distinction between 'major' professions and 'minor' professions advocated by Glazer (1974). The distinction is based on how far the specialized knowledge and skills that underpin each profession are based on rigorous positivist science. The minor professions, which include most of the socially based professions, are not real professions because they are non-rigorous, ambiguous in their scope and are not underpinned by their own credible academic discipline. This hierarchical model that values both stability and unity of practice underpins the traditional view of professions being '*one of the most stable elements in society*' (Carr-Saunders and Wilson, 1933). Schon (1991) challenges the wisdom of the rigidity of professional traditions that ossify practice. He argues the need for professionals to be reflective and use their knowledge and skills as part of a team effort that recognizes the contribution of others. In Schon's view this is the only way to ensure flexibility of practice in a fast changing world.

Within the myriad distinctions outlined above there are some underlying characteristics that can be stated (Friedson, 1994; Barber 1963). Professions have a:-

- Specific and definable knowledge and skills base that has to be acquired and tested.

- A high degree of self-control of behaviour via codes of ethics

- A recognized social responsibility that gives a primary and selfless orientation to the community interest.

These together are said to justify the privileged position in which the professions are held – they have developed in a national context and have become embedded in the institutional structure of the state. The expectations of society regarding standards of professional conduct remain high (Jamal and Bowie, 1995).

However, it is the concept of social responsibility that is the strongest thread in the literature on professions. Lennertz (1991) argues that the essence of the term professional is to apply an over arching framework of trust and social responsibility to particular forms of practice. The role must be perceived to have social relevance and directly influence people's well being. Both Camenisch (1983) and Raelin (1991) promote the idea of a profession as a moral and ethical community with a place of authority in society. Grimshaw (2001) has argued that FM does have a social role and that the ethical basis for FM to claim professional status is based on the impact that the physical environment of work has on individuals. This can be regarded as an element of stakeholder theory in that organisations have a duty to address the legitimate needs of all their stakeholders Carroll (1993). The linking of FM and stakeholder needs reinforces the message that the impact of IT that is driving both the 'business trail' and the 'people trail' has much wider social and economic connotations for people in the workplace.

ii) The Professional Future

The forces that are driving both the 'business trail' and the 'people trail' are undermining the traditional stability that the professions have promoted. FM must be able to respond to the new organisational and social context whilst maintaining the essential core characteristics outlined above. The challenge will be how this professional core can be adapted to the changes people are experiencing in the workplace. This examination of the forces driving each side of the professional interface at least allows a reasonable stab at the shape of the FM profession in the next few years. The following are the key areas where FM will have to adapt.

Transnational Operation

Although the basis for the development of traditional professions has been national, FM clearly does not operate exclusively in a national context – its landscape is increasingly global. The decoupling of capital investment and information management from national constraints means that the interface between people and business is now conducted in a transnationally with strategic decisions being taken outside the national context. This change will increasingly marginalize the national focus of professional institutions and the stabilizing role they have played in national culture. FM will only be secure if it has the right tools to shape both the policies of national governments and the policies of global organizations with the balance shifting relentlessly towards the latter. Much of FM's future power will derive its ability to mediate between international business and fixed national interests. It must overcome any feeling that it can do little to influence the global forces of change and help to identify policies that map out the impacts of global facilities policy.

Embracing Change and Heterogeneous Practice

Much of the academic debate about the nature and importance of the professions has centred on the unity of professional knowledge. The future landscape of FM will make it increasingly difficult to define a single body of professional knowledge that can be ring fenced as FM. This means professional bodies will have to cope with a knowledge base that changes rapidly. This has implications for the way the core competencies of FM are revised and tested.

FM will also have to accept that there will be different facilities solutions for different groups of workers. Reich's typology highlights the emergence of two global categorisations of work where the criteria for the physical infrastructure are completely different. The 'routine production' workspace may always be cost driven whilst the 'symbolic-analytic' workplace will always be value driven by the need to promote creativity, knowledge generation and innovation. Within these broad categories many subsets will emerge – already groups like home workers and teleworkers have different workplace circumstances that are not well understood or supported by FM. This pattern of diverse non-homogeneous practice could undermine the coherence of the profession unless flexible procedures are adopted by the professional bodies and they promote on-going debates about the nature of practice. Historic precedents will be of little use in managing this diversity and lack of stability.

Advocacy for the User

Whilst the element of social responsibility, clearly identified as meeting the legitimate needs of all users in the workplace, must remain as the underpinning of FMs professional role, the impact of the changing context must be recognised. The power of individual workers is diminishing in the context of a global economy and the need for advocacy will grow. The role played by the physical environment in promoting both social well being and productivity must constantly be promoted by FM as a valued added function. The movement for Corporate Social Responsibility gives hope for the future and FM must ensure that facilities strategy is a key element.

Conclusion

The FM profession is developing at a time of rapid change in all the areas that define its practice. It must achieve the difficult balance between developing the recognized characteristics of a traditional profession whilst pioneering a professional ethos that responds to the new environment of business. Failure to do the former will damage its claim to be the 'profession' that represents facilities managers (and other established professions will move in): failure to do the latter will mean it fails to meet the needs of its context in 21st century and it will become less and less relevant to either business or workplace users.

The interface between the ‘business trail’ and the ‘people trail’ in Bev Nutt’s resource based model does provide a useful context for considering the future development of FM as a profession. It highlights the need for FM to be transnational in practice and to be able to mediate between national and local pressures. It also suggests that FM must embrace change and allow diversity in the way it defines and manages practice. It must also develop an ethical role of advocacy for the legitimate needs of users in all workplace settings on the grounds of social and economic benefit.

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The Impact of Facilities on Student Choice of University

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Abstract: *Despite rhetoric of added value, Facilities Management suffers a dearth of objectively researched, publicly available information concerning the impact of facilities on businesses at the level of market sectors or individual organisations. This paper aims to correct that situation for UK higher education institutions. A survey of undergraduates starting university in 2001 has confirmed, to high levels of significance, earlier research with the 2000 intake. For many institutions, facilities factors, where provided to a high standard, are perceived as having an important influence on students' choice of institution. Year-on-year comparisons show strong agreement at the global level and, where data could be gathered, at the institutional level. Individual institutions show marked differences, significant at levels of confidence of over 95%. A comparison of 'reputational pull' and 'facilities pull' is suggested as a means of differentiating the 'brand' of different institutions.*

Keywords: *Higher education, business impact, customer choice*

Introduction

The paradox of Facilities Management's (FM's) claims for strategic or value adding status on the one hand, and the subject's largely operational rhetoric on the other (Grimshaw, 1999), has become widely recognised in recent years. This has raised concern that the subject has failed to produce convincing evidence of its contribution to 'businesses' (Duffy, 2000). An intensive literature review (Haynes et al., 2000) seems to confirm the problem, and FM faces the challenge of either demonstrating its contribution or being limited to a relatively specialised future as the discipline of maintenance management (Price, 2002; Lord et al 2002): Nutt's and Mclennan's (2000) operational trail. The nature of the 'business critical' contribution of FM varies with sector (Price, 2002) and requires specifically tailored research evidence.

Various critical impacts of facilities on the 'business' of a university might be considered, depending in part where a particular institution is positioned, or aspires to position itself, on the widening strategic space of research and teaching options (Matzdorf et al., 1997; Price and Kennie, 1997). Facilities could for example be essential to attract key research personnel, or to provide environments for faster knowledge creation. Its impact on student perceptions of their pedagogic experience (Fleming and Storr, 1999) is not widely appreciated in the literature on lecture theatre design or pedagogy. Meanwhile conventional government-funded and student-funded undergraduate teaching remains a significant, and for many institutions still a dominant, proportion of income. This study investigates the degree to which facilities and locational factors influence the decisions undergraduates make when choosing where to study: effectively the impact of the facility on a core group of customers.

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Literature Review

Investigations into the process through which potential students determine their choice of university have increased over the past decade, though the subject seems to have received more, and earlier, attention in the USA (Discenza et al., 1985; Hossler. and Gallagher, 1987; Hossler, et al,, 1989; Heubner, 1989; Roberts and Higgins, 1992; Bredo, et. al., 1993; Lauren, 1993; Galotti and Mark, 1994;) where a marketing need came earlier than in the UK. In turn this means exploring the mechanisms through which decisions are made, the perceptions that potential students have of the university, and the contribution that these perceptions make to attracting or deterring application. In general the literature does not treat facilities as a potential differentiator or subject them to separate research. Our understanding, based on conversations with estates directors or equivalent, and on more than five years of research in FM for HE, is that most university marketing surveys pay comparatively little weight to facilities-related factors, despite evidence of their impact on the student experience (Green et al., 1994, cited by Yorke, 2000) and by reviews of literature on lecture theatre design and learning experience, which found a wide (and unbridged!) gulf between the architectural and pedagogical approaches (Fleming and Storr, 1999).

The term ‘student-institution fit’ (Banning and McKinley, 1980; Banning and Banning, 1986) has been suggested to examine “the degree of congruency, or fit, between student characteristics and the ability of the institution to respond to those characteristics” (p1). Characteristics of the student should fit with the ability of the institution to respond adequately to those characteristics, ultimately leading to increased student satisfaction, academic achievement and personal growth. Student enrolment and retention are determined in the theory by three sets of variables that comprise student-institution fit:

- characteristics of the student such as their personal goals, abilities, needs, interests and values;
- characteristics of the institutional environment, including the physical, academic, social and psychological variables, where facilities management has the most impact. Included in this variable is the physical design of the campus, such as its openness, privacy areas and wall decorations;
- the outcomes resulting from the interaction of the student with the environment. This will have an impact on the student’s academic achievement, satisfaction and persistence within the institution.

Aspiring students today can apply for up to six places on many different degree courses offered by over 200 educational establishments. The vast range of degree courses and institutions available to them, make the decision-making process rather complex. As Tackey and Aston (1999) argue, “the feasible range of options are limited by a variety of factors but mainly educational qualifications, geographical mobility and financial considerations” (p. 2). Marketing literature concentrates on the decision-making process which consumers go through before purchasing a product. Kotler and Armstrong (1994) describe the stages through which buyers supposedly pass to reach a buying decision. *Need recognition* is triggered when the buyer recognises a need or a problem. It is followed by *information search*, an *evaluation of* *alternatives* and a *purchase decision*. According to Kotler and Armstrong, the purchase decision derives from the consumer ranking the alternatives to formulate a *purchase intention*. Two factors may however intervene. The first is the attitude of others, whose influence will depend upon both the strength of the other person's attitude towards the buying intention and the consumer's motivation to comply with that person's wishes. For the potential student this could include parental attitudes and opinions to their child's university and course choice. The second is unexpected situational factors. Such unexpected situational factors for the potential student could be the failure to achieve the grades needed to warrant the course and university they had decided upon; achieving higher grades than expected, opening up opportunities for universities or courses not previously considered; or alternatively being offered a good job subsequently leading to further alternatives.

The Institute of Employment Studies (Connor et al., 1996; Tackey and Aston, 1999) surveyed over 20,000 students applying for entry to a full-time undergraduate course at a UK university or college in 1998. Questions were asked on who they regarded as being most influential on their choices, their perceptions of the costs of going to university, the likelihood that they would seek paid employment while studying, and views on their chosen university. For the information-gathering stage of the decision-making process, students consulted traditional sources such as UCAS handbooks and prospectuses, and made visits to the universities. More IT-based information, such as websites and CD-ROMs were least used overall. Cost was a significant factor in the choice process of the location of university. It encouraged students to consider choosing a university close to home. For the population included in this research, the most important factor when choosing a university was the course. Factors relating to the facilities management function of the university which were rated as being important were the 'overall image of the university' and the 'social life at university and social life nearby'. Of lesser importance relating to FM were 'accommodation for first years', 'safety and security' and 'sports facilities' (p. 42).

Discenza, et al. (1985) questioned US students about the importance they assigned to various considerations in selecting a university. Medium to least important FM-related variables were 'location', 'housing facilities', 'social/cultural/entertainment activities', 'athletic facilities' and 'dining facilities'. Courses offered were once again the most important variable. Roberts and Higgins (1992) questioned students who had studied at the universities for a year and found the most criticised aspects of their university relating to FM were 'poor facilities', 'housing/accommodation', 'buildings/site', 'Students' Union', 'overcrowding', 'social/sports', 'security and lighting', 'canteen' and 'split site'. The best-rated FM-related aspects included 'environment', 'academic facilities', 'sporting facilities' and 'Students' Union'. For first-year students the availability and quality of accommodation was found to be of high importance, and as such should be an important part of the marketing mix when recruiting students.

An ongoing UNITE/MORI study (Anon., 2001; 2002), sponsored by one of the main players in the field of private student accommodation, covers a range similar to that of Connor et al. (1996) and explores students' choice of university as one of the aspects of 'student living'. Their 2001 survey identifies 'location' and 'social facilities in town/city' as the second- and third-highest priority factors after 'course', with 'able to live at home', 'close to my family', 'able to travel home at weekends' and 'social facilities at university' also among the top ten factors influencing students' choice.

These ratings were generally confirmed in the 2002 follow-up survey (Anon., 2002, p. 13). However, the number of students for whom 'social facilities' were important fell from 24% to 20%, whilst most other location-related factors showed either the same or an even higher level of importance in the second survey (ibid.).

Overall, the results quoted above are somewhat patchy, and the research so far has made no attempts to draw institution-specific comparisons: a gap that this project was designed to fill.

Research Methods

Access for the research was granted by institutions who participate in FMGC's Research and Application Forum HIGHER EDUCATION. Practical reasons of sample size dictated a questionnaire based survey and, in consultation with Forum Members a survey instrument was designed and piloted on the 1999 student intake. A total of 87 closed questions sought rankings of importance on a standard five point Likert scale defined as 'essential', 'important', 'neither important nor unimportant', 'unimportant' and 'not important at all'. These categories were scored from 5 to 1 respectively. Twelve questioning modules were included, among them 'type of university', 'reputation of town/city', 'accommodation', 'learning facilities', 'university security', 'transport', 'social facilities', 'sporting facilities', 'childcare facilities' and 'university environment'. Scores of 3.75 and above are classified as 'important', 3.25 and lower as 'unimportant'. Ratings of 4 or above are considered as 'highly important'. Before the closed questions two open-ended questions asked students to list up to three reasons why they chose a particular university and three reasons why they did not choose an alternative institution.

The methods of distribution of questionnaires varied. Some facilities/estates departments were not able to secure the collaboration of the registry or marketing department at all. Some distributed the questionnaire in the offer package, others in freshers' week or with offers of accommodation. Where all first-year students were accommodated in halls of residence (under central administration), questionnaires were given out and collected there. Wherever we can identify potential bias, this is highlighted below. The problems do illustrate the generic issue of FM visibility. Across the majority of the universities, access to students was closely 'guarded' by the university's Academic Registry. Often this part of the university were unaware of the Forum membership and details had to be provided before access to the students was even considered. In some institutions, access to students was entirely dependent on individual faculties'/schools' co-operation, whilst others organised distribution and collection centrally. From several participant institutions, we got the reply "Oh no, not *another* questionnaire!", as freshers were already 'inundated' with information packs and survey questionnaires. This raises questions about the relationship between facilities providers and their customers – if one can't reach the other, how can the providers be expected to deliver good value to their customers? Some institutions did not see the need for 'another' survey, since they had already embarked on an in-house data-gathering exercise (e.g. student satisfaction surveys). These surveys would indeed complement our research, but would not provide data beyond the individual institution, and therefore not allow for comparison with other institutions and across the sector.

The pilot tests nonetheless proved robust and two surveys were conducted with samples from the 2000 and 2001 intake. Response rates are shown in Table 1. In total the responses cover more or less the full spectrum of universities from Russell Group members to the 'post-1992' sector; but the sample is limited to England and excludes the 'research elite', the group of institutions in the top six places of various RAE league tables.

University code	Year	Questionnaires out	Responses	Response rate (%)
A_1	2000	2,600	1245	47.9%
A_2	2001	2,000	1228	61.4%
B	2001	5,000	1714	34.3%
C	2000	3,000	438	14.6%
D[2]	2000	*7,000*	1106	*15.8%*
E	2000	2,500	244	9.8%
F	2000	2,700	353	13.1%
G	2001	3,550	552	15.5%
H	2001	1,200	358	29.8%
I_1	2000	4,000	844	21.1%
I_2[3]	2001	*n/a*	78	*n/a*
J	2000	7,000	412	5.9%
L	2000	400	32	8.0%
O	2000	500	138	27.6%
Sub-total	2000	29,700	4812	16.4%
Sub-total	2001	11,750	3930	35.3%
Total		**41,450**	**8742**	**21.1%**

Table 1: Response rates for 2000 and 2001

In terms of statistical validity, the total sample has Cronbach-Alpha values of .95 (Year 1) and 0.96 (Year 2) indicating a very high level of internal consistency – values of .7 and above are normally considered to be significant.

[2] Numbers for University D are estimates, since distribution was very decentralised and the exact number of questionnaires given out could not be established. A higher estimate obtained said: 11,000 questionnaires out ⇒ response rate 10%, total 33,700, average 15.8%.
[3] University I could not put a large-scale distribution process in place before term, hence arranged for individuals to be surveyed by a postgraduate student. Strictly speaking, the 78 questionnaires make up a response rate of 100%, but this would seriously skew the overall response figures.

Overall Findings

Closed questions

In both surveys a higher proportion (between 52% and 70%) of female students responded; in fact, the proportion (52%) was unchanged in University A which returned significant numbers in both surveys. The two surveys did not show overall differences in age range of students, geographic origin, ethnic origin or course; however, significant differences were found between individual institutions (see below).

In the 2000 survey 12 factors had average importance scores of 4 or above. In 2001 this number fell to 11, though the differences are small (Table 2). The top eight factors, on average, are identical. Of the top six, two might be considered entirely pedagogical: ‘course’ and ‘teaching reputation’. Four relate to impressions of the study facilities. Of the next six, in both surveys, four might be considered ‘pure’ facilities factors, and two might be influenced by facilities. The evidence provided by the 2000 survey, namely of the importance of factors other than academic reputation in decision-making, was confirmed in 2001.

ITEM	2000 average	2000 ranking	2001 average	2001 ranking
Had the course you wanted	4.84	1	4.80	1
Availability of computers	4.48	2	4.41	2
Quality of library facilities (e.g. availability of books, journals, CD-ROM, IT)	4.47	3	4.41	3
University had a good teaching reputation	4.35	4	4.29	4
Availability of ‘quiet’ areas (e.g. library, study rooms)	4.23	5	4.22	5
Availability of areas for self-study (e.g. group work areas)	4.16	6	4.21	6
Quality of public transport in the city/town	4.07	7	4.13	7
A friendly attitude towards students	4.05	8	4.04	8
Prices at the catering outlets	4.01	9	4.00	13
Cleanliness of the accommodation	4.00	10	*3.92*	*15*
Quality of the university grounds	4.00	11	*3.94*	*18*
Availability of university-owned accommodation	4.00	12	4.00	14
Quality of lecture theatre facilities	*3.90*	*18*	4.03	9
Quality of bars on campus	*3.90*	*19*	4.01	11
Union social facilities	*3.92*	*17*	4.01	12
Diversity/range of shops at the university (e.g. banks, bookshop, travel agents, food)	*3.95*	*15*	4.01	10

Table 2: Average ratings of 4 or higher in the two surveys

For reasons of confidentiality individual institutional data cannot be published; however, it is important to note that for University A, the only participant to return a statistically significant sample in both years, the order of the highest items was unchanged and average scores varied by no more than a trivial +/-0.02.

Open-ended questions

All responses were coded in 2000 and assigned to categories. In 2001 we found that no new categories emerged, hence the same categories were used. Since the number of reasons given varied between one and three per respondent, and, for reasons against other institutions, between none and three, the percentages given here are in relation to the total of reasons given, *not* respondents. In total, 22,627 'reasons for' and 16,855 'reasons against' were analysed. In general the average results from the two years are strikingly similar for items universally mentioned in 3% or more of reasons given (Table 3). In each case individual items at particular institutions also attracted a 3% rating:

The one big change is in the frequency with which course was mentioned, especially as regards a reason for not choosing other institutions but also as a reason for choice. It appears that the availability of a particular course is becoming more of a 'hygiene' factor; something which is essential but is not seen necessarily as differentiating one institution from another.

Reasons for choosing a university	**2000 average**	**2001 average**
Course / subject	22.2%	20%
Reputation of course / department / school / university / League tables	18.2%	18%
Convenient location / proximity to home	10.4%	10.5%
Location	6.7%	7%
Facilities resources	6%	5%
Reasons for deciding against alternative institutions		
Course not suitable (in some way or other)	20.5%	13.5%
Quality / standards / reputation / league tables	9%	8%
Did not get grades / no offers etc	5.5%	6%
Distance too far	10.5%	12%
Location	7.5%	7.5%
Didn't like area / place / city unfriendly etc	5%	5.5%

Table 3: Open-ended items cited by at least 3% of respondents in each institution in each year[4]

Inter-organisational Differences

General Observations

Both the above comparisons point to the survey instrument being reliable and capturing real preferences consistent from year to year. However, a look beyond the apparent homogeneity of the averages reveals major differences between institutions. In 2001 the number of factors rated '4+' (four or above) varies from a minimum of 8 to a maximum of 32, with two distinct groups, one consistently with 10 or fewer factors and the other with 23, 26, 31 and 32 factors respectively. The groups did not correlate with university type. Each included at least one 'modern' university and at least one research-led institution. They did correlate with visual estimates of campus quality in that two of the 'high scorers' are based on single, well maintained campuses, and the others are institutions that, although on multiple sites, are known to us for having made strategic investments in upgrading their estate (and reducing net costs in quality driven approaches to estates and facilities management). There was then evidence that where the estate has been treated as a strategic asset it

[4] The average score is the average of mean results overall and mean results by institution.

figures more prominently in students' perceived reasons for choosing a particular institution. Not surprisingly the four institutions with more factors in the 4+ rankings had higher overall scores for the importance of facilities-related factors in student choice. In 2002 the situation was more complicated. University A was confirmed in the 'facilities-attractive' group with 26 4+ factors, and a further participant known to have invested in new campus facilities recorded 24 4+ scores. At the opposite end, a participating institution without campus investment joined the low-scoring group with 8 high-importance factors. However an 'intermediate' position was established by a university that registered 18 4+ ratings, whilst the institution which had scored most strongly in 2000 had only 15 factors rated as important in the second round, albeit from a much smaller sample, which was also taken fairly late (halfway through the first term). Furthermore, the same institution had, in 2000, distributed its questionnaires by sending it out with accommodation offers. Since the university could only offer approximately 70% of freshers places in university-owned or -managed accommodation (80% in 2002), this distribution method carried the risk of an accommodation bias in the 2000 sample. For both this reason and the low 2001 response numbers, the results for this institution had to be viewed with some caution. Clearly some bias can be expected, although the latter sample was too small to skew the overall results. Nevertheless, this prompted us to examine distribution methods in other high scorers, all of whom confirmed that efforts had been made to distribute to all students, not just those entering university-owned accommodation.

The availability of a desired course was universally rated as the most important factor in every institution, though even here the level of importance attached to this factor showed significant differences (at the 99% level) between the three highest-scoring institutions and the lowest-scoring one. Notably the latter institution had higher ratings for a number of factors relating to the university environment and facilities. Where universities possess a particularly distinctive location and campus, the survey results clearly indicate that this is a marketing lever.

Apart from the number one item, 'course', there is no consistent ranking throughout all institutions. The 'availability of computers' is universally one of the top three items, sometimes relegated to third place by the 'availability of library facilities' and in one instance by the university's teaching reputation. 'Quality of library facilities' reaches the top three in all but two instances: one case is the institution where 'teaching reputation' scored as particularly important, the other one where (by a statistically insignificant margin) the importance of library facilities was edged into fifth place by the 'cleanliness of the accommodation'!

Academic Factors

In a survey aimed at discriminating the relative importance of facilities factors only two strictly academic criteria were entered: the university's reputation for teaching and for research. The former is reported as much more important (in fourth place overall) than research reputation, which sits far down the list in fiftieth place. The overall correlation between the two is weak (0.46 in 2000).

Teaching reputation receives very high importance ratings in two institutions. One, an 'elite' research-led institution, scores significantly higher (at the 99% plus level) than all the others, except the second one, a modern university. That institution scores significantly (95% to 99%) higher than four of the remaining six. At the opposite end of the ratings, one institution scores significantly less, at the 99% level, than five others. We have not tested whether higher scores for importance reflect students' perceived judgement of the actual quality of any factors, though many individual differences (see below) suggest they do. To whatever extent the differences in perceived teaching quality reflect a reality – they are either disturbing or encouraging news for three institutions in particular.

To some extent the answers to the ratings for the importance of **research reputation** support the conclusion that judgements about actual quality are being made. One top-tier research-led institution scores significantly more highly (at the 99% level) than all but two institutions, one a modern university and one not. A second institution in the same league, whilst clearly showing significantly higher scores than four others, scores significantly less than the first. The institutions for whom reputation for teaching is particularly positively or negatively relevant are not those for whom research reputation is markedly different.

Other Non-FM Factors

'Proximity to home' was significantly less important (at 99%) for entrants to one of three 'research led' institutions – lower than all but one other participant. It was also significantly less important for freshers at one new university than to the two others and another city centre institution.

'Opportunities for part-time employment' were significantly less important (95% to 99%) in the institutions attached to smaller towns/cities.

'Graduate employment rate' showed few significant differences except between the highest and lowest rating institutions.

'Parents' opinion' tended to be of more importance in universities with campuses/colleges but only in a few cases the difference could be claimed as having high levels of significance. Interestingly 'parental opinion' was significantly more important in the choices made by students who had attended open days. The difference between the two groups is the largest for any factor. 'Friends' opinion' shows no significant differences while 'cost of living' seems a significantly more important factor to students attending two metropolitan universities but not two others. The scores do not correlate with those for 'proximity to home'.

The location of the campus in a major city was significantly more important (at 99%) for one institution that has made a considerable investment in such a campus and also significantly higher for another with some such investment. Not surprisingly the factor was of lowest importance to those students who had chosen smaller towns/cities and for whom the location in a small city/town was significantly more relevant. No 'out-of-town' campuses were represented in the group but with that proviso expressed, importance closely follows the form of the campus or physical location. Overall however, the type of campus comes way down on the importance list; and even if the strong differences expressed by those who had chosen particular types were factored out, 'type of campus' would not reach the top 50 factors for the sample. 'Collegiate structure' was only significantly different for the institution which operates a collegiate system, but even there it comes 37th in the order of priority.

'Crime rates' revealed few significant differences. One city university which had emphasised its low crime rate in its latest publicity materials, scored a significantly (at 99%) higher importance rating than others and scored more highly for having a 'friendly attitude towards students' than others. It may be no coincidence that an institution which has invested more than many in the development of ancillary staff and has used them, deliberately, as 'roving ambassadors' on open days, received strong ratings for that aspect and for its student-friendly attitude.

Facilities Factors

Accommodation factors tend to follow provision. The importance of 'availability of university-owned accommodation' was, hardly surprisingly, significantly lowest for three institutions where 'proximity to home' was significantly more important. These institutions also had higher proportions of mature students. The 'availability of self-catering accommodation' was rated significantly lowest in a collegiate institution (where basically all first-year students live in catered halls anyway), and high in three institutions that have gone to pains to arrange it (though not necessarily *own* it).

Catered halls were of significantly higher importance in the institutions which provide them. In two of the three, where en-suite facilities are provided, they were rated not only significantly more important but actually in the 4+ list; a stark contrast to most other accommodation ratings, which in general did not show this as an important factor. The message seems to be that where higher-quality arrangements are made, they are perceived as such and become differentiating factors. The same institutions receive significantly higher importance ratings for 'IT in bedrooms', 'telephones in the accommodation', 'cleanliness' and 'cost', factors where the population breaks down into two groups, one of which rates accommodation factors generally significantly higher than the other. They higher-scoring quartet are the same institutions that receive the higher number of 4+ scores overall. With various slight differences of emphasis, the same group generally receive higher ratings on other factors relating to accommodation.

Generally all questions relating to **learning and teaching facilities,** especially library facilities and the availability of computers, receive high importance ratings throughout. Again two groups exist, showing to varying extents significant differences on most aspects except the 'availability of quiet areas for study'. Interestingly the groups are not the same as those for accommodation. The institutions whose research reputation was most significantly rated as important tend to receive lower significance ratings for the importance of teaching accommodation and library facilities. In general importance ratings seem to coincide with the researchers' impressions of aspects of physical quality gained during benchmarking visits, though it has to be emphasised that no rigorous verification has been attempted. In general higher quality environments do seem to have an impact on choice; a conclusion that may also lead to problems of expectation, if impressions gained during recruitment are not matched by subsequent reality.

Discussion

With those caveats the conclusions reached from the 2000 survey were confirmed strongly in 2001. Groups of institutions with wider FM appeal do not correlate with university type. Each group includes at least one 'modern' and one 'research-led' university. They do correlate with visual estimates of campus quality. There is evidence that where the estate has been treated as a strategic asset it figures more highly in students' perceived reasons for choosing a particular location. This is not necessarily a description of an objective reality. Service quality literature is divided as to whether 'importance' and 'satisfaction' can be objectively separated (Robledo, 2001). It is quite plausible that respondents to the questionnaires attached greater notional importance to factors which they perceived as being better supplied: i.e. that they were more satisfied with. On the other hand, it can also be argued that dissatisfaction with a particular service or product might lead to greater attention to this factor and hence higher importance ratings. We have not been able to investigate this in depth, but a number of open-ended 'reasons against' suggest the possibility.

That does not, however, detract from the potential of these factors to differentiate any particular institution. Models of customer service also tend to differentiate so-called 'hygiene factors', without which a customer's basic expectations remain unfulfilled, and 'differentiators', those aspects of a product or service which influence decisions on repeat business. Student choice does not, at least on the timescale of a few years, become repeat business[5], and it is perhaps hard to conceive of the top eight factors (Table 1) as hygiene items. They are, however, what a university *must* have if it is to attract either particular students (the course) and students in general (learning facilities, good teaching, access and a student-friendly attitude). It is the other items, especially many facilities or estates factors that can often differentiate a particular institution. In both years this point was confirmed by reference to specific examples.

In the 2000 survey we identified one member of the low-scoring group as 'facilities-independent'; that is as having a perceived reputation that made it especially attractive to students. In the open-ended questions this was the only institution where comments relating to the university's overall reputation were much more frequent (by a ratio of over 2:1) than those related to having a particular course. One other institution had a ratio slightly above 1:1: i.e. reputation was mentioned more frequently than course although the ratio was lower: In 2001 a new (to the survey) participant had a ratio approaching 2:1 while University A, which had seen a rise in popularity, as recorded by UCAS statistics, between the two application years, saw the ratio change from slightly under to slightly over 1:1.

[5] Though the growing importance of alumni and life long learning is acknowledged

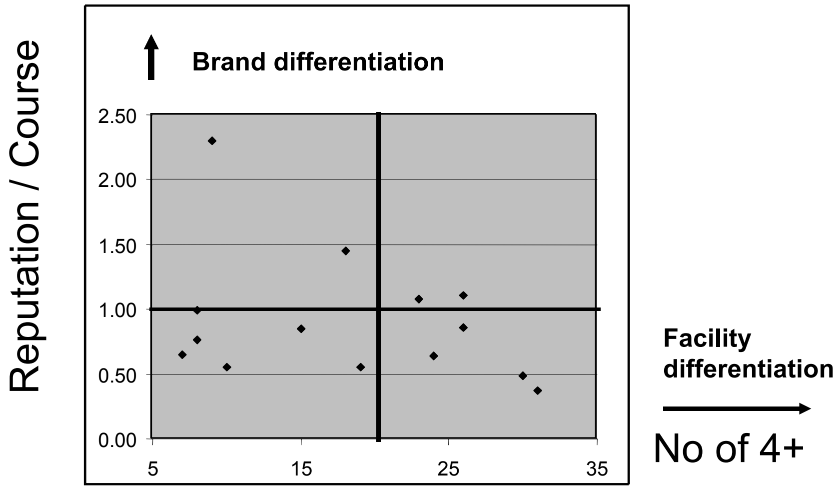

Figure 1. The position of individual institutions according to the number of 4+ factors recorded in the survey (x-axis) and the ratio of 'reputation' to 'course' in reasons given for choosing a particular institution (y-axis)[6]

Taking these responses, and the overall number of factors scoring 4+ begins to identify a means of segmenting the undergraduate 'market' (Figure 1), one which bears parallels with recently developed scenarios (Matzdorf and Price, unpublished; Collis, 1999). One scenario, identified by Collis as the 'liberal-arts college', has been dubbed in our work the 'St Andrews Strategy[7]'; the appeal to the social as well as the intellectual role of a particular institution. It is of course a moot point how sustainable such a strategy is without some form of differential financing but one can see the upper left-hand quadrant of Figure 1 as tending towards such a strategy. The lower right on the other hand is 'facilities-differentiated' using provision of modern campuses as a factor in recruitment. Towards the upper right lies appeal on both reputational and facilities factors, though it remains to be tested whether the highest scorers in academic reputation terms, the 'RAE elite' are differentiated from the 'St Andrews strategists'. Institutions in the lower left quadrant meanwhile struggle to differentiate themselves on either ground, a position which may only be sustainable with low costs and high volumes and which even then is vulnerable to better positioned competitors. We note that among the 'new' universities in our survey some have developed 'facilities-led' positions while one has achieved near parity of reputation and course.

Further statistical analysis of the data to refine a simpler component model of facilities impact on student choice is planned. Meanwhile for a number of institutions that impact is clearly and unambiguously confirmed.

Acknowledgements

The research was sponsored by members of the FMGC Higher Education Research and Application Forum whose assistance and collaboration is gratefully acknowledged. We also thank HEFCE Estates for support for data processing. The conclusions are the authors' own.

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[6] Identities have been removed for reasons of confidentiality
[7] Referred to as the 'Wills effect': e.g. THES 29/03/02

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"Global Service" for the Facility Management of real estate patrimonies: market characteristics and technical-normative innovations in the Italian context.

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Abstract
In Italy, the development of the maintenance and technical management services market appears to be more and more oriented towards the outsourcing of public bodies and private owners or managers of real estate patrimonies.

Within this general framework, the specific section of the market related to Facility Management assumes particular significance: this new segment of the market has shown definite and impressive progress over the last years.

A result of this market tendency is the now widespread use on the part of public and private bodies of the "Global Service" instrument.

Despite the development of the Global Service, there is a lack of shared rules in order to uniform the behaviour of the market. In this context, a special national study Committee at the UNI (the Italian standardisation Body) has been set up, with the task of setting out a set of technical standards called "Global Service for the management of real estate patrimony maintenance - Guide lines".

Once adopted through UNI, these standards will represent the first of their kind in Europe and will be able to supply the grantors and providers of property maintenance services with a common basis of methodological-operational reference in order to standardize the introductory transactions as well as those involved in the capitulary, project and contract transactions related to the Global Service "process" and its correct adoption and usage.

Keywords: Italy, real estate patrimonies, global service, facility management, market, technical-standards

1. The characteristics of the market

In Italy, as has been the case in the other EU countries for some time now, the development of the maintenance and technical management services market appears to be more and more oriented towards the outsourcing of public bodies and private owners or managers of real estate patrimonies.

Within this general framework, the specific section of the market related to Facility Management assumes particular significance: having developed very late in Italy with respect to the other European countries, this new segment of the market has shown definite and impressive progress over the last years, faced with a potential demand for services (for the most part inundated or outstanding up until now) which in the sector of public real estate patrimonies alone is today estimated at over €33 billion per year and with an actual market which, already exceeding the sum of €5 billion in 2002, will tend to treble over the next five years, reaching over €18 billion at the end of 2007 (source: CRESME 2001).

A result of this market tendency is the now widespread use on the part of public and private bodies - in the context of tenders for the assignment of maintenance and technical-management services for their own real estate patrimony - of the "Global Service" instrument, that is to say, of an assignment system with the integrated services of maintenance and property management with full responsibility on the part of the provider for the results in terms of reaching/maintaining the levels of predetermined services.

The State finance law for 2000 (art. 30, para. 8/e) has contributed towards the consolidation of this tendency, in so much that it has identified the contractual formula in Global Service that would make it possible for local administrations interested in the targets of stabilising public finance to achieve higher levels of efficiency and management economy.

The most significative expression of this tendency has been the recent CONSIP tender, the concessionaire of public computer services that organises and manages the e-procurement of the public administrations and which published and awarded a national scale contract of Global Service services for property used for offices belonging to the State for a total amount of over €700 million.

In the light of a market trend that involves and will involve more and more the adoption of, in the property sector, contracts for technical-management and maintenance services of the Global Service type based on the transfer of the direct responsibility for the "results" to third parties, there is to be found however an inadequacy, if not the total inexistence, of specific supports of a technical kind able to standardise market behaviour and regulate the processes, the procedures and services dealt with by Global Service by means of "consensual rules", with particular regard to property maintenance in the interest of all the parties concerned (grantors, contracting companies and firms, users).

The Italian technical standards UNI 10685 of 1998 "Criteria for the formulation of a contract based on the results (Global Service) " represents a fundamental departure point which can find direct application and updating in the industrial sector, but which, however, does not appear to be able to satisfy the particular connotations and demands of the property market, in particular in the presence - on the one hand - of a not yet consolidated culture and practice of outsourcing on the part of the "demand" for maintenance services and - on the other - of a not yet widely developed and certified know-how on the part of the “offer” of the same services.

Hence, the need for the development of a specific project for standards in the real estate patrimony sector with the representatives of both the demand and offer of Global Service maintenance involved. These same representatives have been expressing the need for ad hoc technical-normative support in the property sector for a long time.

2. The technical-normative innovation

In this context, a special national study Committee at the UNI (the Italian standardisation Body) has been set up, with the task of setting out by the end of

2002 a set of technical standards for the Italian sector called "Global Service for the management of real estate patrimony maintenance - Guide lines" [4].

These standards will face the problem of Global Service from the viewpoint of a "process" related to the two main subjects involved: the grantor and the provider of the Global Service.

They will therefore provide the "guide lines" for the management of the Global Service processes, endeavouring to establish some kind of guided methodology and to determine the fundamental phases of development of this as well as the correlated objectives, procedures and instruments.

In this regard, the standards identify systematically:

- the "phases", or that is to say, the key stages of the process placed in planned sequence;
- the "objectives", or that is to say, the strategic targets to be followed in each phase of the Global Service process;
- the "procedures", or that is to say, the sub phases and criteria for the relative development;
- the "instruments", or that is to say, the instruments of decisional and/or operational support to be adopted in each phase according to the objectives established.

The field of application of this set of standards are the real estate patrimonies of public and private ownership.

The standards are divided up into four sections correlated to the four key-phases of development of the Global Service process:

1. phase of needs analysis and definition (grantor);
2. phase of preparation of request for offer (grantor);
3. phase of preparation of offer (bidder);
4. phase of evaluation of offer (grantor).

Each section of the set of standards, besides stating the "objectives of the phase", makes clear - also with the support a detailed flow diagram - the procedures (sub phases and criteria) to be adopted for the development of the different phases of the process.

On the basis of this layout, the standards are structured according to the following index:

Section 1.
1. NEEDS ANALYSIS AND DEFINITION PHASE *(Grantor)*
1.1 OBJECTIVES
1.2 PROCEDURES
1.2.1. The identification of the services to be assigned to Global Service
Identification of the services which could be assigned to Global Service, according to the advantages to be obtained by means of externalisation, on the basis of the objective and historical data relative to the "services";

1.2.2. The evaluation of the services to be assigned to Global Service
Quantification of the services that could be assigned to Global Service and estimate of the economic advantage to be obtained; this estimate must necessarily be based on suitable proof and documentation of the real estate patrimony actually making use of these services, in all its various aspects (size, state of repair, respect of legislation, etc.)
1.2.3. The analysis of the organisational impact
Identification of the transformations in the organisation necessary for the correct and efficient management of Global Service (transformation of the executive functions into control functions, adaptation and eventual integration of the information flows)
1.3. SUPPORT INSTRUMENTS
1.3.1. The "Preliminary Approach Document"

Section 2.
PHASE OF PREPARATION OF REQUEST FOR OFFER (Grantor)
2.1. OBJECTIVES
2.2. PROCEDURES
2.2.1. The documentation of the real estate patrimony to be assigned to Global Service
Suitable documentation of the patrimony in the context of the request for an offer (identification of real estate, information about the size of buildings and plants, specific documents concerning the state of repair, respect of legislation and safety, etc.)
2.2.2. The definition of the services requirements to be assigned to Global Service
Clear and homogeneous definition of the requirements of the services to be assigned to Global Service and the methods of control that will be adopted for the verification of their carrying out (the real objective of Global Service lies in these identified requirements, that is to say in the "services")
2.2.3. The definition of the organisational requirements of Global Service
Identification of the organisational requirements of Global Service (availability of general interfaces and specific planning processes, carrying out and report of services, independence of quality controls, role of data system and definition of any eventual integration restrictions)
2.2.4. The definition of the evaluation criteria
In the definition of the evaluation criteria of the offers, it is necessary to give more importance to the factors of quality and service as the efficacy of Global Service closely depends on these.
2.2.5. The definition of the ways of presenting the offers
Indication of suitable restrictions for the format and the ways of presenting the offers, according to the typologies of service given by Global Service and the requirements identified, so as to guarantee the homogeneity necessary for the following evaluation (with the identification of the evaluation criteria that will be adopted).
2.3. SUPPORT INSTRUMENTS
2.3.1. The "Services Contract"

Section 3.
PHASE OF PREPARATION OF OFFER (Bidder)
3.1. OBJECTIVES

3.2. PROCEDURES

3.2.1. The preliminary evaluation of Global Service

Preliminary verification of the bidder's interest with regard to the tender documents, with contextual evaluation of its own ability and competence as well as the opportunity for possible integrations (partnership)

3.2.2. The Global Service planning

Development of the planning on the basis of the full awareness of the services requirements and the patrimony assigned to Global Service (on the basis of the documents presented for the tender, integrated with "direct" knowledge acquired "on the field"), in which are defined in an organic and integrated way, by means of a repetitive process, the operational, logistic and organisational aspects (this must include therefore: interfaces with the grantor, methods of control and use of data system, definition of starting times, etc.)

3.2.3. The formulation of the offer

Homogeneous and organic formulation of the proposals (description of project) and an accurate economic evaluation (with possible check/representation of project in the case of incongruity)

3.3. SUPPORT INSTRUMENTS

3.3.1. The "Targetplan Check List"

Section 4.
PHASE OF THE OFFER EVALUATION (Grantor)

4.1.OBJECTIVES

4.2. PROCEDURES

4.2.1. The technical-qualitative evaluation of the offers

Evaluation of the technical aspects of the offers (start-up method, services, organisation, economic-experience and quality indicators) by means of the identification of definite parameters and the application of comparative methodologies

4.2.2. The economic evaluation of the offers

Evaluation of prices and/or discounts by means of the application of comparative methodologies

4.2.3. The final evaluation

Overall technical-economic evaluation of the offers by the giving of "weights" for the different factors (technical and economic), which result as being congruent with the objectives of Global Service

4.3. SUPPORT INSTRUMENTS

4.3.1. The "Evaluation Document".

3. Subjects for discussion

The choice, formulation and adoption of the procedural and contractual system of Global Service maintenance arises from the demands of the grantor in order to rationalize and externalise the maintenance services in an "integrated" way and according to economic, managerial and qualitative objectives.

The choice of the Global Service model must, therefore, be founded on the analysis of the grantor’s changing needs with regard to the maintenance management system in use.

As a consequence, the standards in question can represent useful contributions, in order to approach this preliminary "strategic" phase, for the definition of a global service work order, especially for the purposes of obtaining a correct and articulated analysis and clarification of the grantor’s needs and objectives, in relation to its own specific reality and general strategies.

In order to obtain this, the above mentioned standards can be useful to translate the needs into the requirements and objectives of the property maintenance service, which are definable and verifiable in terms of quality, time and economics.

In particular the grantor can obtain methodological-operational references in order to interpret fundamental elements such as:

- the congruence of the chosen Global Service model with the property strategies;
- the characteristics of the organisational structure of the maintenance service;
- the analysis of any possible existing Global Service contracts and the results of the maintenance work carried out with internal resources or by means of separate contracts;
- the definition of the state of knowledge and the inventory of the real estate patrimony;
- the analysis and evaluation of the existing information system (also for the purposes of its possible reconfiguration);
- the characteristics and means of verification of the quality/reliability of the potential providers of the Global Service activities;
- the identification of the activities to be entrusted to Global Service;
- the definition of the Global Service model to be adopted (according to the criteria of gradualness and integration of services);
- the definition of the criteria for the control and measure of service quality.

For the choice of the activities to be entrusted to Global Service, the standards set out a methodological approach for the grantor that, in the first place, regards the gradual moving from "episodic" maintenance to that hinged upon a "management service" or on several "integrated services".

In this way the grantor can consider systematically and rationally, in relation to the obtainable results, the different forms of organisation and the entrusting of the maintenance work management system.

In particular:

- the rationalisation of the maintenance work, with the development of planning, organisational, suitability and control functions, by means of the creation of a specialised sector, into which all the management, administrative and executive competences go;
- the rationalisation and integration of the maintenance and management activities, through forms of services externalisation, planned and controlled by the grantor, with the adoption of an information and reporting system involving the operational integration among the different structures of the grantor itself, the external provider and the users;
- the complete externalisation of the maintenance work, that is not considered as being strategic for the development of the grantor's activities, with the complete economic co- responsibility of the results on the part of the provider.

The approach of the set of standards in "process" terms can however supply the grantor with a sort of "guided course", useful to set out, control and plan a series of aspects characterised, at present, by a high level of complexities, among which are:

- the evaluation of the composition and the entity of the costs sustained by the grantor and the levels of performance reached for each activity, compared with certain services, also in the prospect of the "life cycle costs" evaluation;
- the verification of the levels of services on the basis of parameters which are as homogeneous as and comparable with the market as possible, especially in terms of "benchmarking";
- the definition of the levels of the services being carried out, according to verifiable parameters and in relationship to the needs and destinations of use;
- the preliminary economic analysis;
- the definition of the present needs of the service and the verification of the congruence with the property strategies;
- the analysis of the organisational structure of the grantor.

The set of standards can supply useful guide-criteria for the decision-making and operational support, also with regard to the "knowledge" of the real estate patrimony for which the grantor intends to set up a Global Service maintenance service.

The knowledge of the building patrimony, in fact, (quality-quantitative consistency, technical features, services statement etc.) is a fundamental requirement for the correct setting out of the service reference parameters, the definition of the offer request and the evaluation of the offers. The lack of fact-finding elements relative to the consistency and features of the property often compromises the correct approach to Global Service.

The grantor, before formulating the request for offers of the service, must evaluate the consistency, quality and availability of the information in his possession. This is a preliminary phase, which must be carried out with the correct methodology, based on precise parameters of reference and procedures so as to be able to keep a reliable record of the available information patrimony.

By means of the indications supplied by the set of standards, it is possible to identify the following minimum, indispensable information, divided into four inventory categories:

- location register (site, univocal identification of the property, consistency etc.);
- technical register (building techniques and typologies for the main classes of technical elements, maintenance history, state of conservation, maintenance cost indexes etc.);
- functional register (destination and use, type of user etc.);
- administrative register (usage title, supply contracts for works and services etc.).

With respect to the valutational criteria above, by means of the analysis model of the information present and available as indicated by the standards, three different situations can appear:

- the data available is a knowledge basis which is sufficient for the formation of the requests for an offer;
- the information available is not exhaustive and/or is not integrated and coherent and/or does not perfectly correspond to the real situation of the patrimony. In this case it is necessary to carry out work of integration and reviewing;
- the information is absent or unusable for register purposes. In this case it is necessary to set up a "basic data register".

With regard to this, the standards emphasise that the presence of a "specific information system" constitutes an essential condition for the management of a Global Service maintenance service, in so much that:

- it constitutes an element of continuity and coherence between the information at hand before the start of the service and that acquired during the carrying out of the service;
- it permits the collection, keeping and elaboration, by means of the filing of the information received, of all the data relative to the work carried out during the period of service, whoever the provider of that same service may be;
- it is an important support instrument for the management of the work on the part of the service provider;
- it represents a necessary instrument for the control activities of the quality conformity of the services by the grantor.

In this way, the set of standards being compiled is directly linked to another UNI set of standards "Information systems for the management of real estate patrimony maintenance", published in the summer of 2001 (UNI standards 10951).

Another crucial aspect about which the standards can give further information of a technical-procedural nature is that of the analysis of the impact of Global Service in terms of the organisation of the grantor's company.

Should, in fact, the grantor's company have to resort for the first time to the entrusting of maintenance work by means of the Global Service model, it needs to first of all evaluate the consequences of this in terms of "organisational planning".

The "Preliminary Approach Document", an innovative instrument introduced by the standards, should, in this regard, involve an analysis of the needs and the availability within the grantor's company in terms of personnel and competences for the purpose of monitoring and checking the carrying out of the Global Service contract.

By means of the "Preliminary Approach Document", there should be carried out a forecast of the features of the possible providers of the Global service contract on the basis of the analysis of the offer, so as to identify the best means of interaction between the organisation of the grantor and that of the provider.

The grantor should then, on the basis of such examination, define the amount of work to be entrusted to outside companies.

If, on the other hand, it were to decide to continue with an already experimented approach of previous entrusting of work to Global Service, it would be similarly opportune to carry out an analysis of the organisational assets, which could possibly be submitted to reengineering.

As indicated by the set of standards, the introduction of the Global Service model should lead the grantor's company to reduce the competences of planning and direct management of the maintenance work and to increase the competences concerning monitoring and control of the progress and the results of the work entrusted to external companies.

The grantor should therefore set up its own "Global Service Organisation Unit" dedicated to the running of the Global Service contract, charged both with verifying the respect of the contract on the part of the Global Service provider, and with learning the new techniques used by it for the purpose of channelling them into its own company at a later date.

As also indicated by the set of standards, the Global Service Organisation Unit should, furthermore, take care that the data and information contained in the system be given to the grantor correctly, completely and in good time.

So far the main reasons have been highlighted for the adoption of a "procedural" approach for the set of standards being drawn up, just as the main potential supports of a technical-procedural kind that the same set of standards will be able to supply.

The standards, which are nearing completion, will be drawn up by the end of 2002.

Once adopted through UNI, the set of standards will represent the first of its kind in Europe and will supply the grantors and providers of Global Service real estate maintenance services (the addressees of the standards) a common basis of methodological-operational reference in order to unify the introductory procedures as much as the capitular, planning and contractual ones connected to the Global Service "process", its correct adoption and operational use.

In this way, in not only a European but also an international dimension, it will be possible to evaluate the standards also in terms of potential "transferability" under the methodological-operational approach profile.

End Notes

1 TEROTEC General Director

2 TEROTEC Technical Coordinator

3 TEROTEC is an association-laboratory of national importance, having as its institutional aim the promotion, development and propagation of innovation in the field of the maintenance and management of urban and real estate patrimonies, developing for this aim services of research, experimentation, training, the study of new standards, advice, information and promotion. The incorporators of TEROTEC are:

- ANCE/Associazione Nazionale Costruttori Edili
- Consorzio AGI
- Coopservice
- EUR Roma
- FISE/Federazione Imprese di Servizi
- Groma
- Harpaceas
- Insula
- Manitalidea
- Manutencoop
- Pirelli & C. Property Management.

4 The UNI National Committee set up for the study and formulation of the standards has the following members:

- President: Prof. Claudio Molinari
- Coordinator and responsible: Prof. Silvano Curcio
- Technical secretary: Ing. Roberto Ravaglia
- Referees: Prof. Angelo Ciribini, Ing. Angelo Guerrieri, Ing. Fiorenzo Guidoreni, Ing. Marco Mandarino, Prof. Rossella Maspoli, Arch. Pier Giuseppe Mucci, Arch. Laura Papanti Pellettier, Ing. Enzo Scudellari, Prof. Cinzia Talamo.

Integration of facilities provision and facilities support services provision – A management process model

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Abstract:
The paper supports the view that research efforts aimed at improving management effectiveness of operational real estate assets should be channelled to provide frameworks or models that promote understanding to all parties involve in the process, from a knowledge base that can better explain the following:

1. *Requirements of core business(es);*
2. *Key real estate and facilities services attributes, and*
3. *Options evaluation to meet dynamic changes.*

In previous papers the author proposes a proactive management model for corporate real estate resource that calls for a constant two-way dialogue: from strategic management - the strategic intentions and direction of where the company is going; and from operational management - the best way of achieving the desired outcome in resource terms and their ongoing management. At the heart of the proactive management model are the interrelationship between the Strategic Facility Brief and the Service Levels Brief.

This paper extends on the above model with a management framework that supports the implementation of both the Strategic Facility Brief (SFB) and the Service Levels Brief (SLB) in an organisation setting. Within a business context, the SFB provides the context for placing the role of operational real estate assets that is aimed at continuously aligning the real estate resource to the strategic intent of business plans. Similarly, the SLB provides the basis for considering the role of facilities support services that is aimed at continuously aligning the service performance to the strategic intent of business plans.

Introduction

The primary focus of this paper is the physical resource base that supports any business - the operational corporate real estate assets. In order to achieve the much-needed alignment between business strategic direction, organizational structure, work processes and the enabling physical environment; the organization's strategic intent must clearly reflect the facilities dimensions in its strategic business plans.

A comprehensive literature review by Then (1996) highlighted three emerging themes, which influenced the research direction:

- The need to link real estate/facilities decisions to corporate strategy.
- The need to proactively manage functional space as a business resource.
- The need to incorporate physical asset requirements in an integrated business resource management model.

The above themes, in turn, lead to at least *three requirements* in any attempt to develop an integrated resources management structure that binds facilities provision to facilities management in any organizational setting:

(1) The requirement for an appropriate linking mechanism for considering facilities implications of business decisions by promoting meaningful dialogue between business corporate planners and real estate/facilities personnel.

(2) The requirement for management processes to monitor the strategic relevance of facilities requirements and monitoring their performance over time.

(3) The requirement of appropriate skills and competencies within the real estate/facilities function to monitor and continuously review procurement strategies to take advantage of advances in technological development and market offering on the supply side.

An earlier paper (Then, 1998b) reported on the justification and management implications of arising from research proposition (1) above. This paper reports on process models in respond to research proposition (2) above.

BACKGROUND

The role of real estate asset management (REAM) in the context of business management is to ensure the timely supply of appropriate, fully serviced functional space, as a supporting business resource to the fulfilment of business objectives.

A qualitative approach has been adopted as the principal research method based on case study interviews, supplemented by questionnaire surveys of respondent organisations. An integrating resource management framework was developed to model the nature of interactions between strategic business planning and operational asset management within an organizational setting. The proposed framework is grounded on an understanding of the nature and demands of the core business requirements. Business operational requirements are the drivers of real estate demand and facilities services provisions. The proposed REAM model represents a dynamic integrated management process that optimizes the business resources (people, property, technology, knowledge and finance) towards the fulfilment of corporate objective and targets.

A three-part analysis was adopted to meet the separate requirements of data analysis for each of the above research propositions. The overall methodology framework of the research undertaken is summarised in Figure 1.

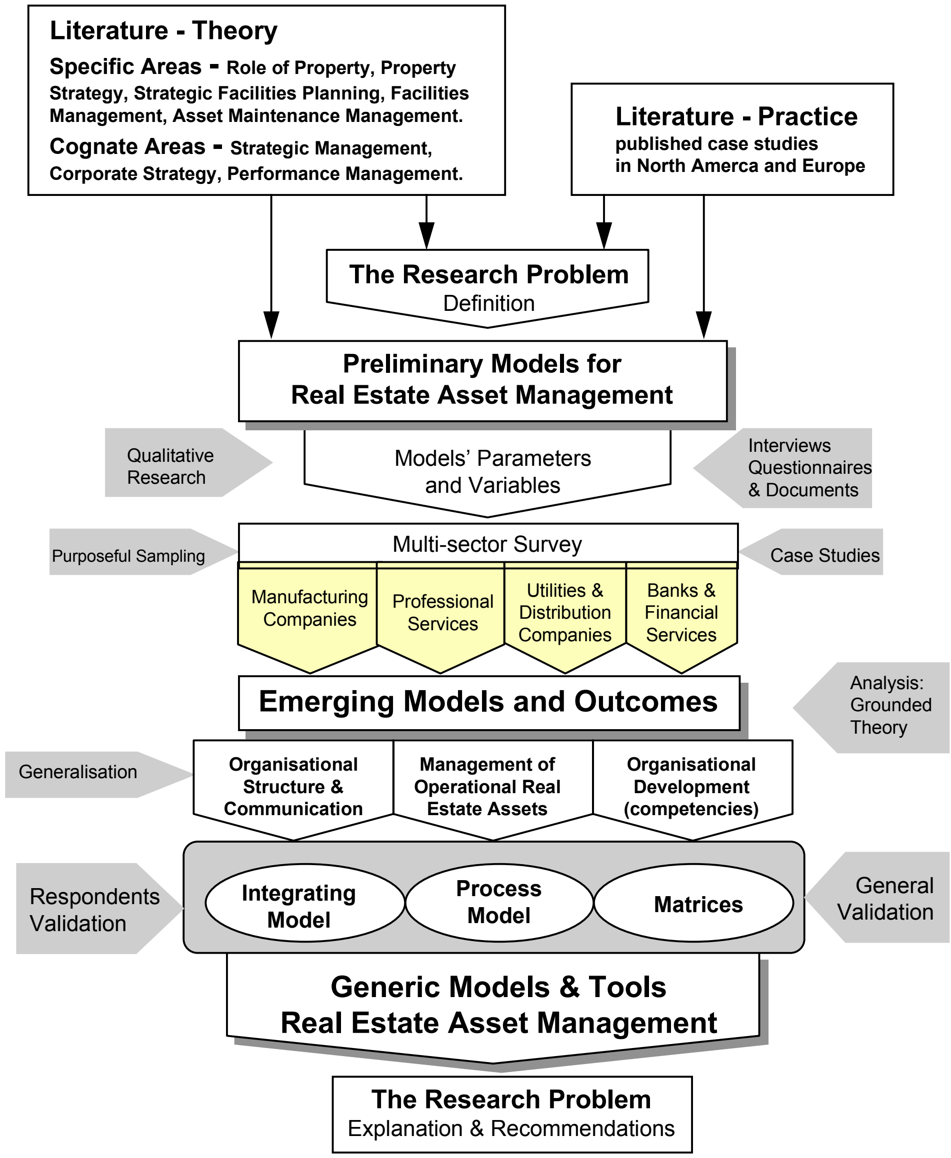

Figure 1: Research Methodology Framework (Then, 1996)

Note: Real Estate Asset Management (REAM) embraces two principal areas of management of the corporate physical assets: *facilities provision* (that is, the definition of demand, design, acquisition and management of functional space to house the core business activities) and *facilities management* (that is, the definition of service levels, procurement and management of facilities-related support services required for the proper functioning of the working environment within the corporate real estate portfolio).

Justification for an Integrated Model for REAM

Requirements of an Integrated Proactive Management Framework

Proactive management of the corporate real estate resource demands well articulated strategic direction from senior management and well defined measurable deliverables from operational management. The relationship between business management and the supporting role of operational property is often not properly defined at the strategic level. This often results in operational policies that do not clearly reflect the contribution of property assets in terms of the organization's overall performance measured in terms of improved profitability, productivity and customer satisfaction. Two main categories of roles are discernible from the range of activities associated with REAM:

1. Activities related to the role of providing appropriate buildings (i.e. the corporate operational asset base measured in terms of *functional space*) required by the organization to carry out its core business activities, and

2. Activities related to the role of ongoing management and servicing of buildings in use (i.e. the workplace environment).

The first facet is essentially concerned with the role of "*facilities provision",* while the second facet is concerned with the role of "*facilities support services management*" of property-related support services. Successful resources management should consider these two facets as one overall issue.

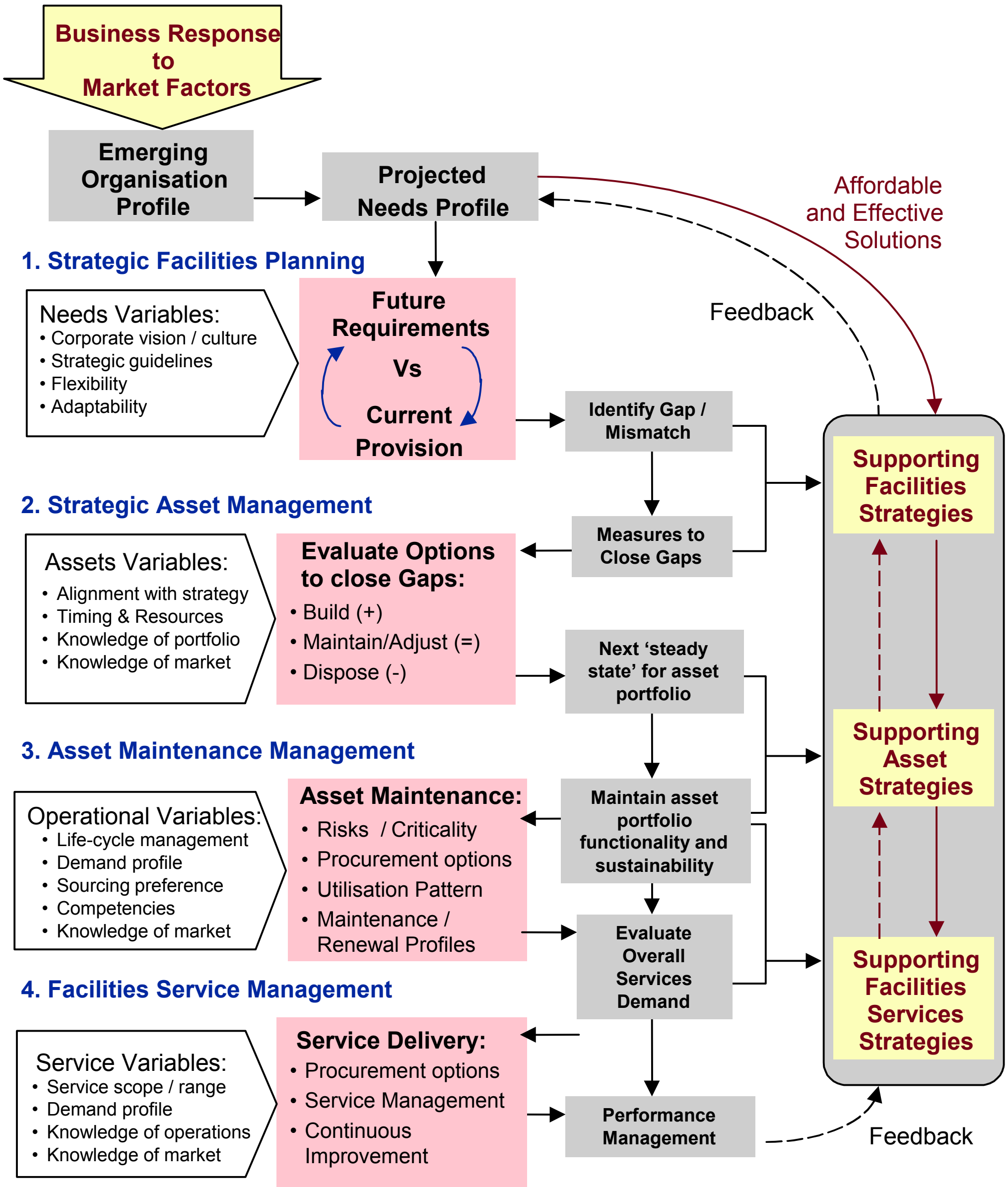

Figure 2: *Real Estate Asset Management – An Integrated Resource Management Framework (Then, 1996, revised 1999)*

The need to improve the communication interfaces between strategic business planning and operational asset management resulted in a model proposition for REAM comprising of four related components of *Strategic Facilities Planning (SFP), Strategic Asset Management (SAM), Facilities Service Management (FSM),* and *Asset Maintenance Management (AMM)*. The interrelationship and interactions of the four principal components of REAM in continuously sustaining corporate strategic relevance is illustrated in Figure 2.

REAM as Managing the Enabling Working Environment

The external business environment impinges on both the core business performance as well as the facilities support services delivery strategy. The *enabling workplace environment* within an organization is an outcome of the response to these two sets of variables:

1. *real estate variables,* and
2. *facilities services variables*

Figure 6 provides a framework for considering the various factors that impact on the output from the *Strategic Facilities Brief* (SFB) and *Service Levels Brief (SLB)*. In deriving the variables that are ultimately reflected in the quality of the enabling working environment, evaluations are carried out at three cascading levels: (i) external market environment, (ii) organizational response, and (iii) key demand and supply factors.

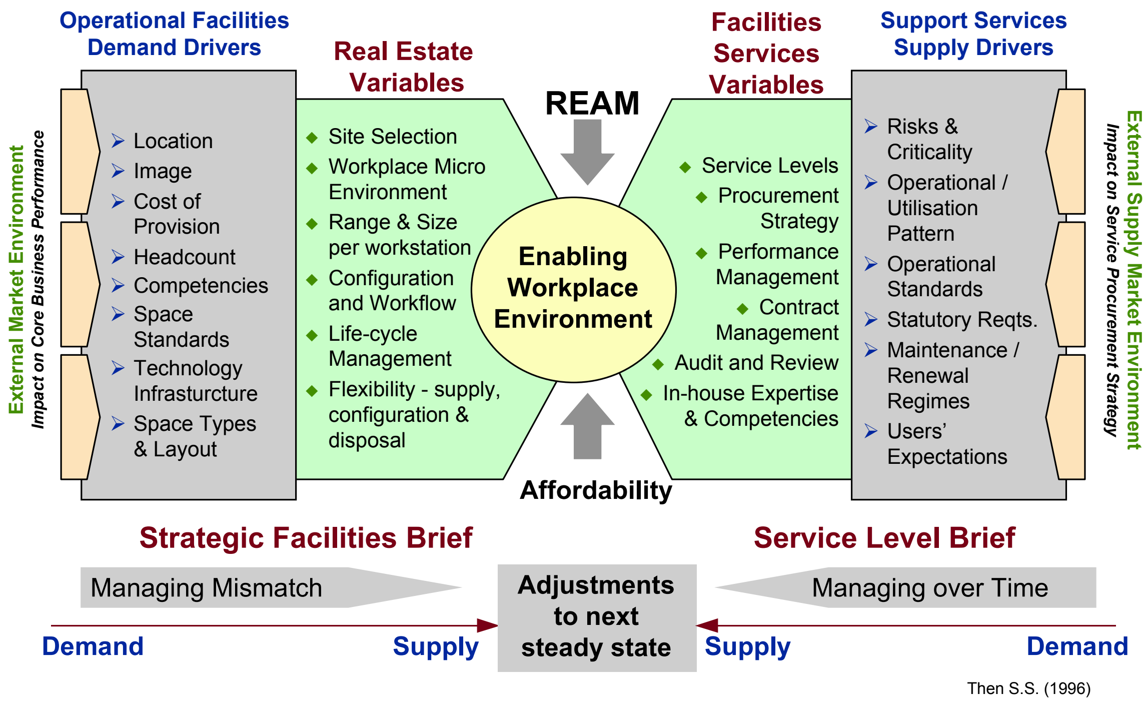

Figure 3: *REAM as Managing the Enabling Workplace Environment (Then, 1996)*

Figure 3 emphasizes that the common denominator is the need to constantly adjust to a next 'steady state,' in response to external factors. The outcome is to provide an enabling workplace environment that supports the achievement of the corporate goals, whatever the final product(s).

Within the SFB domain**,** strategic management concerns are with managing mismatch between demand and supply as a response to the dynamic market environment within which the organization operates. The primary concerns of REAM within SFB are with decisions relating to asset ownership and asset management.

The strategies adopted in response to the market factors are then translated into *operational facilities demand drivers* at the intermediate level, which will in turn determine the appropriate *real estate variables* for the business it is supporting. The *real estate variables* represent the output of the SFP domain. The variables listed represent the strategic parameters that govern the facilities provision from demand initiation through to the supply of the appropriate functional space. At any point in time, the relative weightings given to the real estate variables identified will influence the emerging supporting facilities strategies.

Within the SLB domain, management concerns are with managing the existing property assets over time, with the emphasis on meeting operational and users' requirements within agreed parameters of service and financial limits. The primary concerns of REAM within SLB are with decisions relating to minimizing risks of disruption and service management.

The strategies adopted in response to corporate strategic plans are translated into facilities *support services supply drivers* at the intermediate level, which will in turn determine the appropriate *facilities services variables* for the working environment within the existing operational real estate portfolio. The *facilities service variables* represent the output of the SLB domain. The variables listed represent the tactical and operational parameters that govern the facilities service provision from demand initiation through to the supply of the appropriate levels of facilities services. At any point in time, the relative weightings given to the facilities services variables identified will influence the practice of the support services delivery process.

A central theme in the dialogue between SFB and SLB is the significance placed by senior management on the capability of options evaluation or having alternative 'strategic scenarios' against possible business outcomes. The dominant concept of REAM is to provide an informed interface between strategic business planning and operational asset management via SFB and SLB. REAM takes as its inputs - the business response to the changing market factors, the processes of evolving the most appropriate supporting facilities strategies in support of the new strategic direction, and as outputs - action plans for adjusting the existing asset base to a next 'steady state.'

The emphasis on *affordability* as a central driver for the practice of REAM is important in that the concept of 'living within one's means' accords with key stakeholders' concerns within the overall business management process:

- senior management's preoccupation with the costs associated of real estate asset provision and facilities occupancy costs;
- business units' demand of value for money from service providers being meet by performance related service contracts based on mutually agreed service levels and performance measures;

- service providers, in-house or external, working within a strategic framework of provision guided by continuous constructive dialogue between SFB and SLB.

The preceding discussions described the convergence of real estate variables and facilities services variables leading to the creation of appropriate enabling workplace environment as an outcome of REAM in an organization setting. The range of factors to be considered demonstrates the need for an integrated management process.

The next section builds upon the preliminary models presented above and incorporates the empirical evidence from the case study organisations to propose a pair of conceptual process models to elaborate the management roles associated with *Facilities Provision* and *Facilities Service Management.*

Process Model for Facilities Provision

Figure 4 illustrates a conceptual process model of a management framework for placing the role of operational real estate assets (i.e. operational property) within the realm of business management. The model centres on the key role of the *Strategic Facilities Brief* in defining the parameters for facilities provision. The model describes a 6-stage process aimed at continuously aligning the real estate resource to the strategic intent of corporate business plans.

Figure 4: *Management Framework for Facilities Provision. (Then, 1996)*

The depiction of the model as a cyclical process is intended to reinforce the fact that the re-alignment process of operational assets to business plans is a continuous one of adjusting to the ‘next steady state’ in response to external market forces. The 6-stage process has been derived from published literature and reinforced by evidence from empirical data from the case studies and interviews. It attempts to incorporate elements of best practices in a generalized model that focuses on the key stages and management emphasis between any two stages.

It is apparent from the six stages model that the management focus shifts as one move from one stage to the next. The emphasis progression from; evaluate -> influence -> competencies -> systems -> measurement -> communicate; gives an indication of the wide range of skills necessary within REAM.

The outcome of the facilities provision component of the process model is the appropriate supporting facilities strategies based on the organization’s capability to generate alternatives or scenarios to ensure that the existing corporate real estate assets maintain their strategic relevance in supporting the corporate business plans.

Process Model for Facilities Service Management

Figure 5 shows the companion model to Figure 4. It illustrates a process model of a management framework for placing the role of facilities support services in business. The model centres on the key role of the Service Levels Brief and proposes a similar 6-stage process that is aimed at continuously aligning service performance to operational real estate portfolio in line with the strategic intent of business plans. Similarly, the proposed model incorporates elements of best practices in a generalized model that focuses on the key stages and management emphasis between any two stages.

In the evaluation of services levels, it is important to balance the needs of the various business units against the relative contributions to the total corporate business by each individual business units. In practice, there may be several service levels even for an individual service as dictated by the relative importance of each business unit’s contribution to profitability.

The outcome of the facilities service management component of the process model is appropriate supporting facilities service strategies with emphasis on managing the operational assets over time and supporting the enabling working environment within the real estate portfolio.

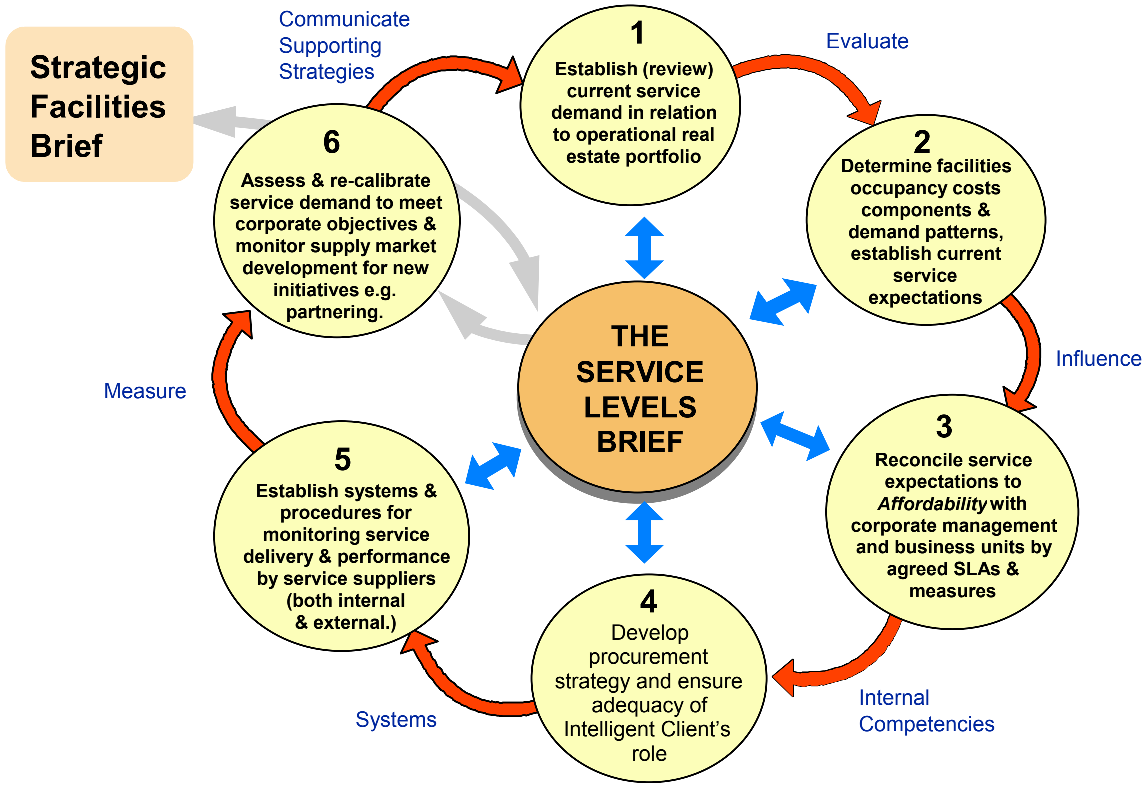

Figure 5: *Management Framework for Facilities Service Provision. Then (1996)*

It is emphasized that the cyclical processes represented in Figures 4 and 5 above are not necessarily sequential, but an iterative one emphasizing the advantages associated with organizational learning. Within an organizational setting, both models provide a management framework that supports two important interfaces:

1. Strategic interactions with senior management and business units; access to vital *business information,* in order to sustain (by being proactive) and to continue to maintain strategic relevance (by having the capacity to generate solutions), in terms of the operational asset base;

2. Operational interactions with business units, as purchasers of services; the provision of *service performance information* in order to ensure economical and consistent delivery of the appropriate service packages through effective procurement and performance monitoring.

Emerging Proactive Management Models

The emerging models are derived from three principal sources of data:

1. Established management and economic theories applied to a particular class of durable physical assets, real estate assets, in an organizational setting.

2. Published case studies and interviews from practitioners in the related fields of real estate (property) management, facilities management, maintenance management, etc.

3. Case studies and interviews conducted as part of this study.

The models are presented as concepts to explain context, causes and implications in practice.

A traditional reactive management model for the practice of REAM is presented as the starting point of theory generation for an integrated proactive model. A preliminary proactive management model, encompassing both the facilities provision and facilities service management dimensions of REAM, is also proposed. These two models represent the extremes along a continuum rather than typical representation in reality.

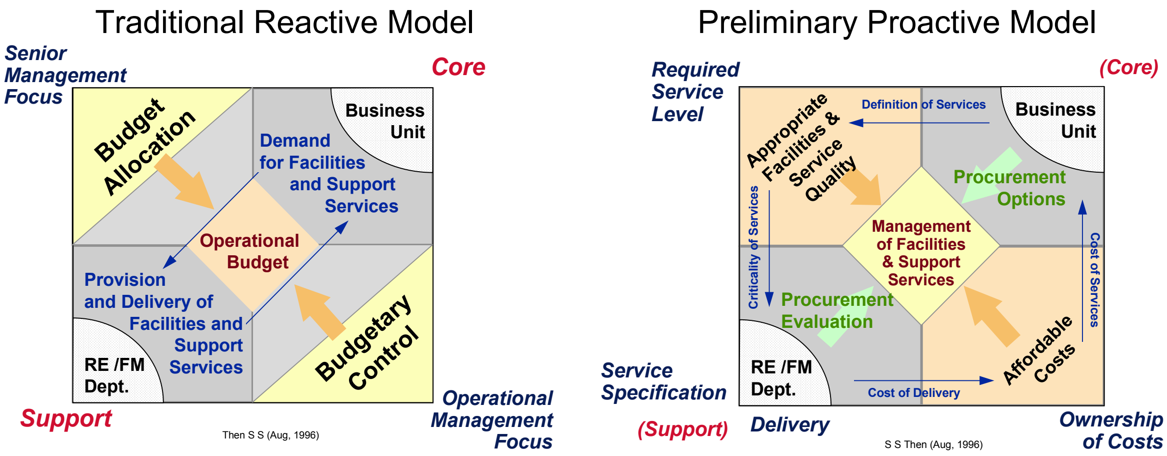

Figure 6: *Comparison of Reactive and Proactive Models (Then, 1996)*

The traditional reactive model contrasted sharply with the preliminary proactive model in both management approach and focus, and in the nature of relationships between the business units and service providers (i.e. the in-house real estate/facilities department). The former being essentially a cost (budget)-driven approach while the latter relies on a process-driven approach guided by clear articulation of facilities and service demands through the SFB and SLB.

Following the analysis of feedback from a validation workshop, it was decided that in the case of the preliminary proactive model, the real estate variables from the domain of SFB and the facilities service variables from SLB are sufficiently unique to warrant separate considerations.

Figure 7 provides a revised emerging proactive model as two components; one focusing on the management of operational facilities (i.e. real estate assets), the other focusing on the management of facilities support services. The acknowledgment of a shift in emphasis, from fulfilling transactions on demand under the traditional reactive approach, to a process-driven management approach is fundamental in justifying and defining the emerging role and scope of REAM.

The context and role of the SFB in providing a corporate perspective of the real estate resource ensure that demand is defined and articulated as corporate facilities guidelines, and supply is effected with affordable cost criteria without lost of criticality and quality.

Within a corporate setting, the proactive model caters for the translation of business units needs by providing affordable solutions via a process cycle comprising of:

- demand for space,
- key attributes of functional space,
- time-scale of delivery, and
- recovery of facilities occupancy costs

In a similar manner, the business units' demand for facilities services within the context of SLB can be meet via a process cycle comprising of:

- definition for service,
- criticality of service (which influences procurement options),
- cost of provision, and
- recovery of facilities service costs.

Management of Operational Facilities   Management of Facilities Support Services

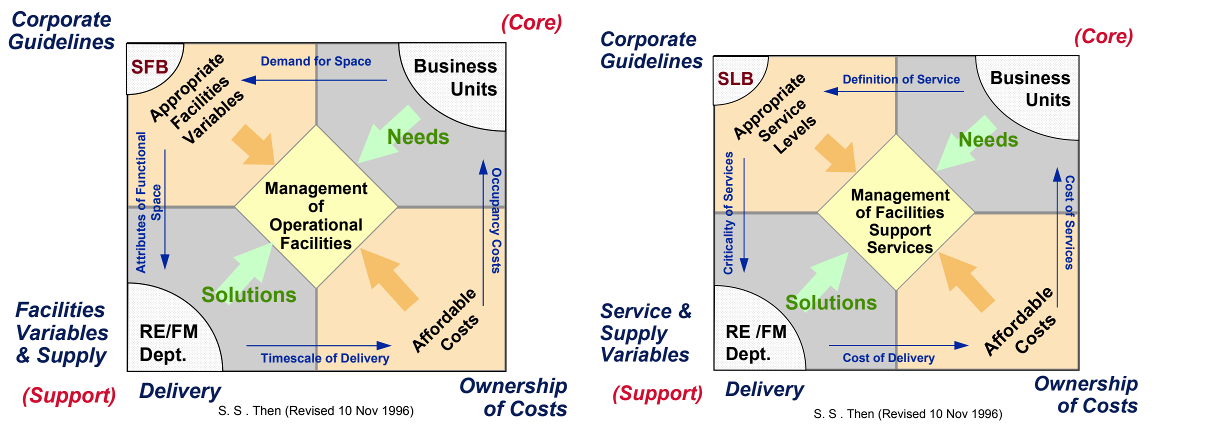

Figure 7: *Emerging Proactive Models (Then, 1996)*

Effective matching of demand for, and supply of, functional accommodation and associated support services to meet operational requirements in a dynamic business environment demands the management of the real estate assets as a dynamic integrated management process. The realization of an integrated approach necessitates a formal planning framework that must cater for the cultural, procedural and existing knowledge base of the organization concerned. Ultimately, the practice of REAM is concerned with the delivery of the enabling workplace environment – the optimum functional space that supports the business processes and human resources.

Figure 8 illustrates the dynamic capabilities of a model framework to *review* strategic relevance against the competitive realities of the business environment within which it operations, as well as, *measuring* operational management effectiveness and efficiency against external best practice. The business imperative from a resources management perspective is to align the appropriate supporting facilities strategies to the current strategic business plans.

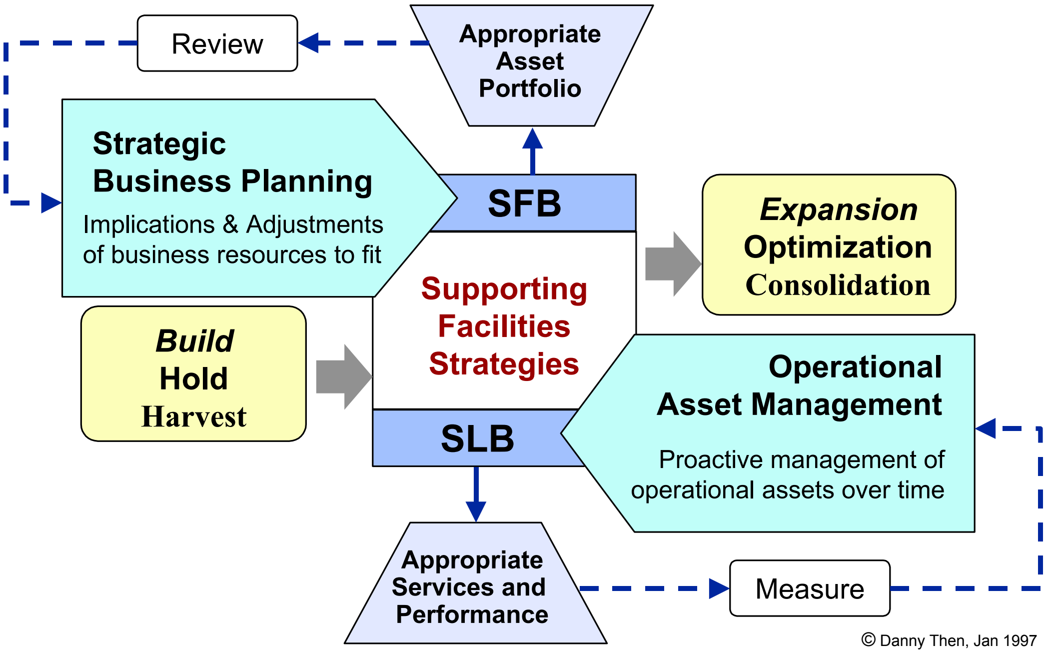

Figure 8: *An Integrated Resources Management Framework (Then, 1996)*

The justification of REAM is to meet the business challenges that confront the organization it is supporting, as an enabler in the first instance. In the long term, a more sustainable role must be to build upon an aspiration to continuously add value by providing appropriate and innovative 'facilities solutions' to business challenges through the skilful manipulation of all business resources - the optimum balance between people, physical assets and technology.

Key features of a proactive integrated resources management framework illustrated in Figures 8 above are summarized as follows:

1. A growing awareness of the need to fully understand each business units cost structure has promoted a closer scrutiny of occupancy costs of operational facilities.

2. A shift in culture from being a 'free goods' absorbed as a 'hidden' corporate overhead expense, to full ownership of occupancy costs has had the impact of dramatically altering the approach, as well as, the focus on management of functional space provision and support services procurement.

3. The continuing restructuring of the supply market in facilities support services, has altered the traditional role of facilities service management side of REAM; shifting from management of directly employed staff to management of service

providers and ensuring performance standards are met. On the facilities provision side of REAM, however, the real estate (property) supply market has remained relatively static, development innovations and opportunities largely constrained by inflexibility in funding arrangements.

4. Concerns of senior management are in defining the *appropriate* service requirements and quality in line with ensuring business continuity and success. In this respect, the onus has shifted to the business units to define their service requirements and criticality, tempered by the economics of *affordability.*

5. A service relationship between business units, as purchasers of functional space and related services, and in-house service provider, acting as an intelligent client interface, with the relevant competencies to provide effective and economical solutions to business units' expressed needs with full awareness and ownership of the cost of provision.

Conclusions

The current emphasis on appropriateness and affordability in space demand and facilities support services calls for a management approach that is underpinned by an understanding of the drivers of business demands and the processes required to meet the business requirements. This underlying principle has seen a growing acknowledgement in both the property and facilities industry in recent years (O'Mara, M., 1999; Weatherhead, M., 2000; Capital Economics, 2002).

This study was initiated on the premise that the role of the corporate operational real estate assets represents an increasingly important component of business resources in the overall management of corporate success. A common theme that emerged from the literature survey through to the case studies and the validation exercise carried out, was the prevailing perception or attitude of the role of operational assets held by senior management and the profound impact it had on the practice of operational asset management in an organization. This perception is fundamental in that it is always the prerogative of senior management to allocate resources to the various functional divisions within the organization. However, it is equally important to acknowledge that almost all strategic business decisions have implications on real estate and/or facilities dimensions.

The crucial question is *to what extent are such implications thoroughly evaluated, articulated and presented at senior management level where strategic business decisions are made?* Executives charged with responsibilities for the real estate and facilities support roles must develop the competencies and capabilities to provide realistic options within the business propositions remit in the hope of influencing senior management decisions to arrive at appropriate optimal *facilities solutions* to *meet business needs*. In this respect, raising the corporate strategic awareness to the strategic role of the real estate resource is a fundamental pre-condition for an informed interface to materialize. It is hoped that the models presented in this paper go some way to explain, justify and promote the critical need for constructive dialogue between strategic business planning and operational asset management via an integrated resources management framework.

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Note 1: The sources of literature reviewed are listed below. The emerging trends and research directions are the results of an international literature review over the last two decades. The main focus of the review was the role of physical assets in supporting business objectives.

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Structured Process Improvement in Facilities Management Organisations using the "SPICE FM" Approach

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Abstract:
Facilities Management is a newly emerging and fast growing business sector. Currently there is limited research in process improvement in this sector. This paper discusses SPICE FM, a research project, which developed a process improvement framework for FM. The paper explains the SPICE FM framework, research methodology and well as a case study in implementing the framework.

Background

This paper provides an overview of the SPICE FM research project[1]. SPICE FM sets out to develop a process improvement framework for FM organisations.

Facilities Management (FM) is a term, which encompasses a wide range of activities involved in the effective management of built assets. It involves the total management of all services that support the core business of the organisation. Alexander (1996) identified FM as the process by which an organisation ensures that its buildings, systems and services support core operations and processes as well as contribute to achieving strategic objectives in changing conditions. Understanding of process initiative aspects of FM behaviour in particular, remains relatively undeveloped. To date little data is available to assess how extensively the use of process thinking has diffused in FM organisations, what factors have influenced this diffusion, and how they affect the overall organisational performance. To this extent, SPICE FM's aim was "to develop a structured organisational learning framework for facilities organisations". It investigated if some of the existing organisational improvement frameworks used in other business sectors could be integrated and tailored to create a comprehensive FM solution. In particular the research investigated two existing frameworks, namely (i) SPICE; and (ii) the Balanced Scorecard.

SPICE (Sarshar 2000), is a process improvement framework for construction organisations. However, a shortcoming of SPICE was that the process improvement framework did not have clear links with business strategy and business priorities (Finnemore 2000). SPICE FM attempted to address this shortcoming by integrating SPICE with a major business strategy framework, namely the Balanced Scorecard.

The Balanced Scorecard (BSC) (Kaplan 1996) is a strategic management framework developed by Harvard University. BSC is a conceptual framework for translating an organisation's vision into a set of performance indicators distributed among four perspectives: financial, customer, internal business processes and learning and

[1] SPICE FM was a two year research project sponsored by EPSRC (Engineering, Physics and Science Research Council) and the DETR (Department of Environment, Transport and the Regions) in the UK.

growth. The BSC is used with a large amount of success in a wide range of industries. This paper will provide a short overview of BSC in later sections.

This paper is based on the SPICE FM study and attempts to identify critical processes and process improvement concepts in FM. Further, it will address the following issues:

- Introduces the concepts of SPICE FM research;
- Illustrates the methodology of the research; and
- Discusses the outcomes of the research.

Process Improvement in Facilities Management

Facilities management (FM) is a distinct management discipline, which is concerned with the overlap between “people, process and place” in an organisation (Akhlaghi, 1994). Barrett (1995) defines FM as, “an integrated approach to maintaining, improving and adapting the buildings of an organisation in order to create an environment that strongly supports the primary objectives of the organisation”. Understanding business organisation, managing people, managing premises, managing services, managing the working environment and managing resources are some of the core competencies of FM, therefore, the recognition of FM as a business process has been emphasised. Hinks (1998) suggests that since FM is a co-ordinating process-based function, a high level of management process capability is central in improving FM capability.

Most FM organisations have a culture that is focused on tangible short-term business results. In such a culture managers are naturally inclined to emphasise issues that are tangible, visible or measurable and resist activities that do not contribute to short-term tangible results. FM managers often view process and organisational improvement activities as low priority. A major problem here is that tangible and visible results are usually backward looking. They indicate how the organisation has performed in the past, rather than project how the organisation is likely to perform in the future.

Improving process capability via process evaluation techniques affects FM because of the composite nature of the FM function. Lack of specific theories and models on FM process improvement have resulted in borrowing many of the methods and tools from manufacturing processes. There is clearly a need in FM for frameworks projecting a customer-oriented view of the organisation to replace the departmental isolated view of FM processes.

Research Methodology

For SPICE FM it was important to ensure that the integration between the BSC and SPICE were not “shoe horned” for FM organisations. Lillrank (1995) identified that the transfer of innovation across geographical and industrial boundaries is not a linear one, but rather concepts very often need to be re-packaged, modified or tailored to suit the new environment. The research used “testing out” methods (Starke 1995) to ensure that the above frameworks fitted well together and also suited facilities organisations.

A study was made of the various research methodologies in order to select a suitable approach and the nature of the how and why questions to be posed during the research and the involvement of both qualitative and quantitative data, pointed to the use of the case study methodology. According to Yin (1994) this approach is ideally suited for areas where knowledge building is in its formative stages with few prior studies to build on. In this sense, case studies have an important function in generating hypotheses and assessing existing theory (Feagin et al 1991; Starke 1995).

During the case studies, the SPICE FM questionnaire, semi-structured interviews, analysis of archival records and documentation were the research tools to collect quantitative data. This approach is particularly suited and valuable in building up relationships among elements to be analysed and in testing the model built during the exploratory stage of the research work.

The SPICE FM Process Improvement Framework

The SPICE FM process improvement model promotes continuous process improvement based on many small, evolutionary steps. It provides a system for initiating and implementing continuous improvement. SPICE was based around a successful process improvement framework in the software industry, namely CMM (Capability Maturity Model) (Paulk 1994).

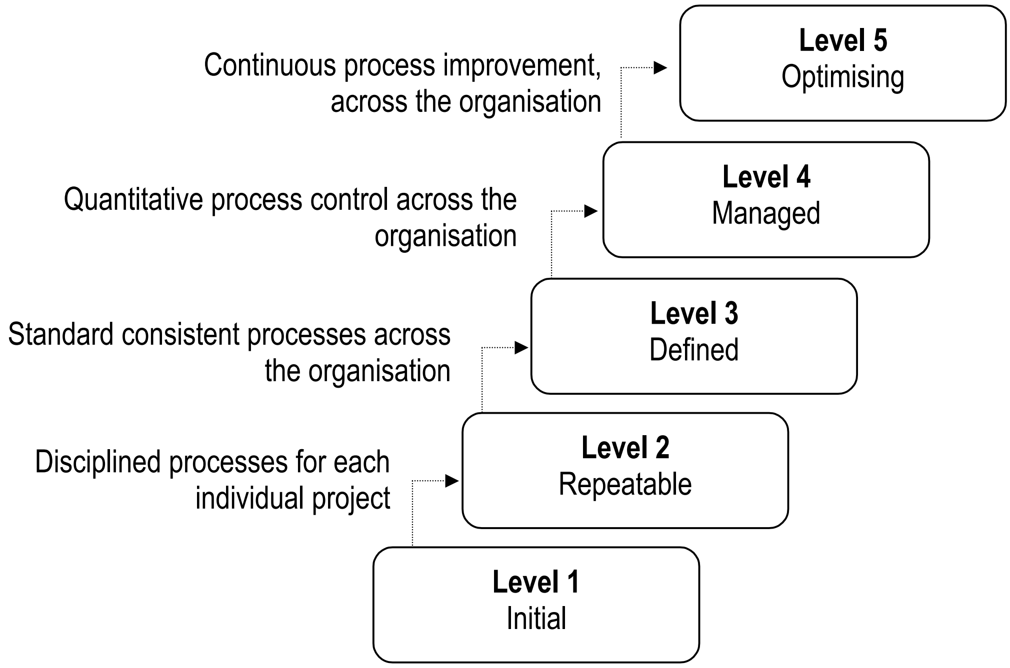

***Figure 1** SPICE framework*

The model divides these evolutionary steps into five maturity levels, as shown in Figure 1. These levels lay successive foundations for continuous process improvement (Sarshar 2000, Paulk 1994, Zahran 1998). The maturity levels form a scale for measuring the capability of a facilities management provider's individual management processes, and its overall process capability. Each level of maturity consists of a set of key processes. When an organisation is successfully applying each key process, it can stabilise an important part of the service delivery process. The five levels provide guidelines on how to prioritise efforts at process improvement.

For each level, the model specifies a number of "key processes". By following the steps in the model, an organisation can achieve effective and continuous improvement based on evolutionary steps.

An organisation can only be at one level of the model at any one time. If an organisation is at level 1, but implements some of the key processes of level 3 or 4, it is still considered a level 1 organisation. This is because each level lays successive foundations for the next. The model shows that the organisation has little to gain by addressing issues at a higher level if all the key processes at the current level have not been implemented.

Organisations at level 1 have little process focus. They achieve high capability in managing service delivery, at level 2. Level 3 focuses on knowledge management and best practice sharing across the organisation. The model then introduces statistical controls and measurement in levels 4 and 5. Sarshar (2000) and Paulk (1994) provide more detail of the concepts behind each level. The SPICE FM research project only investigated the applicability of Level 2 of framework.

A level 2 an organisation has established policies and procedures for managing and delivering customer requirements. Service performance standards are established and service delivery is co-ordinated to minimise disruption to the core business. During service delivery, continuous service monitoring ensures that performance standards are met (Sarshar 2000).

Tailoring SPICE Level 2 Key Processes for FM organisations

Each level of SPICE is characterised by a number of Key Processes. The research tailored the Level 2 Key Processes from the construction SPICE to the needs of facilities organisations.

Based on literature search the research team developed a first draft of the FM Key Processes. These were first shared in a workshop with nine FM industrialists. Based on their input, the Key Processes were slightly modified. The applicability of these processes was then tested via four case studies. The studies were all conducted in the Facilities Directorate of a major local hospital, and are reported in Construct IT (2001). The model was improved in an iterative manner, based on the learning from the case studies.

Table 1 illustrates the results of the conversion of construction SPICE Level 2 Key Processes to FM.

SPICE (construction) Key Process	SPICE FM Key Process
Briefing and Design Mgt.	Service Requirements Mgt.
Project Planning	Service Planning
Project Tracking	Service Performance Monitoring
Sub-contract Mgt.	Supplier & Contract Mgt.
Project Change Mgt.	Not applicable
Risk Mgt.	Risk Mgt.
Team Co-ordination	Service Co-ordination
Health & safety management	Health & safety management

***Table 1**- SPICE Level 2 Key Processes*

The major difference of construction with FM is that FM is service-oriented, whereas construction is project-oriented. Some of the major processes in construction, such as “project change management” are not applicable in service-oriented organisations. “Briefing and design management” in construction is the process of capturing client requirements. Therefore this translated into “service requirements management” in FM. “Subcontractor Management” has been translated into “Supplier and Contract Management”. Some FM organisations, especially the FM providers hire contractors and are in charge of service management activities. The Key Processes were evaluated in case studies. The case studies demonstrated that the modified Key Processes are applicable, and the general concepts of process maturity within SPICE and CMM are applicable. In order to identify the capability of these Key Processes, in an organisation, they are tested against a number of process enablers.

Process Enablers

How can the manager ensure that key processes are performed “appropriately”? Zahran (1998) differentiates between “incomplete processes” as opposed to “disciplined processes”, and lists a number of characteristics for these. Paulk (1994) also lists a number of “key management features” for a complete and coherent process. Based on these philosophies, SPICE has developed a number of “process enablers”.

Process enablers are generic characteristics, for any disciplined process. They focus on results, which *can be expected to be achieved* from a key process. This is a forward-looking approach, which indicates process capability *before* a process takes place. They provide detail of features, which a key process must posses in order to yield successful results. Ensuring that all the process enablers are in place, improves the performance and predictability of key processes. Process enablers are common across all the key processes. SPICE process enablers are briefly listed below [Sarshar 2000]:

- **Commitment** - This criterion ensures that the organisation takes action to ensure that the process is established and will endure. It typically involves establishing organisation policies, and senior management commitment.

- **Ability** - This describes the preconditions that must exist to implement the process competently. It normally involves adequate resourcing, appropriate organisational structure, and training.

- **Verification** - This verifies that the activities are performed in compliance with the process that has been established. It emphasises the need for *independent, external* verification by management and quality assurance.

- **Evaluation / Measurement**- This describes the basic internal process evaluation and reviews and some measurement mechanisms.

- **Activities** - This describes the activities, roles and procedures necessary to implement processes. It typically involves establishing plans and procedures, performing the work, tracking it, and taking corrective action as necessary.

The Process Enablers are identical in SPICE and SPICE FM frameworks. The case studies demonstrated that no change is required to the Process Enablers.
It was important to link the SPICE FM framework to business directions. SPICE FM identifies process immaturities in organisations. As a result a number of improvements are prioritised in each organisation. In order to focus on key improvements, the improvements had to be linked to business priorities. The SPICE FM research achieved this goal by aligning the model with the BSC.

Introduction to BSC- The Strategic Challenge

An increasingly popular technique for measuring performance criteria that are not immediately linked to bottom-line profits, but will have an impact on future profits, is the Balanced Scorecard (figure 2). The BSC encouraged managers towards “a fast but comprehensive view of the business” (Kaplan and Norton, 1992) – likened to dials in an aeroplane cockpit – in terms of financial, customer, internal business and innovation and learning perspectives. “The BSC integrates traditional financial measures with operational and softer customer and staff issues, which are vital to growth and long-term competitiveness” comments Newing (1995). In addition, while traditional financial measures report on what happened during the last period, without indicating how managers can improve performance in the next, the scorecard functions as the cornerstone of the organisation’s current and future success (Kaplan et al, 1993).

The BSC measures are built around the following four perspectives:

- **Customer** – what do existing and new customers value from us?
- **Internal processes** – what processes must we excel at to achieve our financial and customer perspective?

- **Learning and growth** – can we continue to improve and create future value?
- **Financial** – how do we create value for our shareholders?

The four perspectives of the scorecard permit a balance between short-tem and long-term objectives. While the multiplicity of measures on a Balanced Scorecard seems confusing to some people, properly constructed scorecards contain a unity of purpose since all the measures are directed towards achieving an integrated strategy.

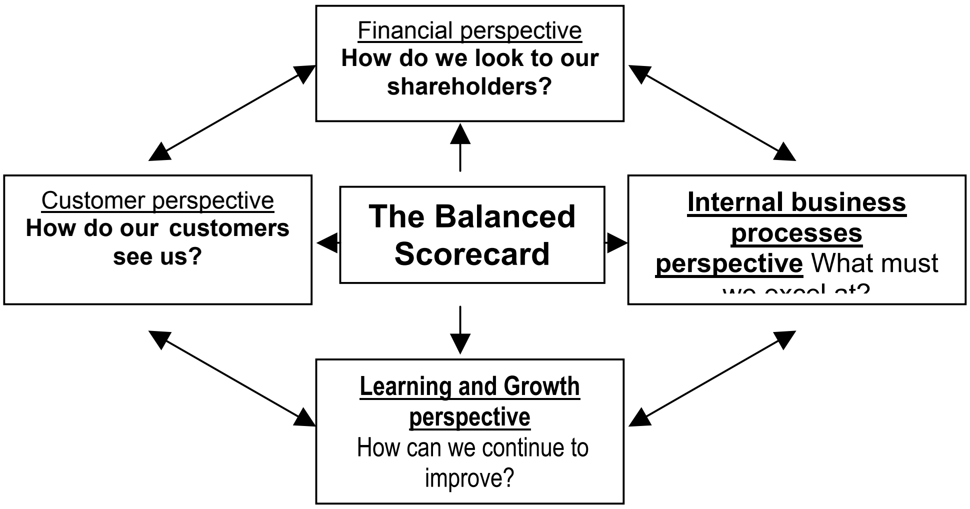

***Figure 2** – Different Segments of the Balanced Scorecard (Source: Kaplan and Norton, 1996)*

Amaratunga (1999, 2000) has explored the applicability of the BSC to the FM sector. The methodology has proven applicable and of significant value. The SPICE FM research team conducted two detailed case studies to identify if SPICE FM can be used in conjunction with BSC, in order to provide a more holistic business improvement methodology for FM organisations. One of the studies is explained below.

Detailed SPICE FM Case Study

This case study was in a facilities directorate at a NHS Trust in the North West of England. The NHS recognises the Trust as a national and international centre of excellence in healthcare and research. However, as a large and complex organisation, with a turnover in excess of £150m, the Facilities Directorate plays an important part in ensuring the Hospital's effectiveness.

At the commencement of the study, the Directorate's senior management were concerned about staff morale. This was due to the impending transfer of many of their services to the private sector under the Private Finance Initiative. Furthermore, management were concerned about the inability of the Directorate to implement its plans and strategic directives at an operational level. Consequently, they were keen to see the results of the study. Four vital services of the department were chosen to participate in the study: catering; operational estates; domestics; portering.

Strategic awareness and performance assessment

The development of the Balanced Scorecard at the Central Manchester NHS Trust Facilities Directorate attempted to pull together current measures, the Patient Environment Assessment measures and new measures drawn from the NHS plan, into a Balanced Scorecard using its four perspectives.

An essential component of the directorate’s strategy was the establishment of facilities performance targets, against which the performance of the facilities can be monitored and measured. The development of a BSC provided a results oriented approach for evaluating the Trust's facilities management system. The BSC looked beyond compliance and evaluates performance and operational effectiveness.

Customer	Internal processes	Learning and growth	Financial
Quality	Healthcare in partnership	Development of Facilities	Value for money
Service partnership	Operational services	Staff development and training	Achieving the financial recovery plan
Timeliness	Risk Management	Service Delivery Innovation	

***Table 2**: Critical success factors*

A BSC was developed to act as an effective communication strategy. Table 2 lists some of the critical success factors identified against the BSC’s four perspectives. Key indicators provide real focus and these can be cascaded to a departmental level, particularly important is a large organisation such as this. Regular reporting of the measures in this format could provide the information necessary to keep the Directorate on track and to take corrective action rather than having to wait until after the event to realise that things have not gone according to the plan. Based on the above critical success factors, appropriate performance targets were drawn to ensure:

- Improvements in the quality of the operation over time;
- Improvements in statutory compliance, reduction in risk, and achievement of controls assurance standards;
- Changes in the revenue cost of the operational estate over time;
- Improvements in the utilisation of the estate over time; that is, condition appraisal in seeking out underused and surplus estates; and
- Improvement in the quality of the environment for patients.

The facilities directorate has further taken several steps to encourage support for Balanced Scorecard activities by:

- Making a commitment at the senior management level;
- Incorporating the issued identified through the BSC development programme to its business plan;
- Offering training in improvement techniques;
- Establishing a reward and recognition system to foster performance improvements;
- Breaking down organisational barriers; and
- Co-ordinating with the entire trust and responsibilities of other directorates;

Process capability findings

To ensure the process capability finding's accuracy, it was necessary to secure a representative sample of staff to participate in the study. Due to the size of the directorate, the assessment team held workshops with operational staff, thus allowing larger numbers of staff to participate, whilst not requiring an extension to the overall duration of the assessment. Figure 3 summarises the directorate's process capability against the SPICE FM model.

The directorate's management accepted that improvement in their monitoring systems was vital in order to review their performance against national targets established within the NHS Plan. Furthermore, effective monitoring systems will provide management with an effective tool to supervise the transition of services to the private sector under the Private Finance Initiative.

In addition to generic matters, the assessment highlighted some service specific process issues. Each of the services had its own capable processes for determining service requirements, planning delivery and managing suppliers. For example, a national patient charter established clear guidelines for menus and choice in the catering service. These broad requirements were further defined in standards for food hygiene, patient feeding, nutritional requirements and purchase specifications. These complex standards had been translated into clear operating systems for use by staff on a day-to-day basis. Furthermore staff attended regular training to ensure they remained aware of important issues.

After reviewing the findings, the results were summarised in a process capability matrix, as shown in figure 3. The matrix depicts the Key Processes along one axis and the Process Enablers along the other. The cells are filled with traffic light colours to demonstrate if the Key Process is performed adequately.

The directorate's management were satisfied that they represented an accurate reflection of the department's current capability. The directorate is now addressing many of the issues raised. Table 3 demonstrates the relevance of the issues to the department's critical success factors and highlights the subsequent actions.

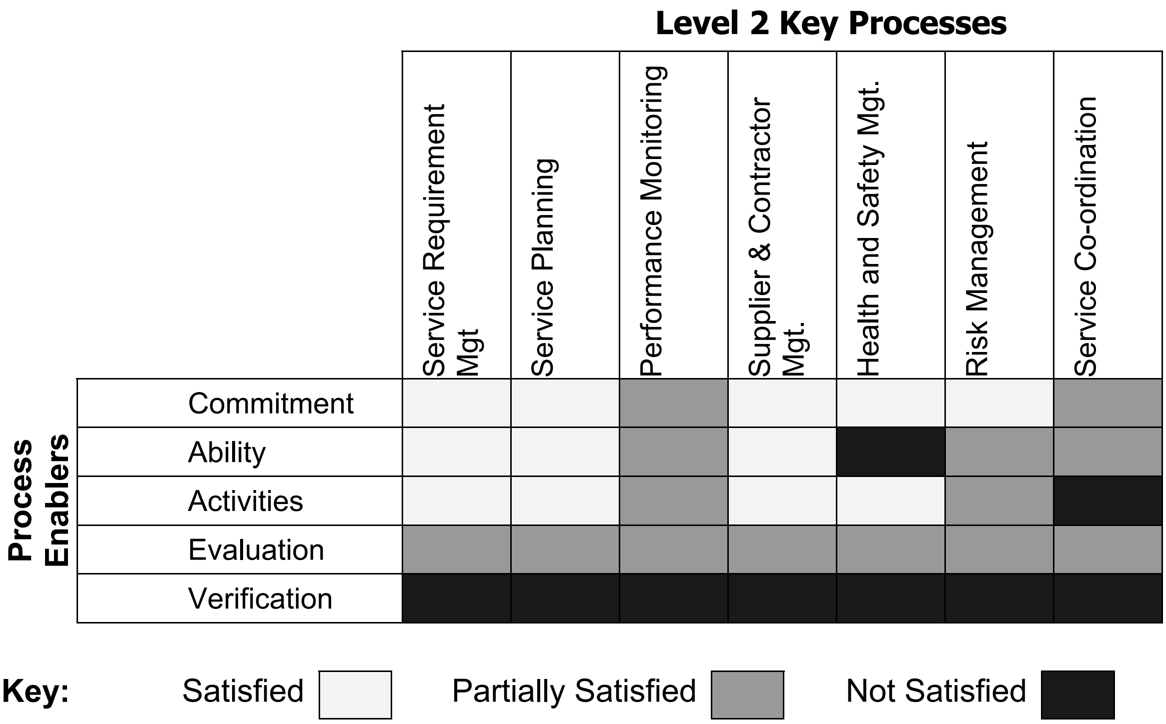

***Figure 3**: The directorate's process capability profile*

The department's perspective

"The size of our operations at the Trust makes it difficult for our senior management team to understand the problems faced by our operational staff. We like the approach that SPICE FM takes in trying to bridge the gap between our strategy and day-to-day operations, commented the Facilities Development Manager on the SPICE assessment.

Following the assessment, they have appointed a member of the staff to take the actions forward. The Trust see this as the start of a continuous change process and hope to use the SPICE FM tool again in the coming months to monitor the progress.

Areas identified for improvement	Critical success factors addressed	Suggested actions
Service performance monitoring	Quality	Develop an integrated facilities questionnaire for distribution to customers.
	Timeliness	Appoint a dedicated resource to undertake monitoring activities and drive through resulting actions
Service co-ordination	Service partnership	Develop service performance standards between different facilities service streams
		Establish a dispute resolution mechanism
Health and safety management	Staff development and training	Develop an induction programme for new domestic staff that addresses health and safety

***Table 3**: Strategically aligned process improvement opportunities*

Summary

Despite large investments and considerable achievements, FM is a field that remains under-researched, supported by an inadequate knowledge base, with few secure methods and techniques of its own to underpin best practice. FM recognises the need for process improvement as a means to improve its service delivery but lacks a clear set of guidelines to direct their improvement efforts and benchmark with other organisations.

SPICE FM, a research project at Salford University, has developed a structured learning framework that provides FM organisations with the capability to implement their vision. The framework aligns a process maturity model with the Balanced Scorecard, which is a strategic management system. Thereby, it creates an environment where improvement priorities are directly linked to the strategic business directions of the core business. SPICE FM provides organisations with:

- A method for developing and implementing strategy;
- A method for measuring the maturity of current business processes;
- A five level framework for achieving step-by-step improvements.

The framework has been tested in a number of case studies. This paper has examined the SPICE FM framework, as well as the research methodology used by the team. It has further reported a detailed case study at the Facilities Directorate of a UK hospital.

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Healthcare facilities management operations and organisational decisions

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Abstract
This paper presents a research which analyses healthcare facilities not just as fixed assets, but as a tangible part of the service chain underpinning the provision of clinical services to both internal (departments and/or directorates) and external customers (patients, visitors and staff). It also discusses operational and management issues involved in the provision of support services in the healthcare sector and explore the responsibilities across all functional lines of authority in NHS trust. Based on field studies, this paper argues that strategic management of healthcare FM operations brings about competitiveness and best value in the running of the healthcare facilities and services.

Keywords Healthcare, facilities management, best value

Introduction

The past decade has seen the UK's Trust hospitals subject to elastic limits of competitive service delivery uncertainty, as illustrated in Figure 1. There has also been an immense demand and pressure exerted by healthcare service consumers and stakeholders for Trusts to purchase, manage and deliver care services at best value. With these milestones and parameters set ahead for them, Trusts hospitals are ever in search of sustainable strategic options, which would proactively re-engineer their businesses to manage risks effectively and to deliver core clinical services to consumers.

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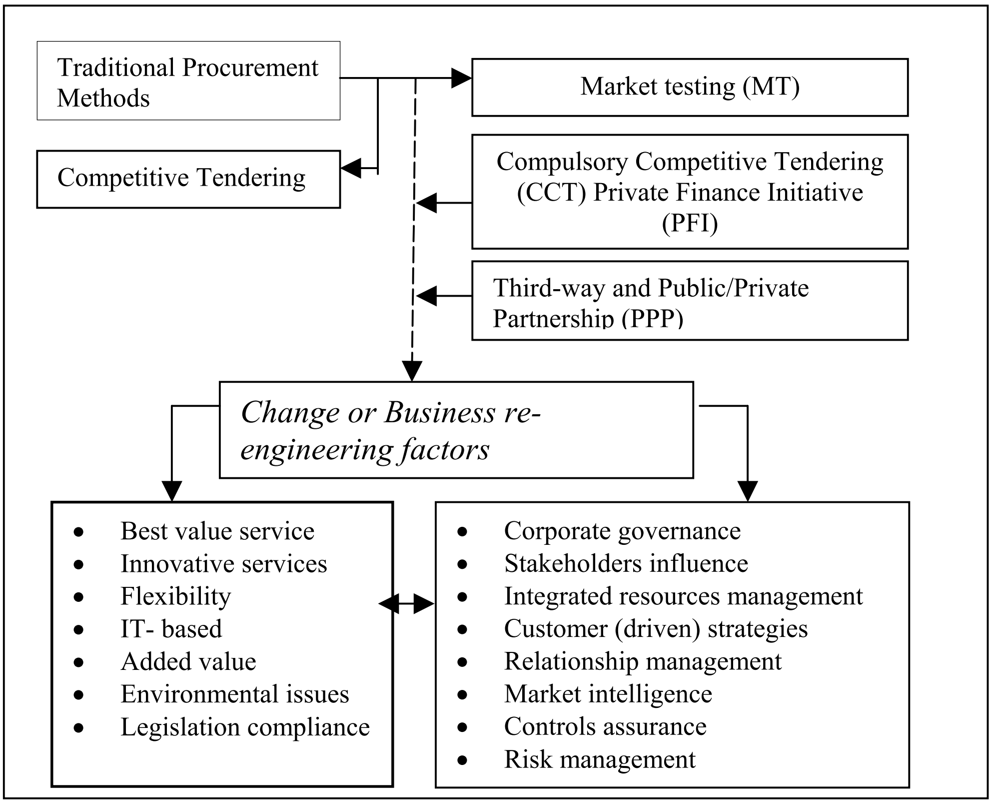

Figure 1: Evolutionary change factors in NHS Trusts Hospitals non-clinical services
Source: Okoroh et al (2002)

The White Paper Working for Patients (1989), proposed the need for NHS Trusts to operate commercially and viably, while incorporating business approaches such as those utilised in the primary care sector. The White Paper strongly believes that the NHS at its best is without equal. More business integration is therefore needed to bring the National Health Service in line with managing hospitals in dynamic business environments. This approach has also been enhanced by the publication of HFN 17 (1998), which emphasises business guide towards best practice experiences and the strategic management of healthcare FM in Trusts. The approach recommended by the White Paper looks at how to improve clinical service outcomes while integrating non-clinical services such as healthcare FM in the delivery system. This paper looks at how far the post-modernist approach to managing UK NHS Trusts ancillary/support services under FM umbrella has developed as proposed by the Working for Patients White Paper.

The management of non-core/clinical services in the NHS Trusts under the auspices of FM has revealed that healthcare business integration and congruency are continuously changing. This trend has been due to the chaotic business environ that constantly changes to meet the demands of care service consumers. Due to the little understanding of FM by Trusts, executive managerial functions have been seen to revolve around various senior care executives. Rees (1998) suggests that the idea of co-ordinating a “single” facilities management service directorate borrowed from commercial organisations has been the key influence in the development of FM and its management structures in NHS Trusts. According to Rees (1998), this approach has resulted in the appointment of senior managers with responsibilities for the provision of a range of non-core clinical services.

Most writers and commentators have argued that the historic approach used in the healthcare industry for managing numbers rather than outcomes, has operated inefficiently. Featherstone and Baldry (2000) and Andaleeb (1998) suggest that one of the major root of such a crisis has been the focus on medical effectiveness research by clinicians without giving due consideration to other customer satisfaction and measurable service factors (such as healthcare facilities and support services) during service design and delivery process.

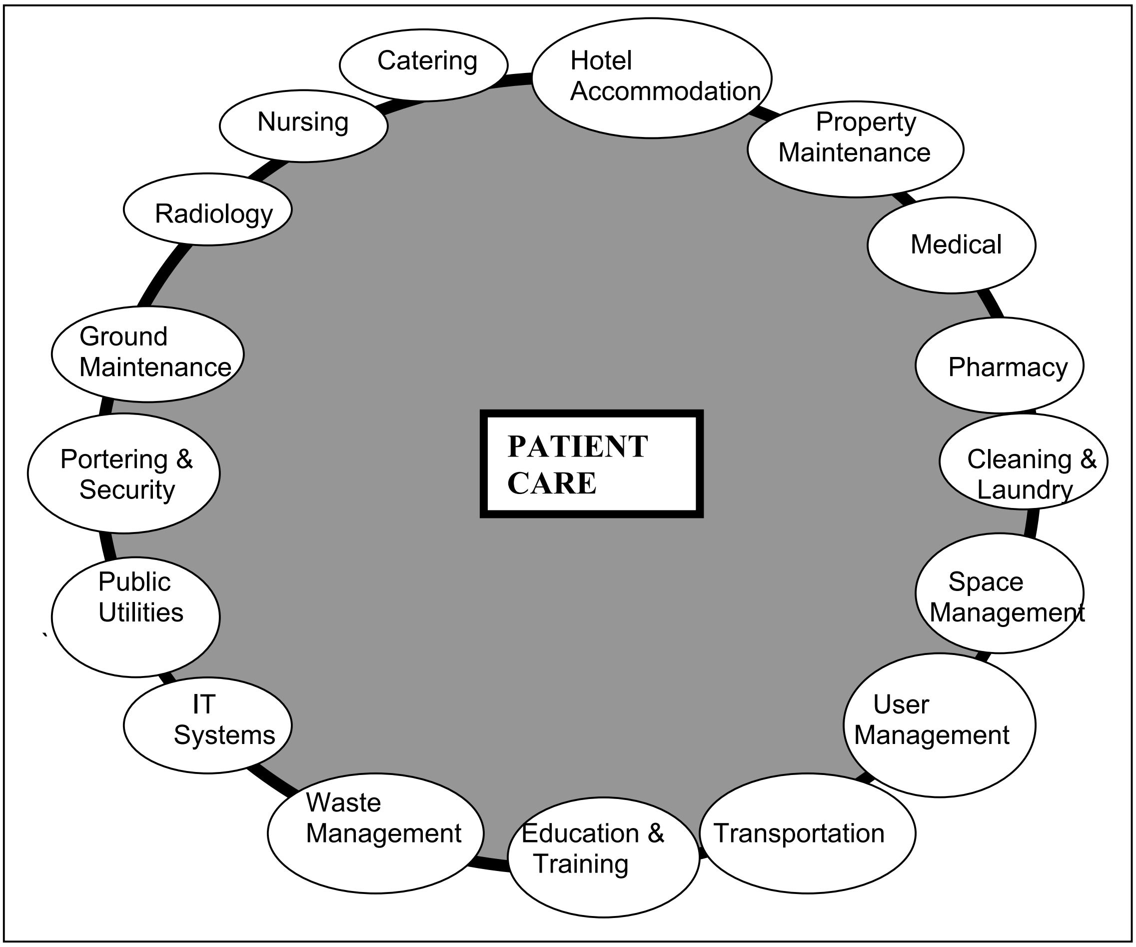

Figure 2: Modern healthcare services and their inter-dependencies
Adapted from Howell et al (1999)

Furthermore, clinical effectiveness as argued by Featherstone and Baldry (2000) has a narrow academic focus, with little or no appreciable relevance to customers and clinicians in this sector where rationing of resources determines the quality of care to be delivered to patients. This argument is much appreciated in the commercial business service sector where most successful organisations base their competitive strategy by putting customer issues first before any other organisational objectives.

An integrated management approach to healthcare FM

As a key to the practice of healthcare FM, an integration of management and control of support services represents effective business decision-making by healthcare executives towards delivering value for money services. The making of such a decision can only be viewed in light of Peter Drucker's (1979) emphasis on effective organisational control:

"Executives do many things in addition to making decisions. But only executives make decisions. The first managerial skill is therefore the making of effective decisions"

It is crucial that an integrated approach shown in Figure 2 is designed and incorporated into the main operational strategy of any Trust in order to reap maximum benefits from FM. By integrating management and control of clinical and non-clinical services, senior Trust executives ranging from the Chief executives or the management board will have a one-stop direct accountability for non-core clinical service functions dynamically linked to the patient care system. This approach represents a shift from the previously separate traditional management of these support services either as estate, hotel, and site services (Okoroh *et al.,* 2001). It can be said to represent the post-modern one-stop organisational management structure exhibited in NHS Trusts as observed by Grimshaw (1999) and Akhlaghi and Price (1999).

In search for more care business flexibility and best value in providing responsive care to patients, staff and service-users, several models of providing FM services have been tried in the Trusts. These models of FM service providing organisations are based on the competitive scope of delivering FM service to various segments of customers in business (Payne and Rees 1999).

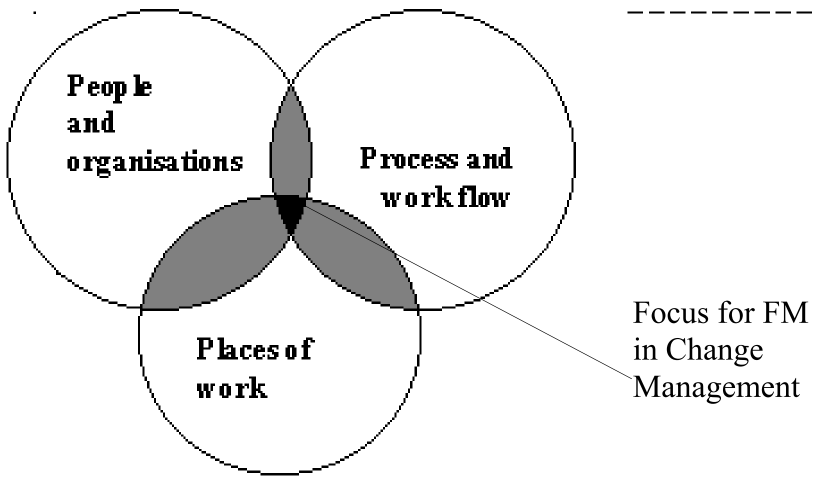

Figure 3: FM focus on organisational change
Source: Payne and Rees (1999)

Various researchers and practitioners have proposed a number of FM organisational and operating models. This FM model (figure 3) is based on factors that have evolutionary lead to the development and operational changes within organisations such as hospitals. The model encapsulates the role of facilities managers as that of being a change agent or manager. This challenge will allow the organisation to be flexible to adapt to future changes in the market and business environment. Thus, a focus on the changing business environment will bring with it a handful of opportunities for the facilities manager to practically co-ordinate and package the required portfolio of property, goods and services that best support the organisation's needs. Payne and Rees (1999) argue that the facilities manager must also have a clear focus on changes taking place, which are relevant within their organisation's core business environment.

Bridges (1998) on the other hand based his FM model on a theoretical and hypothetical framework under mature market conditions, and used an empirical study of facility procurement decisions from insourcing to outsourcing to determine his model limits. He regards this process of procurement shifts as moving towards "maturity" stage in FM organisational behaviour. His framework comes from Becker's (1990) model, which focuses on the competitive niche provided by FM services in organisations.

Research methodology

Data collection involved structured questionnaire and interviews with leading healthcare managers (providers, purchasers and customers). Firstly, a round table discussion was held with the Derby Royal Infirmary (DRI) NHS managers in the project, in order to raise interest and foster collaboration. This measure was taken with a view to encourage participation and rapport between the DRI management and the research team. These discussions formed the background of the research project was followed by a detailed study of a healthcare partnering arrangement between DRI (now part of the Southern Derbyshire Acute NHS Trust) and Carillion and Bateman Services, a well-known healthcare service provider.

The DRI contract was chosen as it was regarded as one of the 20 best performing hospitals in the UK (DoH, 1993*)*; DoH, 1998). The DRI partnering contract was formed to provide estate, support and site service. The discussions led to the development of a structured questionnaire which was piloted with the DRI managers and selected healthcare managers, providers, purchasers and researchers within the NHS Trusts. When the research team members were satisfied with the questionnaire, it was sent to 365 NHS Trust hospital executives and facilities managers within England and Wales. The selection of the participants was based on a "non-randomised" controlled study (Moon and Mullee, 1999).

In addition to fieldwork surveys, primary and secondary sources of NHS and business literature on support services operations were also used to supplement and validate findings. As this research involved investigation of healthcare effective management of non-clinical services in the NHS hospitals, it was important for the researchers to validate the research data with archival information kept in the databases of the surveyed NHS providers and purchasers in the UK.

Job titles of NHS Trust Executives	Number of respondents	Percentage of respondents
Chief Executives	64	31.2
Trust Secretaries	2	1.0
Operations	16	8.0
Finance and Allied Services	19	9.0
Risk Management	4	2.0
Corporate Affairs	6	3.0
Business Development	5	3.0
Clinical Support	1	1.0
Strategy and Planning	3	2.0
Hospital Services	1	1.0
Resources	8	4.0
FM and Support Services	60	30.0

Table 1: Composition of the survey sample

A validation of the results was conducted with three healthcare general managers (Gombera and Okoroh, 1999) and took the form of unstructured interviews or attitudinal statement. This approach is commonly used in opinion polls associated with government elections. As attitudinal statements have their limitations (Oppenheim, 1966), after each reply, the manager was asked for richer qualitative details on why he/she has this view and what causes him/her to take it. One of the main advantages of this research method is that it isolates people's attitudes, impressions, opinion, beliefs and judgement (Buckley *et al.,* 1975). Some of its main deficiencies are that it may suffer from bias inherent in the design of the survey instruments; for example, prior selection of questions and response sets and systematic bias in the way the respondents answer the questions such as bias between favourable or unfavourable, or familiar and unfamiliar questions (Buckley et al 1975).

The composition of care executives who participated in the survey was multi-disciplinary (Table 1) (i.e., ranging from the most senior executive (CE) to operational and middle management). The diverse composition of care executives is a significant indicator that, for care FM support services to back the provision of an integrated care service, a multi-disciplinary (clinical and non-clinical) team is needed which utilises multi-disciplinary pathways of care (Hands and Wilson, 1997).

Analysis and Discussion

Table 2 displays the main core care services offered by most Trusts surveyed. The NHS Trusts core service competencies identified includes Acute, Community/Mental, Teaching, Acute and Community and others (Integrated). These services are the most generic types of core care service portfolio found provided by the majority of NHS Trusts although variants are emerging. The reason is mainly due to the ever-changing needs of care stakeholders coupled with internal (political, economical, social and technological (PEST) and external (strengths, opportunities, weaknesses and threats (SWOT) business factors.

Type of NHS Trust	Number of NHS Trusts	Percentage of respondents
Acute	71	35.5
Community/Mental	57	28.5
Teaching	18	9.0
Acute and Community	55	27.5
Others	35	17.5

Table 2: NHS Trusts core service competencies

From Table 2 it can be seen that 71 (35.5%) of Trusts surveyed were those providing Acute services. This percentage is not surprising, as there is currently a high demand of Acute services in the whole continuum of care in the UK. Acute services are the primary services most Trusts offer to their customers, as they are needed on daily basis. As a result of this, support related services in these hospitals would also be needed on daily basis to underpin the complex care delivery of the core care services. Apart from those providing core services, the remainder of hospitals surveyed also offer other care services or a combination of clinical services such as community, mental, teaching and integrated care services. The order is dependent on the effective use of healthcare facilities and support services.

Up to 57 hospitals (28.5%) provide Community and or Mental services, while 18 (9%) are Teaching hospitals. From this percentages, it can be inferred that community and teaching services in the NHS represent a greater part of an on-going modernisation process in the public services by the current Labour Government, to improve medical manpower and technology resources, community involvement and learning, that have been neglected for sometime in the NHS. Community and Teaching Trusts have always been vital in the continued improvement and advancement of medical research and technology to provide best quality of healthcare models to patients through the use of high-class facilities. Another value issue that emerges from this analysis is that, although healthcare development and clinical leadership or their equivalents are being prioritised in the new NHS, care support services (FM) will have to be developed in order to underpin and cope with the effective delivery of such care. Community and teaching Trusts have always been vital in the continued improvement and advancement of medical research and technology.
While FM is not the industry standard for managing healthcare support and ancillary services in the NHS, some traditional archetypes of managing non-clinical and support services have long been in practice alongside the continuous development of FM as a business tool for managing change processes in Trusts (Gallagher, 1998; Williams, 1996, and Payne and Rees, 1999.

Strategic occupancy and space management in Trusts

Space management in Trusts forms one of the core competencies in support or FM service directorates (Wagstaff, 1997; Gallagher, 1998). Space is utilised by every customer, staff, visitor and the provider (in-house or external). Under FM, the support service directorate offers site, hotel and estate services to support clinical services

(Okoroh *et al.,* 2001). As a result, space management does impact on the service delivery environment. For example, the provision of enough space would allow better bed management, thus increasing inpatients admissions and a much safer working environment for staff. Therefore, this question was designed to evaluate the strategic occupancy and space management levels in relation to the number of sleeping beds one Trust can accommodate. Table 3 shows the occupancy levels of the Trusts surveyed. It indicates that over 60 % of the respondents stated that their occupancy levels were more than 400 beds per hospital. Results from such Trusts show that these hospitals needed more effective space planning policies, and as a result, would need to rely on effective FM to deliver the most effective space requirements.

Effective space utilisation would also mean effective management of services that would be needed to run the facilities. About 10% of the Trusts surveyed had between 800-900 beds, while 20% of the Trusts had between 200-300. Both types of Trusts can be regarded as small to medium size facilities. Only 5% had between 1000-2000 beds. These can be classified as large hospital Trusts serving a large number of customers. The average number of beds from the population sample was 512, which signifies that the average bed capacity of the surveyed Trusts was between 400–599 beds. This average represents 36% of the surveyed population. It can be assumed that effective space management was a prerequisite for creating more bed space, thus increasing the carrying capacity and the number of patients to be treated in any Trust. This point would also mean more capital to run facilities in Trusts.

Number of sleeping beds	Number of Trusts	Percentage of respondents
0-99	9	4.5
100-199	17	8.5
200-399	43	21.5
400-599	49	24.5
600-799	29	14.5
800-999	19	9.5
1000-2000	17	8.5
Others	9	4.5

Table 3: NHS Trusts total bed capacity

Type, function and bed capacity are generally used to classify hospital trusts in the UK. Any increase in the number of hospital beds allows for more clinical business and facilities, as well as fostering a virtual support environment for both customers and healthcare staff. The major objective of this question was to determine how efficient Trusts utilise their physical environment in terms of patient care facility provision and delivery. This idea is in line with Porter's (1985) thinking on value chain processes in the workplace. It also indicates the amount of risk a Trust can carry in terms of health and safety issues, infectious diseases control, space utilisation and working environment. The greater the occupancy levels, the more the need for Trusts to adopt cost cutting measures and benchmark the best practice in FM practice, in order to reduce the propensity to keep spending.

FM service procurement options in Trusts

Table 4 shows Trusts services purchasing behaviour, which is characterised by progressive outsourcing, out-tasking or insourcing. In healthcare Trusts FM service provision can be a one-off (*out-tasking*) or a plural task requirement (*outsourcing*). The other modern and innovation service requirement is under the auspices of privatisation - Private Finance Initiative (PFI) and Public Private Partnership (PPP), a full-blown package of FM service portfolio functions. It demands from the contractor to provide a complete revolution of FM "bundled" services now being considered by most Trust hospitals under the banner of progressive outsourcing (Pearson, 1998). The Trusts were classified as providing an integrated FM approach due to them having at least 95% of the FM competencies listed by the British Institute of Facilities Management (BIFM). The BIFM listed about 22 competencies that are classified as part of a comprehensive list of FM services (Ridout, 1997).

FM Function	No. of Trusts	% Outsourced	% Outtasked	% In-sourced
Gardens and Grounds	105	53	7	40
Estate Management	15	8	33	51
Hotel & Catering	70	35	13	52
Mechanical & Elect.	15	8	3	89
Domestic	87	43	21	36
Risk Management	5	3	2	95
Building Services	40	20	20	60
Waste Management	120	60	8	32
Total FM	5	3	7	90
Energy Management	60	30	7	63
Car Parking	80	40	45	15
Health and Safety	45	23	73	4
Reprographic	5	3	45	52
IT & Telecom.	20	10	73	17
Cleaning	90	45	10	45
Portering & Security	25	13	10	77
Pathology & X-ray Services	19	9	20	71
EBME & Medical Equipment	115	56	20	14
Courier and Lock Smith	61	30	10	60
Low Dependency Patient Care	13	6	15	79
Patient Transport	30	15	10	75
Specialist Support	11	4	5	91
Police Force	41	20	5	85

Table 4: NHS Trusts service purchasing behaviour analysis

It can also be said that on the average from the survey, at least 48% of the bundled FM services were outsourced to external contractors, from which 23% of the FM functions were out-tasked to the same contractors. On the other hand, at least 52% of the Trusts managed their FM services in-house. Other FM services unique to Trusts such as pathology, patient services and transport, medical equipment and sterile suppliers and low dependency patient care account on average 60% of FM services that were in-sourced from in-house contractors.

- In their own independent survey, the Building Services Research and Information Association (BSRA) identified the level of outsourcing in the commercial sector of the above six main FM functions as 60% compared with the 30% indicated on Table 4. The difference could be attributed to the concerns expressed by Bell (1998) and Blumberg (1998) that outsourcing can be a “good management tool” in organisations with high labour usages and sharp, steep learning curves. This situation is typical of healthcare Trusts, where continued medical technological development and political reforms are always changing. Outsourcing however can expedite improvement changes in staffing levels, working practices, management controls and costs, service levels and quality of care.

Outsourcing can be a risky business undertaking in the sense that it often requires great changes in management mind set if not a new innovative method of communication levels among trust employees. It has also produced insecurity for most healthcare staff and trade unions especially in issues relating to the transfer of business to the external service provider - Transfer of Undertakings Protection of Employment) (TUPE) Regulations 1981 as amended. The management and monitoring of outsourcing are often very complex. It is also important to note that outsourcing is a long-term objective rather than a short term one. This idea can often mislead Trusts to think that this measure is an immediate cost-cutting exercise. In some cases, long term FM contracts that have a feature of short-term savings can prove to be very expensive at a latter stage. Bridges (1998) recommends that better methods of procuring support services must be based on an organisation’s ability to manage cost profiles across all facility services, and internal versus external capacity to deliver the services.

Strategic procurement options

The results shown in Table 5 indicate the various FM services purchasing routes used by various trusts.

Type of procurement route	Number of Trusts	Percentage of respondents
Traditional contracting	133	66.5
Partnering	16	8.0
Compulsory Competitive Tendering	103	51.5
Joint ventures	15	7.5
Partnerships	20	10.0
Private Finance Initiative	9	4.5
Service Level Agreements	6	3.0
Nil	3	1.5

Table 5: NHS Trusts strategic procurement options

The traditional procurement was being used by more than two-thirds (66 per cent) of the 200 Trusts surveyed, signifying that most Trusts are still using the traditional system of service procurement.

The participation of the private sector in the management of healthcare facilities is a current approach that has also given impetus to the modern approach of commercialising care services. This has also resulted in the injection of the necessary resources (capital, manpower and technology) in a sector operating on a low budget. The emergence of PFI and PPP is beginning to pay dividends as can be seen by the response rate of 4.5%. PFI and PPP are approaches for sharing service operation risks with the private sector and NHS staff are still to come to terms with them.

At least 6 (3 per cent) Trusts stated that they have used service level agreements (SLAs) as a basis for specifying or buying FM services in the NHS. These results indicate a low usage of SLAs for service procurement. SLA is a modern specialist contract practice in FM provision in Trusts. They have only been restricted and used recently in those Trusts that are knowledgeable with their service process and procedure.

Cost of managing healthcare facilities

Healthcare facilities and support services represent a substantial investment for Trust hospitals in the United Kingdom. As a result, there is a need to accommodate and support a range of clinical services, often taking into account competing customer and clinical needs. The results indicate that occupancy costs are typically between 25-30 per cent of a Trust’s total investment portfolio (income) (Thomas-Scott, 1998; Wagstaff, 1997). The cost of running care facilities can help facilities managers to improve their understanding of how hospital facilities are used and identify any future development potential. In most hospitals, patients directly use less than 50 per cent of the gross area; e.g., most of the floor area supports the indirect services Wagstaff (1997).

Comparing these indirect costs to other industries might also be useful. This step helps to indicate those areas where there could be significant improvements in cost effectiveness and those most suitable for market testing. More financial investment into the operation of care facilities allows key management comparisons - costs of occupation amount of income derived from the facility, percentage of occupancy cost of total Trust income, and return on capital assets. The cost of occupation is derived from combining fixed asset and variable operational cost components. Results on FM operations costs can be used for business planning, so that the strategic direction reflects the Trusts’ strengths and weaknesses. In view of the importance for FM budgets, this question set out to investigate the amount of capital investment tied down each year for running of facilities by Trusts. The results are shown in Table 6.
Table 6 shows that 181 (90.5%) of the Trust hospitals surveyed have FM budget of up to £10M, signifying that the amount spent on care facilities and support services is quite high and would require effective management strategies to be in place to guard against over-expenditure. The rest of the 19 (9.5%) Trusts have budgets ranging from £11M- £250M, indicating that the majority of those Trusts own other complex care facilities and also offer secondary services such as teaching, ambulance and paramedical services.

Amount in Million Pounds	Number of Trusts	Percentage of Respondents
0-10	181	90.5
11-20	11	5.5
21-40	2	1.0
41-80	1	0.5
81-100	1	0.5
100-150	0	0.0
151-200	1	0.5
200-250	1	0.5
250+	0	0.5
Others	3	1.5

Table 6: FM annual operating budgets

The improvement of any healthcare services has always hinged on having adequate financial resources to remunerate NHS staff, procure drugs, operae and maintain healthcare facilities, equipment and utility services, and develop competitive service strategies.

Furthermore, to provide integrated healthcare service quality in Trusts, there must be sufficient healthcare facilities available to sustain the core business. Managing of hospital services cost money to both government and customers who pay for it indirectly as tax. Thus, for any hospital to have efficient and well-managed facilities, there must be sufficient financial resource investment to sustain its assets and service delivery objectives. It has been observed that efficient doctors and clinicians are always comfortable to care for patients in a hospital environment where the technology, facilities and resources, especially finance are available, in order for them to manage clinical outcome effectively. As a result, those Trusts that do not posses enough resources (i.e., healthcare facilities) tend to have problems in the recruitment of specialist clinical experts who would deliver quality clinical services. As observed recently in the NHS, poorly funded Trusts end up winding up or merging their business with other better performing Trusts due to incapabilities to operate.

From the survey, large hospitals mostly provide acute and integrated services, or community and teaching services, while the small to medium offer tertiary clinical services that do not involve much usage of facilities. Those considered small to medium size are mostly responsible for providing customers with less facility occupancy services such as paramedical, community and teaching services. The finance of small to medium Trusts is mainly to fund “lighter” clinical services as different from those providing acute clinical resources. Their facilities are mainly used for service production, as opposed to the large one-stop shop hospitals. Effective resource management would be vital to both types of Trusts in competing for service delivery with General Practitioners. Most Trusts now tend to look for funding not only from the State but also from elsewhere in the private sector to revitalise their service strategies (clinical and non-clinical services).

Conclusion

In the healthcare sector, FM is somehow ambiguous, not only in terms of its structural definition, but also in the functional boundaries or peripheries to which it stimulates the core clinical business ties. In Trusts, the issues pertaining to the management of the non-clinical support services are under FM directorate and are beginning to emerge, despite not being realised as value adding elements. Due to the re-configuration of Trusts with a view to delivering a patient focussed care service as opposed to market-force driven one, FM service can include more intermediate roving service functions which are responsible for crisis management in the delivery of an efficient and cost-effective healthcare. Some of NHS Trusts managers, through the use of outsourcing arrangements to meet the ever-growing demands of their non-core services, are encouraging this exercise.

It is crucial that an integrated approach must be designed and incorporated into the main operational strategy of any Trust in order to reap maximum benefits of FM. By integrating the management and control of clinical and non-clinical services, senior Trust executives will have a one-stop direct accountability service functions which is dynamically linked to the patient care system.

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Key Performance Indicators for maintenance of hospital buildings

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Abstract: *Maintenance management of hospital buildings is one of the more complex issues in the field of maintenance. The performance and operation of hospital buildings are affected by numerous factors. These include hospital occupancy relative to standard occupancy, age of buildings, and building surroundings. The purpose of this research was to quantify the effects of users, building characteristics and systems on the buildings' performance and maintenance. The following factors were investigated:*

1. *Overall performance of the building: A Building Performance Indicator (BPI), based on systematic performance and maintenance rating scales, was used to monitor the building's performance.*
2. *Age of the building: A high correlation was found, using a Life Cycle Cost analysis, between maintenance expenditures and the age of a hospital building.*
3. *Building's level of occupancy: The maintenance labor inputs of two identical hospitalization wards with different occupancy levels were compared over a period of 3 years. The results showed that maintenance labor inputs for the higher occupancy ward (133% of the standard) were 22% higher than for the other ward.*
4. *Level of labor outsourcing: The financial benefits of outsourcing maintenance activities were investigated through a field survey. Facilities with high occupancy levels and frequent breakdowns were compared with facilities with standard occupancy levels that practice preventive maintenance extensively. It was found that for standard occupancy facilities, outsourcing of maintenance resulted in a saving of 8% of the overall maintenance expenditure. For facilities with high occupancy levels, use of in-house labor resulted in a 6% decrease in maintenance expenditures.*

The coefficients and diagrams developed were integrated into 4 Key Performance Indicators for Hospital Buildings. The model was examined in 6 Case studies one of which is presented.

Keywords: Facility Management, Key Performance Indicators (KPI), Maintenance, Outsourcing, Performance.

Introduction

Maintenance management of hospital buildings is one of the more complex issues in the field of maintenance. Contributing to this are the great complexity of hospitalization buildings, the high criticality of hospital mechanical and electrical systems, and the shortage of maintenance budgets. Moreover, the performance and operation of hospital buildings are affected by numerous factors. These include hospital occupancy relative to planned occupancy, age of buildings, building surroundings, managerial resources invested, and labor sources for execution of maintenance (in-house provision vs. outsourcing). The objective of this research was to develop a model for the prediction of the performance and operational costs of hospital buildings. The study examined the effect of the above-mentioned factors on the performance and maintenance costs of buildings, as a basis for the development of Key Performance Indicators.

Background

Building maintenance is gaining a central role in the construction activity worldwide. In Britain, for example, building maintenance activities have reached a level of 50% of all annual construction activities (Baldry, 2002). Many researchers are involved in the prediction of maintenance costs for various types of buildings (Domberger and Jensen, 1997; Underwood and Alshawi, 1999). Many studies indicate that the performance and maintenance of a building are influenced by a large number of factors, including the age of the building, labor sources, and the type of the building (Neely and Neathamer, 1991; Atkin and Brooks, 2000). Nevertheless, a need exists for the development of models that integrate building performance into asset management and budgeting of management and maintenance activities (McDougall and Hinks, 2000).

Methodology

The methodology of this study included gathering of data from hospital engineering departments, statistical comparative analyses, and quantitative analyses of maintenance costs under various conditions based on previous empirical studies (Shohet, 1999). In addition, case study analyses for the examination of the Key Performance Indicators developed on the basis of the various coefficients were performed. This paper focuses on three parameters that influence hospital building performance and maintenance, namely the age of the building, the building's occupancy level, and the available labor sources. Performance analysis of the buildings was based on the Building Performance Indicator (BPI).

Statistical Findings

A model was developed for the overall maintenance management of hospitalization buildings based on indicators of performance, budgeting and resource allocation. The basis for the development of the model was a field survey of 17 major hospitals in Israel and a statistical analysis of the survey data. Subsequently, four Key Performance Indicators were developed, based on the research findings and on the development of budgeting and performance coefficients for hospitalization buildings. The indicators were validated and tested using case studies at 6 hospitals.

As mentioned, the field survey included 17 hospitals and was performed in the course of 2000-2001 in reference to the budgetary year 1999. The average built area of the hospitals in the survey was approximately 80,000 sq m. The average number of patient beds per hospital was 660 and the average number of beds per 1,000 sq m. built area was 8.25. The average annual maintenance budget per hospital was about $3,000,000, i.e. approximately $37.2 per sq m. per year. The average Reinstatement Value was calculated according to the final invoices of several projects and was equal to $1678 per sq m., i.e. the average actual annual maintenance budget amounted to 2.22% of the average Reinstatement Value. A parallel analysis of the required annual cost of maintenance, based on the standard life cycles of 10 of the buildings' main systems, revealed that the average annual maintenance budget, required to maintain a hospitalization building at a high state of performance, was 3.23% of the average Reinstatement Value, i.e. $54.2 per sq m.

per year. The implication of these two last data is that the actual average annual maintenance budget equals approximately 70% of the optimal value.

Coefficients and Measures of Budgeting and Maintenance Performance

The statistical analyses examined the following aspects:
- The effect of various labor sources mixes (outsourcing vs. in-house provision) on the annual maintenance expenditures of hospital buildings.
- The effect of the occupancy level of hospitalization wards on their maintenance costs.
- The effect of the building's age on the annual maintenance costs.

Findings and Results

Outsourcing vs. In-house Personnel

An examination of the proportion of maintenance works performed by outsourcing (contractors and external firms) versus in-house provision shows that hospitals can be divided into two different categories: (1) High-occupancy hospitals (over 10 patient beds per 1,000 sq m.); and (2) Hospitals with standard, or lower, levels of occupancy (up to 10 patient beds per 1,000 sq m.). The analysis compared total work expenditures and divided them into two categories of labor sources: in-house provision, and outsourcing. Figure 1 presents a regression analysis of the relationship between outsourcing (Y-axis) and in-house provision (X-axis) of maintenance work in standard- or low-occupancy hospitals. The regression analysis shows that, when hospital occupancy level is standard or lower, outsourcing results in a saving of approximately 8% (R^2=0.89). On the other hand, when hospital occupancy levels are higher than planned, as seen in Figure 2, the use of in-house provision leads to a 6% saving in maintenance expenditures (R^2=0.98). These finding are explained by the fact that under high occupancy conditions the deterioration of some of the hospital building systems is accelerated and a high availability of maintenance workers is required for the execution of breakdown maintenance. Therefore, under such conditions, the employment of in-house personnel offers opportunity for savings. This conclusion differs from that of previous studies on the subject (Australian Industry Commission, 1996), and is more complex. At occupancy levels that are standard or lower, there is indeed an advantage and saving in the employment of a manpower mix in which the majority of the maintenance workers are external personnel. On the other hand, under high occupancy conditions, there is a clear advantage to a manpower mix in which the majority of personnel are in-house maintenance workers.

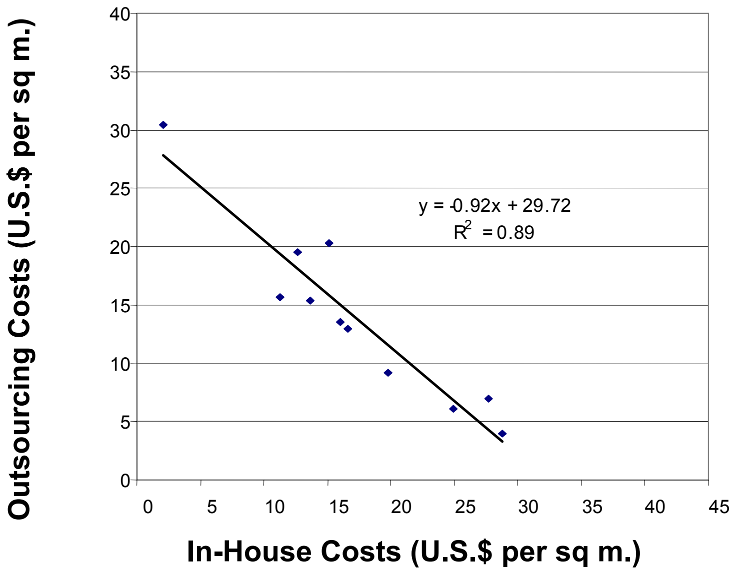

Figure 1: Annual labor expenditures per sq m.: Outsourcing vs. In-House Provision – Low level of occupancy

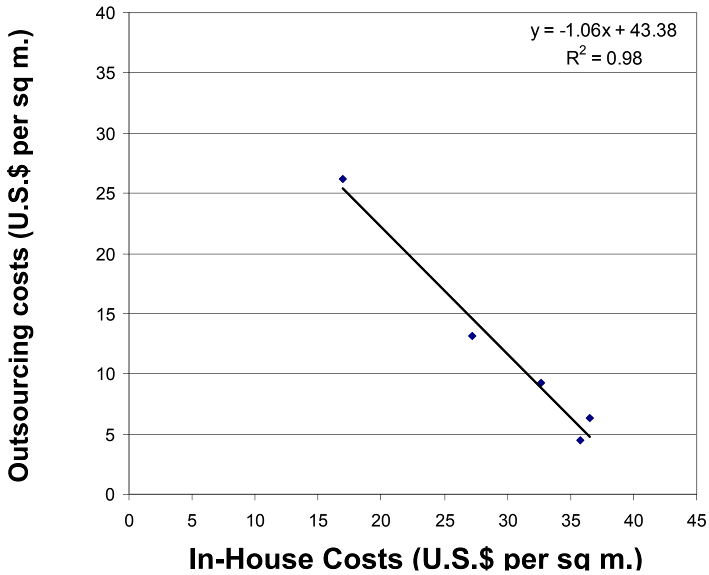

Figure 2: Annual labor expenditures per sqm.: Outsourcing vs. In-House provision – High level of Occupancy

Effect of Occupancy Level on Annual Maintenance Expenditure of Hospitalization Buildings

The effect of the occupancy level on the deterioration rate and annual maintenance results was examined in two ways:

a) Two identical hospitalization wards located in the same hospitalization building were compared. One ward had an occupancy level of 133% of the standard occupancy rate (13.3 beds per 1,000 sq m.), while the other ward, the control ward, was an identical ward located in the same building and had an occupancy level of 10 patient beds per 1,000 sq m., which is the planned occupancy rate for such wards. Table 1 presents a comparison of the maintenance inputs for both wards over a period of three years. The comparison indicates that average labor inputs for the over-populated ward were 22.3% higher than for the control ward (standard occupancy conditions).

b) Maintenance costs for high and low occupancy rates (up to 133% and as low as 80% of the standard occupancy, respectively) were estimated by quantifying annual maintenance costs according to the life cycles of building components under accelerated deterioration conditions as opposed to moderate deterioration conditions.

The analysis for accelerated deterioration conditions was based on previous findings, which showed a 25% increase in the replacement rate of finishing components and various building systems. The calculation for moderate deterioration conditions was based on a moderate replacement rate of interior finishing components and some of the electro-mechanical systems. It is emphasized that for certain systems no decrease in maintenance expenditures was seen, since the analysis was based on <u>preventive</u> maintenance only. We assumed that maintenance of certain systems, such as Elevators and Fire Extinguishing & Detection, would not decrease because inspection and replacement activities would continue to be executed even under moderate deterioration conditions.

Our analysis showed that the predicted saving, as a result of moderate deterioration under low occupancy conditions, is but 5%. By comparison, according to the same analysis, it was found that maintenance expenditures would increase by about 20.0% for high-occupancy condition and accelerated deterioration of finishing components and electro-mechanical systems. This figure is very similar to that found in the labor input analysis (22.3%), so that both results are reinforced.

The occupancy coefficient was therefore determined to be 1.22 (according to actual labor input measurements) under maximal occupancy conditions of 133%, and 0.95 (according to expenditure analysis) for minimal occupancy conditions of 80%. Figure 3 presents the change in the occupancy coefficient as a function of the occupancy rate, according to a simplified model which assumes the existence of a linear relationship between the occupancy coefficient and the occupancy rate under standard conditions (100% occupancy) and under extreme conditions of high and low occupancies.

In-depth research must be conducted on this issue in order to formulate a more complex and accurate model, such as, for instance, the gray line that represents the second order change of the occupancy coefficient.

Ward	Occupancy Level (No. of beds per 1,000 sq m.)			Average Annual Maintenance Labor Input (hours)	S.D.
	Standard	Actual	Occupancy Rate (%)		
1	10.0	13.3	133	836.2	108.2
2	10.0	10.0	100	683.6	55.5

Table 1: Annual maintenance labor input (in hours) per hospital ward for high- and standard-occupancy levels

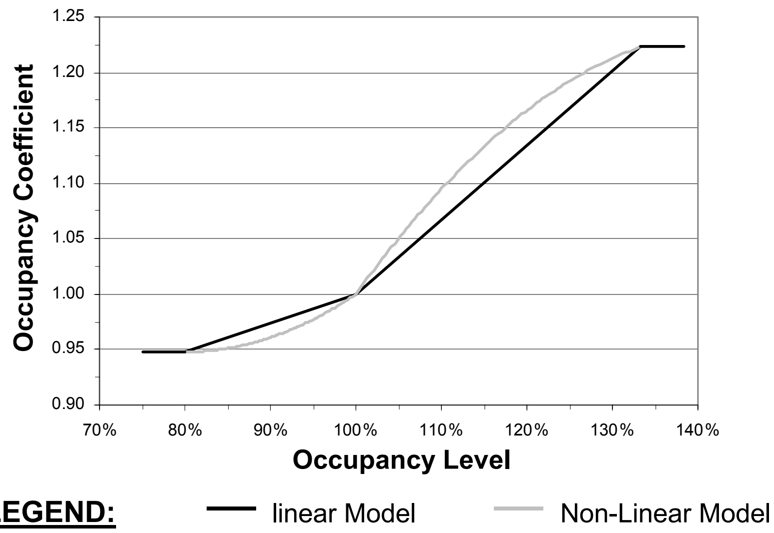

Figure 3: Occupancy coefficient (for annual maintenance expenditure) for different levels of occupancy

The Effect of the Building's Age on Annual Maintenance Expenditure

The effect of the building's age was examined by an analysis of the annual maintenance costs according to the life cycles of building components, as identified in surveys of energy and construction companies in Israel, and according to additional literary sources (Building Services Component Life Manual, 2002).

Annual maintenance costs were determined according to the ongoing cost of maintenance of the building's various components, and the replacement cost of components at the end of their life cycle. An analysis of annual maintenance costs revealed a great deal of fluctuation from year to year, due to the accumulation of a high number of replacements during several specific years (for example years nos. 20, 25, and so on).

In order to curb such fluctuations, the building's Age Coefficient (AC_y) was calculated according to the value of the moving average (over a period of 10 years) of the ratio of annual maintenance costs for year *y* to the average annual maintenance cost for the building's entire life cycle ($54.2). Figure 4 and Table 2 present the analysis results. Age Coefficients range between 0.55 for the first decade to 1.32 for the third and fourth decades. This expresses a high rate of replacement in Decades 3 and 4 compared to a low rate of replacements in the first decade.

The coefficient demonstrates the problematic character of maintenance budgeting of complex buildings, such as hospitalization buildings, and the need to investigate this issue in a systematic, quantitative, and scientific manner. This diagram reveals that the development of a maintenance budget must be tracked continuously and the budgeting examined both for each specific year and in relation to the building's performance.

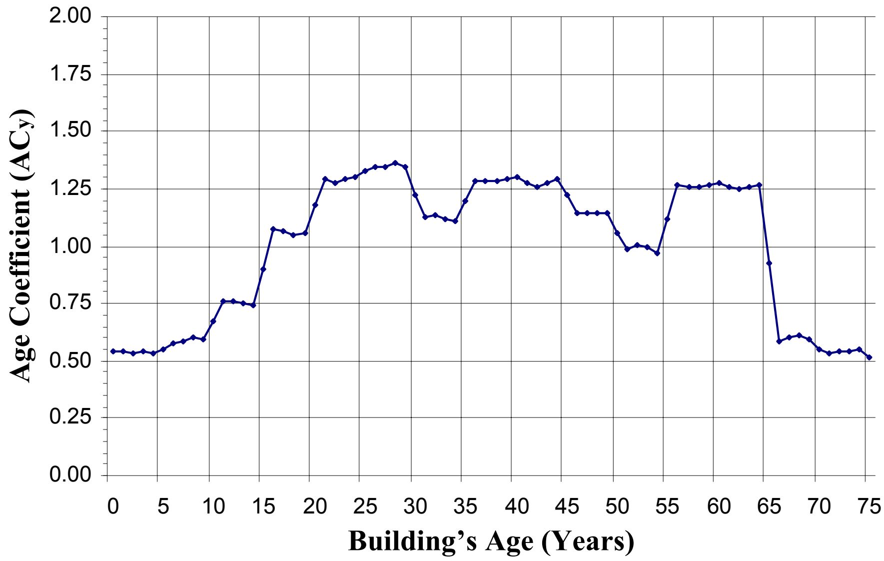

Figure 4: Age Coefficient (Ac_y) vs. age of building

Age of Building [Years]	Age Coefficient AC_y
5	0.55
10	0.67
15	0.90
20	1.18
25	1.33
30	1.22
35	1.20
40	1.30
45	1.22
50	1.05

Table 2: Age Coefficients for hospitalizing buildings of various ages

Summary of findings regarding influence parameters

Research findings reveal that the three parameters examined have a fundamental effect on the performance of the buildings studies, as well as on the maintenance costs. The influence of the above-mentioned factors must, therefore, be quantified into a comprehensive model that will relate the facility's characteristics to its performance and predicted costs. This study assumes the existence of a linear correlation between the level of performance and the level of maintenance expenditure.

The age of the building (or the average age of a larger building complex) has a substantial effect, which is expressed in values that are up to 45% lower than average for the first decade, and up to 32% higher than average for the third and fourth decades. The effect of the building's age must, therefore, be quantified for use in any quantitative model that addresses maintenance budgeting and control.

Occupancy of the building also has a significant, albeit more moderate, influence on the annual maintenance expenditure. A statistical and quantitative analysis of the high occupancy levels of hospitalization buildings revealed consistent results indicative of a 20-22% increase in annual maintenance expenditure. On the other hand, under low occupancy conditions, savings are not symmetrical, but rather much more modest, and amount to only 5%.

Sources of labor have an additional effect that might have a restraining impact on the annual maintenance expenditure. It was found that by exchanging in-house labor with outsourced labor under low-occupancy conditions an 8% saving may be obtained by, while under high-occupancy conditions (when a significant increase in costs occurs) a saving of 6% can be created by use of in-house personnel.

In order to examine the above-mentioned findings, a comprehensive model was developed, in which the various coefficients investigated in the analysis and formulation of maintenance policies in large hospitals are manifested.

Comprehensive model for hospital maintenance management

The hospital campus management model is implemented via four Key Performance Indicators, as follows:

1. The physical-functional state of the building – Building Performance Indicator (BPI);
2. Manpower Sources Diagram (MSD);
3. Maintenance Efficiency Indicator (MEI);
4. Managerial Span of Control (MSC).

Following is a concise description of these four indicators:

<u>The Building Performance Indicator</u> of a hospital comprises the following 10 building systems: Skeleton, Envelope, Finishing Components, Electrical System, Water & Sanitation System, Elevators, HVAC, Fire Extinguishing & Detection, Communications & Low-Voltage, and Medical Gases. Each system is made up of its basic components. For example, the building's Skeleton comprises basic units, such

as columns, beams, walls and ceilings. Each system is analyzed on a performance/ maintenance scale that covers three main aspects: (1) Suitability of the components to their intended use; (2) Past malfunction and failures; and (3) Preventive maintenance. Each system is graded on a 0-100 scale, and this score is integrated into the Performance Indicator according to the proportional weight of the system in the hospitalization building's life cycle. The indicator reflects the hospital building's performance as described by the four categories: good to very good (BPI>80); satisfactory-marginal (70<BPI≤80); deteriorating (60<BPI≤70); and run-down/dangerous (BPI≤60). The Indicator is described in detail in another paper (Shohet, 2002).

<u>Manpower Sources Diagram</u> – This diagram presents the manpower source mix (internal and external sources) and enables identification of the optimal manpower mix that will enable maximal labor utilization.

<u>Maintenance Efficiency Indicator</u> – This indicator expresses the cost of maintenance per performance unit (BPI). Two indicators are incorporated into this indicator, namely the budgetary Age Coefficient for the building (ACy) and the Building Occupancy Coefficient (OC), described previously. Equation 1 yields the Maintenance Efficiency Indicator:

(1) $$MEI = \frac{AME}{ACy} * \frac{1}{BPI} * \frac{1}{OC}$$

Where MEI is the Maintenance Efficiency Indicator, AME is the actual Annual Maintenance Expenditure (in \$/sq m.), ACy is the Age Coefficient for year y, BPI is the monitored Building Performance Index, and OC is the Occupancy Coefficient.
Values of this indicator range from 0 and up. For a hospitalization building, values lower than 0.4 indicate a shortage of resources and/or efficient execution of maintenance. Values between 0.4 and 0.6 mean that resources are reasonably utilized, while values higher than 0.6 indicate a surplus of resources or inefficient utilization of resources relative to the building's performance.

<u>Managerial Span of Control</u> – This indicator reflects the number of employees subordinate to the maintenance managers and principal engineer, The MSC helps identify a shortage or surplus in managerial resources as well as an overload on the managerial level.

It is noted that the implementation and analysis of all four indicators must be carried out simultaneously. Analysis of only part of the indicators might create a partial and misleading view of the situation.

Case Study

As mentioned, six detailed case studies were performed, and one of the more interesting of them is presented below.

Hospital Characteristics

The hospital analyzed in the case study had approximately 1,000 patient beds, with an average of 9.3 beds per 1,000 sq m. built area. This gave a resultant occupancy coefficient of 0.98. The annual maintenance budget for 1999 was $4,420,000, i.e. $38.50 per sq m. The distribution of the maintenance budget among its three main components shows that 49.9% was spent on the execution of work by external manpower sources (outsourcing), 39.4% of the budget was designated towards in-house provision, and 10.7% was designated towards materials and spare parts. The average age of the hospital buildings was 23, and thus the Age Coefficient for the campus was 1.31, due to the fact that the hospital was in its third decade during which many electro-mechanical systems and finishing components are due to be replaced. The analysis of the hospital's performance-maintenance state using the BPI led to a score of 66.1, indicating that the hospital was in a condition of deterioration. This low ranking was mainly the result of the low performance of finishing components, which indeed are not vital to the functioning of the hospital, but nonetheless constitute 35% of the BPI. On the other hand, the Medical Gases, Fire Extinguishing & Detection, Elevator, and Water & Sanitation systems were found to be in "good to very good" condition.

An analysis of the maintenance organizational structure revealed that the Principal Engineer's Span of Control was 3, but the number of subordinates on the Maintenance Manager level reached 7, a high and marginal value, which if reduced, could improve maintenance efficiency.

Analysis using hospital Key Performance Indicators

The annual maintenance budget of the hospital examined was $38.5/sq m. (approximately 2.3% of the Reinstatement Value). This, together with the average Age Coefficient for the campus (1.31) and the Occupancy Coefficient (0.98) resulted in a Maintenance Efficiency Indicator (MEI) of 0.45. This value is in the low range of 0.4-0.6, which is a reasonable range for the operation of hospitals in Israel.
Such a value is indicative of a satisfactory utilization of maintenance resources, but at the same time points to a significant shortage of resources, as was evident from the performance of the hospital. It may therefore be concluded that the performance reflects the level of resources invested in the hospital, its relatively old age, and its standard level of occupancy. The hospital's deteriorated condition can be improved by an increase in resource allocation.

Figure 5 presents the current condition of the hospital. The X-axis represents the performance level according to the BPI, and the Y-axis represents the total maintenance budgetary increase per sq m. Zero increase (horizontal line at y=0) represents the current budgetary level of $38.5/sq m. In addition, the figure presents two alternatives for improvement of hospital performance by investing additional resources.

Alternative 1 proposes to elevate the hospital's performance to a level of BPI=70 while maintaining the present level of efficiency (MEI=0.45) by increasing the performance of some of the building's systems to a minimum of P_n=70.

In Alternative 2, the performance of all building systems is improved to a level of P_n=70 which will lead to BPI=74.

At the same time, an appropriate labor source mix may be found using a Manpower Sources Diagram for each of the two alternatives.

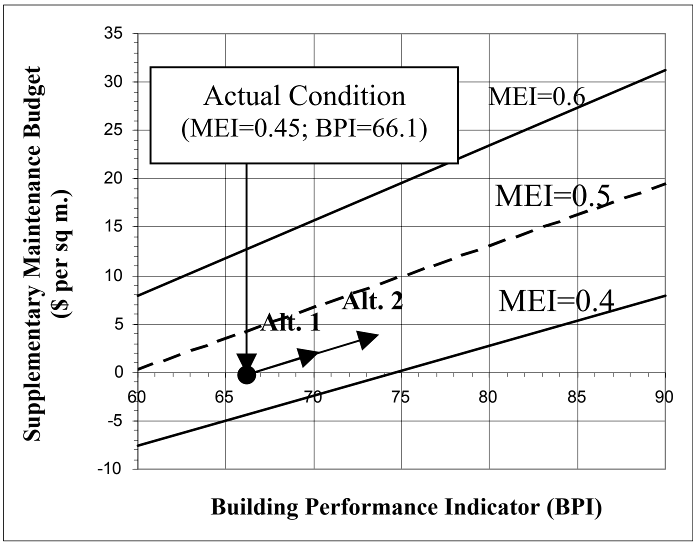

Figure 5: Supplementary Maintenance Budget vs. Building Performance Indicator (BPI) for various levels of resource utilization (MEI)

Summary of Case Study and Conclusions

1. The Building Performance Indicator (BPI), the Maintenance Efficiency Indicator (MEI) and the Managerial Span of Control (MSC) enable the identification of the hospital's state of performance, and an analysis of its budgeting level.

2. Factors, such as the building's age and level of occupancy, have significant influence and are manifested in the building's performance. Thus, they must find expression in the budgeting of maintenance operations.

3. The Indicators afford a wide perspective in the examination of the maintenance issue. Aspects covered by the Indicators include performance, budget per sq m., manpower mix, maintenance management, age of buildings, and occupancy level of hospitalization wards.

Summary and Conclusions

This paper examined the effects of three factors on the performance and maintenance of hospital buildings. All of the factors investigated were found to have a significant effect, which enables, but also necessitates, their inclusion in a quantitative model for the management of hospital buildings. An analysis of the building's age revealed that, over the course of time, maintenance requirements are characterized by a great deal of fluctuation (between +33% to –45% of the multi-year average value). Therefore, there is a need for the development of a managerial-quantitative model to address this issue. Furthermore, it was found that occupancy exerts a considerable effect on the deterioration of the building and its systems. This effect ranges from +22% at very high occupancy levels to -5% at low occupancy levels. Manpower sources exerted the least influence and their effect was not conclusive.

The coefficients developed in the study were integrated into a model for the analysis of the performance and maintenance state of hospitalization buildings. Examination of the model, using sample case studies, revealed that it is possible to accurately diagnose the state of maintenance, as well as the suitability of the maintenance budget to the current performance, as opposed to the expected performance.

Nevertheless, our study indicates that continued research is required to refine the effect of the building's occupancy on the rate of deterioration and of the building's surroundings on its maintenance.

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A risk management model for healthcare facility services purchasers

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Abstract
The non-core business objectives for NHS Trusts in the UK are to provide modern and comfortable healing environments for patients, staff and visitors (customers), as well as flexible workplaces that front the provision of responsive and seamless clinical services. The need to achieve these objectives economically has meant that healthcare FM operations are now being considered strategically as value-adding business services. This is in comparison to the past where they were considered as "backroom" services with no corporate or strategic value. In managing non core/clinical operations, key performance risks associated with such complex business transactions in the NHS are highly unavoidable from a business process re-engineering perceptive. Furthermore, today in a 24 hour shopping environment healthcare is provided in the UK, the management of FM operations involve highly qualitative and critical management risk factors. Quite often healthcare facilities managers as decision-makers tend to use a multivariate of factors and sub-attributes/constructs to evaluate the total influence of such factors on the FM service delivery process. Hence precise prediction of how each risk factor collectively with its respective constructs will affect the NHS trust's FM service delivery (best practice) strategies by means of an absolute evaluation value is too "risky". This paper provides preliminary results and an analysis of the major critical risk factors faced by healthcare FM purchasers in a bid to improve their business performance.

Keywords: Non core business, Healthcare facilities operations, Management risk factors, Multivariate, Business performance

Introduction

The business demand for FM purchasers (NHS trusts) to either outsource or insource "soft and hard" non clinical service solutions at best value from service providers (commercial or/and in-house) on the competitive market continues to be elastic. This is in line with the central government's political (best value) strategy of modernising the NHS services supply chain (i.e. improving hospital facilities, integrated resources and changing the organisational culture) to cope with the business demand of customers when delivering and managing clinical outcomes in the UK.

However, in core service organisations such as the NHS where the design, procurement, performance management and delivery of facilities solutions is driven by customer-necessity of care needs and expectations as opposed to demand. Purchasers of healthcare FM services quite often face hazards in managing these strategic business risks and uncertainty involved in the FM servicescape that underpins the delivery of clinical services to NHS customers. In addition, the post-modern environment healthcare is provided today has shown that there is a consensus at both corporate and strategic management levels in most trust hospital organisations regarding continuous growing awareness that effective risk management can provide a competitive edge in an agile business environment such as healthcare. It is therefore apparent today that a business approach of managing non clinical operations risks now challenges the traditional view that risk management in healthcare operations was mainly to do largely with healthy and safety accidents and probable physical loss matters. This meant that exposure to healthcare operational risks could only be insured. However, the modern view now enabling most healthcare businesses to perform strategically is that, by providing customer-focused non clinical service solutions purchasers can benchmark best practices that control and reduce potential clinical business disruption thereby improving customer care or repeat business. This strategic business approach also allows FM service purchasers to have contingency business recovery plans in cases of service delivery failures.

Risk and facilities management in NHS Trust hospitals

It is extremely relevant in the business of healthcare to remember that risk management is a recent advent within the healthcare setting especially in the NHS (O'Donovan, 1997). Starting 1st of January 1990 NHS Trusts as corporate entities are now accountable or liable for any clinical tort and customer dissatisfactions in the NHS. In reality, the attainment of Trust status meant that these NHS hospitals together with their outsourced or insourced service businesses were no longer able to enjoy the Crown immunity they had before. In business performance terms, trusts now have no exemption regarding, corporate governance, clinical tort and lack of strategic competitiveness. Hence, have to avoid the costs of service mistakes (which might result in customer dissatisfactions or higher patient deaths). Since then, trusts have increasingly started evaluating, analysing and managing non clinical operational risks when providing "a safe environment (the estate), clean surroundings and an appropriate diet (hotel and catering services) which are integral parts in the diagnosis, treatment and recovery of those who are ill" in hospitals (Rees, 1998). As a result of such commercial initiatives, NHS trusts have had to seek for viable business approaches that were advocated by the White Paper Working for Patients (1989). The NHS Executive (1999) as part of clinical quality assurance regards the effective management of risk in healthcare operations, as one of core competencies of every healthcare executive in NHS trusts hospitals.

Therefore, NHS FM managers have a duty of care to both their customers and stakeholders to identify, analyse and economically control those business hazards (customer service failures) that may disrupt the continued use of healthcare business support services that front clinical services delivery. In light of this, Davies and Walters (1998) categorically stated the major business role of facilities managers as that of effectively managing business risks and uncertainty in their respective service organisations. According to Davies and Walters, the effective management of business risks improves the protection of the organisation's image and assets, and allows healthcare executives to better manage core business (clinical) objectives. As a result of this, it is the facilities manager's duty as part of the hospital executive team to manage and control the level of exposure to risk in healthcare facilities and business support services to allow for business continuity. From preliminary results analysed in this investigation, it can concluded that the main objectives of managing support service risks and uncertainty in the NHS are to:

i. Reduce business disasters or crisis and allow for repeat business or continuity;
ii. Protect and manage effectively the organisation's assets, resources i.e. human, finance and healthcare facilities and business systems;
iii. To offer value decisions which improve the performance of support services in underpinning responsive care delivery to customers (i.e. offers customer care through effective FM);
iv. Improve and manage the organisation's changing environment with regards to the total workplace (premises, people, technology and the processes) in order for it to be competitive in delivering the core business (Becker, 1990; Akhlaghi, 1995).

Research Methodology

The conceptualisation and realisation stage of this investigation as with most research projects focused on a careful review of primary and secondary sources of literature regarding NHS facilities management service and risk management practices (Andaleeb, 1998; Jackson,1998; Brown and Bell, 1998). This method is commonly known as the extensive research approach and has been recommended for use when measuring survey perceptions by Hoinville and Jowell (1989). In order to facilitate effective FM business information collection, healthcare FM knowledge on key risk factors was elicited from domain FM experts and from a "live" case study that was identified by the authors as a best practice experience in the NHS. Soon after several knowledge eliciting meetings (Delphi approach) with NHS FM experts followed by the sampling of possible participants, a questionnaire was designed. The main research instrument used collecting FM data was the impersonal or questionnaire survey method. This method has great advantages such as low cost of data acquisition, less interviewer bias, a high degree of anonymity, and wide access to geographically dispersed samples (as such is the case with UK NHS trusts).

Immediately after designing the main questionnaire, one hundred mail questionnaires were sent out to FM purchasers by post, for them to reply urgently to a set of questions asked. The questionnaire was only sent to those trusts that practised an integrated FM approach (i.e. the management of all non clinical service under a single directorate.)

Characteristics of FM participants and responses

Out of the three hundred and sixty five (365) FM purchasers to which the questionnaires were sent to, only ninety two (92) questionnaires were positively returned back. The respondents who participated in the questionnaire survey were mainly FM executives from UK's five main NHS trust hospitals. Facilities executives in the NHS are responsible for the strategic management and effective decision-making of non-clinical services. As a result were considered appropriate participants for this study due to their day-to-day (knowledge/experience) involvement in FM operations. FM executives were also chosen as they represented variations that existed in the delivery healthcare FM operations within the UK's major NHS Trust hospitals. Table 1 shows the types and statistics of purchasers surveyed in the NHS.

Healthcare facilities managers were chosen in this survey due to the following reasons:

Type of FM purchaser	Number of responses
Integrated Acute	26
Acute	18
Acute and Community	15
Teaching	18
Community/Mental	15

Table 1: *Composition sample of FM purchasers surveyed*

Main research objectives

The main objectives of this investigation were:

(i) to identify critical business risk factors faced by FM purchasers when benchmarking the best practice in delivering value adding non-clinical services in the NHS.
(ii) to measure the perceived importance of the identified critical risk factors using the relative importance index technique
(iii) to classify these risks into their respective groups and;
(iv) finally, to discuss and evaluate the effects of these risks towards the effective delivery of clinical (core) services in the NHS.

The hypothesis used in this study is that the provision of effective business and customer driven facility solutions in healthcare operations will continuously lead to improved seamless and responsive care services. These services should always be provided on the basis of clinical needs in NHS trusts (Wagstaff, 1997). As a result of this approach business objectives in trusts can be enhanced through FM performance. Furthermore, many business and facility related risk factors that might have a potential to adversely affect, or even negate attempts of the provision of best value clinical services are minimised. In practical terms, effective service management in trusts by benchmarking best practices in health FM will lead to an uninterrupted supply non clinical service to support the core business objective in NHS trusts. This strategy will result in minimising risks associated with business disruption and NHS corporate image of delivering cost-effective healthcare.

Relative importance index technique (RII)

The relative importance index technique was designed in the survey to mirror healthcare facilities managers' (i.e. for purchasers) perceived importance of each risk factor to the non clinical business process re-engineering established by this investigation. This measure allowed for the appropriate categorisation of non clinical business risk factors based on value judgements (using a Likert Scale where: 1 = not important and 5 being extremely important) of surveyed NHS FM executives. Input to the final weighting index (W) adopted from Akitonye *et al* 's (1998) work on client and consultant-generated risks in construction operations in the UK was mainly composed of the relative importance index. These were then transformed into relative importance indices using the well-recognised relative importance index technique. By computation of the RII formula listed below, the risk factors were ranked and classified according their membership classes as shown in table 2. The use of such an importance index might be debated at this stage of the study due to lack similar FM studies that currently exists for comparative analysis.

Relative Importance Index =

$$\frac{\sum \mathbf{W}}{A * N}$$

Where:

W = weighting given to each factor by the respondents and ranges from 1 to 5 where '1' is the least important and '5' the most important;

A = is the highest weight or score (i.e. 5 in this survey);

N = total number of respondents.

Risk factors/constructs	Relative important index of construct	Ranks of constructs	Overall index for risk factors	Overall rank risk factors
CUSTOMER CARE			**X = 0.75**	**1**
Customer satisfaction	0.8	1		
Service delivery certainty	0.792	2		
Customer involvement	0.784	3		
Service quality reliability	0.776	4		
Service value management (Best value)	0.752	5		
Service speed	0.744	6		
Service measurement	0.72	7		
Medical technology innovation	0.624	8		
BUSINESS TRANSFER RISKS			**X = 0.71**	**2**
Service cost certainty	0.784	1		
Service availability	0.768	2		
Staff participation and partnership	0.752	3		
Continuous service improvement	0.728	4		
TUPE	0.72	5		
Performance guarantees	0.72	6		
Service innovation	0.656	7		
Management accounting systems	0.64	8		
Business transfer costs	0.624	9		
LEGAL RISKS			**X = 0.669**	**3**
Health statutory compliance	0.752	1		
Service contract design	0.68	2		
Service level agreement	0.68	3		
National minimum wage	0.656	4		
Agency	0.576	5		
FACILITY TRANSMITED RISKS			**X = 0.662**	**4**
Health and safety	0.768	1		
Environmental issues	0.648	2		
Medical technology innovation	0.624	3		
Clinical related	0.608	4		
CORPORATE RISKS			**X = 0.654**	**5**
NHS trust image	0.688	1		
Information strategy	0.680	2		
Clinical strategy	0.664	3		
Environmental issues	0.648	4		
Organisational culture	0.632	4		
Management development	0.632	5		
Social corporate responsibility	0.624	6		
COMMERCIAL RISKS			**X = 0.63**	**6**
Information strategy	0.688	1		
Partnerships	0.688	2		
Service competition	0.68	3		
Market intelligence	0.632	4		
Medical technology innovation	0.624	5		
Business process re-engineering	0.616	6		
Management responsibility transfer	0.608	7		
Third-way (Political and Physcho-social)	0.6	8		
Stakeholder involvement	0.592	9		
Primary care impact	0.576	10		
FINANCIAL AND ECONOMIC RISKS			**X = 0.615**	**7**
Service cost certainty	0.744	1		
Price competition	0.728	2		
Financial transfer/stability	0.68	3		
Economy (national and International)	0.632	4		
Provider reimbursement method	0.6	5		
Return on capital employed	0.592	6		
Insurance liability costs	0.576	7		
Working capital	0.568	8		
Profit margins	0.536	9		
Corporate business taxation	0.496	10		

X = mean index of risk constructs giving overall of the critical risk factors

Table 2: Purchaser's group ranking of FM risks

Discussions and Analysis

After a careful membership classification of all the FM constructs in Tables 2, seven (7) main risk factors for the purchasers were identified and ranked according to the following types: *customer care, financial and economic, commercial, legal*, *facility transmitted, business transfer and corporate risks* to show their effect on FM operations in the NHS. The risk factors were arranged in order of relative importance starting with: customer care (0.75); followed by business transfer (0.71); followed by legal (0.669); followed by facility transmitted (0.662); followed by corporate (0.654); followed by commercial (0.63); and then financial and economic (0.615) risks. From Tables 2, it can also be seen that all the seven risk factors were important with relative index above 0.5 except for corporate business taxation (0.496), of which trust hospitals are exempted from paying. Furthermore, in Table 2 it can be seen that out of customer care (0.75) group risks were viewed as the most important to both operators. For a detailed review and discussion on the main risk factors, the writers have be submitted another novel article to the Risk management, International Journal which will also incorporate the views of in-house and external service providers. In overall, this research has established that in managing the non-clinical business process, there are seven major classes of strategic and competitive management risks faced by purchasers. Furthermore, these risks can be modelled into a best practice model using constructs to manage the FM business process in the NHS. Therefore, the section below will now discuss the seven novel risk factors faced by purchasers in the NHS.

Corporate risks

These are strategic and competitive factors associated with the FM service purchaser’s (overall trust) organisation meeting its core business objectives. These business objectives can be short-term or long-term (strategic). Corporate risks also encompass good clinical governance, statutory and regulatory services, the service culture, the NHS servicescape, vision, values, beliefs and the welfare of its customers in meeting the core clinical business objectives (HFN 17, 1998). Therefore, it can be said in no uncertain terms that the effective management of competitive and strategic risks is critical to any healthcare service organisation considering to be successful in delivering non clinical/support services effectively in the NHS. The lack of healthcare business focus can result in “corporate myopia”. Hanson and Hinks (1998) consider corporate myopia as a clear symptom of the apparent lack of “overall business competitiveness in an increasing global market”. Also, Alexander (1992) in his discussion about facilities risk management identified the positive impact of FM in service organisations using the following factors;

(a) Identity – corporate social responsibility and image to customers and stakeholders
(b) Continuity – continue to improve business performance and meeting customer needs. This also involves an organisation being able to identify its niche of the market and still continue to be competitive.
(c) Sustainability – optimum use of organisation resources, management of obsolescence and redundancy.
(d) Adaptability - the ability of an organisation to offer a “prescription for change” in business approaches (Payne and Rees, 1999).

(e) Responsibility – duty of healthcare for customers and stakeholders
(f) Viability – opportunity costs and business performance.

Legal risks

This relates to those business risks arising due to FM contractual liabilities and, or service operation performance arrangements between the service purchaser (NHS Trust) and provider(s). The relationship ensures that a legal challenge is dealt with perfectly which may follow any non-performance or breakdown in relationship. It is therefore imperative in healthcare service operations that FM purchaser have adequately designed and defined service provision parameters/levels and contractual arrangements that can be effectively used in delivering flexible healthcare support service solutions. This will entitle both purchasers and providers involved in FM service provision to clearly focus on putting n place sound risk reduction strategies that will monitor all critical success aspects of an FM operation such as;

a) Service level design (thresholds), procurement strategy and management levels
b) key performance indicators and quality audit procedures
c) management accounting and limits of responsibility
d) duties of parties

In healthcare business, managing legal factors of a service operation means transferring risk to the best non clinical managers. This will involve insurance to facilities, staff and customers, indemnities, "hold harmless" agreements, performance bonds, guarantees, sureties/securities, liquidated damages and staff contracts and transfer of employment (TUPE) including health and safety issues described below:

a) Obligations
b) Health statutory compliance
c) Service sourcing or contractual arrangements
d) Terms of payment and reimbursements
e) Dispute resolution and organisational operating structure
f) Termination of service provision

In overall, legal risks in healthcare FM operations relate to the transfer effect of instruments and service obligations to purchasers and providers to avoid operational and "contractual pitfalls" (Gracia, 1998; Hanson, 1997). These may include statues, regulations and codes of conduct between the FM provider and purchaser. This can at a localised level i.e. within hospital settings, NHS level, Government and European Community (EC) and international level.

Facilities transmitted risks

These are risks associated with poor hospital facilities management standards especially, general standard of hygiene, cleanliness and the use of internal hospital space for healthcare business by customers. Recently, infections acquired in hospital facilities have risen to 100 000 each year resulting in deaths of up to 5,000 patients in England each year and cost the NHS 1 (one) billon pounds. It is also estimated that across all NHS Trusts infection rates could be reduced by 15% through effective FM and application of existing business knowledge and realistic infection control practices, with a potential saving of around 150 million pounds a year. Most of these savings can be achieved by practising an integrated FM approach in the NHS (Wagstaff, 1997). It is therefore apparent that in the business of healthcare, good hospital facilities will provide customers with a comfortable, pleasing and healing environment. Modern healthcare facilities will also contribute to the delivery of healthcare service excellency by being a health and virtual place to work while not harming the health of the environment, thus will be seen to be reducing risks associated with the use of a hospital by NHS customers. Since then, FM purchasers and providers have become increasingly informed that a safe environment (the estate), clean surroundings, an appropriate diet (hotel services) and happy support services staff are all integral parts in the delivery of high quality healthcare (diagnosis, treatment and recovery) to customers. Healthcare facilities have special design and management needs as a result will need to demonstrate that they are environmentally well-managed providing high air quality and the internal operating space standards that do not contribute to more clinical risks (facility related diseases) to customers. Healthcare facilities will also have to undergo rigorous inspections (in terms of health and safety compliance) as a risk management process because of their complexity, interaction with working staff (clinical/non clinical), and sick or injured people. The provision of a desirable physical environment that fosters the provision of healthcare will therefore be seen by customers as an effective business strategy of reducing hospital acquired infections (HAI) risks associated with the trust hospital facilities. Thus, safe and clean facilities will help in providing customers with a comfortable environment while being flexible in use to customers' individual necessities when receiving healthcare in the NHS.

Customer care risks

Customer healthcare risks in healthcare FM operations are those related to the provision of high quality healthcare service outcomes to satisfy customers' clinical needs and allow for repeat business. These risks are faced by FM service operators (providers and purchasers) in the NHS as a result of the ever evolving and competitive environment of healthcare facility services provision. The FM servicecape in the NHS has necessitated that in order for service operators to survive or be best in class, they would need to provide super support service solutions that can be awarded by customers a better value-/cost relationship or quality-/cost relationship. In this process of delivering high quality FM service solutions to NHS customers, FM purchasers have had to face risks related to satisfying their customer and delivering service strategies that enhances customer satisfaction and achieving best value money models or goals. A summary of the customer care constructs faced by purchasers when delivering customer focused FM services in the NHS are shown in Table 2.

Commercial risks

These are business risks emanating from the use of various strategic and competitive FM procurement options, transactional costs and the day-to-day (strategic) management of healthcare facilities within or outside the hospital Trust environment. These risks are necessitated by the need for FM services to be delivered using business approaches that are focused at providing high quality FM solutions through market competition. FM purchaser and provider service organisations in the NHS competing for business markets are obliged, for survival and to have business intelligence about various non clinical services performance of their competitors either by benchmarking best FM practices or providing care service excellency to patients, staff and visitors. In so doing, this approach exposes FM service operators to various business and customer service management risks. Since the NHS now operates an internal market that requires best value FM services, service operators working in NHS Trusts are vying for a larger loyal customer base and market share and are also willing to procure and deliver FM services competitively. Therefore, FM service operators will no doubt encounter business risks whilst trying to define their strategic direction, fighting business competition and operational plans. The ideal service strategies that must be implemented should commercially match the customer and market demand for health care with the available non clinical services – human, financial and physical assets. Usually FM services have to be competitively procured and delivered at best value to the customer at a commercial risk premium.

Financial and Economic risks

This relates to risks arising from economies of scale and the injection of finance (investments) or working capital tied into the management of healthcare facilities by either the provider or the purchaser to meet the clinical business objectives. The increasing role of business approaches that are being pursued to manage clinical and non-clinical service outcomes in the NHS and UK economy require huge capital outlay and cashflow for them to be carried out efficiently. Therefore FM service operators' financial performance measures define the long/short term objectives of FM businesses and indicate whether the strategy, implementation and execution are contributing to bottom-line improvement. This point serves to illustrate that, for most NHS FM business decisions made regarding the delivery of quality healthcare services to customers to succeed, purchasers must be financially sound to meet their current and future business expansion plans. This situation therefore calls for the entire management of the purchaser' business resources using cost effective and service efficiency measures. The management of resources especially in healthcare FM operations represents a substantial financial investment for trust hospitals in the management of modern comfortable and healing environs that need to be serviced at all business times in order for them to support the core business objectives of the purchaser (i.e. to provide responsive healthcare services) or else risk service disruption and failures in the NHS.

In view of the current situation in the NHS regarding the effective modernisation (privatisation and public management) of healthcare FM plus core clinical services, a good cashflow outlay to finance such capital intensive operations is essential on the part of purchasers. Financial stability of both the purchaser and provider is an element of effective healthcare FM business, to ensuring that the business of delivering non-clinical services by providers (in-house/external) on behalf of the purchaser does not fail (business continuity/success). Given that the NHS is heavily under-funded for major technological and capital intensive projects, trust hospitals have found themselves with no financial resources option except to bring in private sector participation using three pathways; the first directed to estates, site services and hotel investment decisions, the second to the management of property assets, the third to the management of facility operating costs, all within the context of the property market, which tends to be the most illiquid vehicle for investment.

Business transfer risks

This relates to risks arising from the transfer of all (i.e. outsourcing) or part of the FM services from the trust to service operators (external and in-house) through market competition because they perceived advantages for the organisation and staff in entering the market early on a voluntary. Commercial businesses are, of course, accustomed to facing new challenges posed by legislation and regulation.
Business transfer risks are also associated the transfer of support service resources - FM staff, physical and financial assets to the new service provider who will no doubt be affected by TUPE.

Conclusion

This study has just reported on the preliminary results of an otherwise very complex study concerning the development of a risk or decision management tool FM operators (purchasers, in-house and external providers). However, this study has only focused on service purchasers only. The research has clearly demonstrated that FM risk factors can be classified into seven main important groups, of which future business decision support and risk a management system/models can be developed for the effective management and treatment of these risks within the FM process in healthcare operations. By developing business models for the management and decision-making, FM purchasers will be able to monitor management related risks effectively either in the pre- or post contract stage of healthcare FM operations to improve the delivery of high quality non-clinical services in NHS trusts. An effective corporate risk management and decision support system or model will ensure that these business factors although qualitative if carefully managed become the critical success factors (the best practice) for benchmarking future healthcare FM operations.

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Strategic Client Briefing: Lessons for Strategic Facilities Management

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Abstract:
Strategic client briefing is now recognised as an essential element in strategic facilities management activities. A number of different approaches have evolved, or are being developed, to coordinate and manage this important stage in the life of a project. Strategic Needs Analysis is a client briefing approach that was adopted by the authors in six project inception studies. The projects were real client proposals based in developing and deciding on a strategic direction for the projects being considered. The studies were analysed using action research methods with the authors closely involved in the activities and organization of the process.

These studies involved five different client groups, several design agencies and a varied group of stakeholders for each study. A survey of stakeholders was carried out using six key process characteristics developed by the authors: management commitment (strategic), stakeholder participation, group dynamics, workshop organization, tools and process (problem-solving). These key characteristics were further analysed into a total of forty-one attributes considered as important as contributing to the client briefing process.

Analysis of this stakeholder data has revealed some interesting positive and negative features of the process, approach and project inception environment in which these activities take place. The Strategic Needs Analysis approach was refined as a result of the survey analysis and experience gained in the first four studies. The authors present the major findings from their work, make some observations on the process and offer suggestions for improving future applications of strategic client briefing using Strategic Needs Analysis, or similar approaches.

Keywords: Client briefing, stakeholders, Strategic Needs Analysis.

1.0 The Process

1.1 Strategic Needs Analysis: the Chosen Approach

A number of approaches are available (Analytical Hierarchy Process (*Expert Choice*) (Saaty, 1990a, 1990b), decision analysis (Coyle, 1972; Raiffa, 1968; Watson and Buede, 1988) that are aimed at creating and developing alternative strategies during the development of policy during strategic management activities. However, few of these techniques appear to have been applied to the process that converts the organisational strategy into property investment decisions or corporate real estate that support them. Indeed, Green (1992, 1996a), Latham (1994), Egan (1998) and CSM (1998a) have highlighted the need for skilled specialist practitioners to bridge the gap between corporate strategy and the development of building projects to realize their strategy.

Any process adopted must make a valuable contribution to the strategic stages in project inception. The process should confirm and extend the decision to build (new-build, extend, renovate, upgrade, remodel). It must reflect the environment of the organisation by being sensitive to the strategic direction identified in the strategic management process by capturing the mission, vision and values expressed by the organisation. These must guide the process of considering alternatives to satisfy the strategic direction already determined. The process must also be useful, flexible, well organised, sensitive to client and *stakeholder* needs and objectives and designed to provide more effective, efficient, innovative and better solutions (Gray, *et al,* 1994; Karma and Anumba, 2001).

Discussion of a proposed methodology with several client bodies, consultants, academics and colleagues pointed to a series of features that should be incorporated into the design of the methodology. However, the challenge was to have a minimum of compromise over conflicting characteristics whilst still largely achieving the aim of each characteristic. Thus, in summary any methodology must ideally have all or most of the following characteristics to be effective at the pre-design stage and be successfully implemented:

- satisfy the principles of problem solving;
- create a number of strategic options for the future direction of the organization;
- actively involve a range and number of different types of stakeholder;
- adopt a rigorous means of decision-making;
- allow each participant to contribute to the decision-making process irrespective of their position and role in the organisational hierarchy;
- involve those external stakeholders who can contribute to the development of a strategic direction;
- challenge organisational assumptions and prescriptive responses to service delivery;
- provide commitment to decisions made to improve their chances of implementation;
- be supported by senior management in the process and through to the decision, and
- provide sufficient, but not need an excessive time commitment to the approach and conclusion of the process. in other words, try and complete the process in as short a time as possible and preferably in a maximum of two days.

After many discussions and pilot testing a model was designed to operate in this strategic environment. This model was termed, *Strategic Needs Analysis* (SNA), in an attempt to capture its essence in a few words and to identify its concentration on the strategic efforts of the client and stakeholder group. In addition, a feature of the adopted approach was the use of *Strategizer* (decision-making software (Wyatt, 1995a, 1995b, 1999) in the SNA applications.

1.2 Strategic Needs Analysis.

Strategic Needs Analysis was designed with the aim of making a positive contribution to the inception of a project. It also starts with the premise that the solution delivered will be the most appropriate to satisfy the stakeholder's strategic needs and this is likely to be, but may not always be assumed to be a construction project. Strategic Needs Analysis also reflects and is sensitive to the strategic direction identified in the strategic management process and so overlaps it. Indeed, strategic management (Viljoen, 1994; David, 1997; Thompson and Strickland, 1995) and problem solving approaches (Ackoff, 1978; Popper, 1994).

The process is based on the involvement of as many significant *stakeholders* as is practically possible. These are representatives, direct and indirect, who may have an interest and can make a contribution to the proposed project, such as:

- Owner;
- managers/executives, facility managers, project manager(s);
- staff or employees;
- purchasers, sub-contractors, suppliers and other process or service providers;
- tenants, residents, community representatives, neighbours;
- visitors, customers, potential and future customers, users, partners or interest groups;
- design team members (if appropriate);
- and others, depending on the project and attitude of the organisation to participation, and involvement in the process.

This stakeholder group should ideally include members of the client group from the strategic to the operational levels of the organization. Clearly, it should involve some participants who have an interest in the service, product or possible facility. An essential aim of the process is that stakeholders should broaden and re-orientate their frame of reference in defining projects (project inception) from the prescriptive and standard response, to one where they have a strategic view of their own organisation's true goals, objectives, needs and requirements. Any identified options must be consistent with the strategic direction enunciated by the organization in its strategic management process and statements.

Irrespective of the approach adopted in the project inception stage(s), it should be a broad-based process that can deliver the following benefits:

- recognition of the opportunity created by the decision to build;
- client commitment to the project;
- greater client understanding of the brief and the problem(s) it is attempting to solve;
- clearer formulation of the service needs, functional needs and objectives;
- improved versatility or flexibility of the selected project option because a more thorough evaluation of its purpose has been carried out;
- dissemination of client and user information to the design team, and
- broad discussion of the proposed activities within the new facility by all the participants.

1.3 The Strategic Needs Analysis process

Taking these factors into account the broad aims of the Strategic Needs Analysis process are to:

- develop a service vision for the organisation based on a clear understanding of the nature of the use and demand for such services;
- involve as many of the existing and potential stakeholders in such a facility in the definition of alternative strategies;
- identify as many realistic alternative strategies for the achievement of the vision;
- analyse the alternative strategies with the stakeholders;
- decide on a preferred strategy;
- assist in the preparation of the *Performance Brief* to guide the design in the development of the later more prescriptive Design or *Project Brief.*

Finally, any process at this stage must recognise that in a strategic environment the options or choices facing the decision-maker(s) may not, and often cannot, be fully described. It recognises that information at this stage is not exhaustive or perfect, but nonetheless a decision to set the course for the project has to be made. However, in this case Strategic Needs Analysis process probably represents an effective *decision gatekeeper* for reflecting on the choices, possibly introducing a new one (or new ones) not previously considered and then confirming the agreed choice.

1.4 Structure of the Process

The SNA process follows standard planning workshop, problem-solving approaches (Popper, 1994; Lichfield, *et* al, 1975; Rosenhead, 1989; Checkland and Scholes, 1990) described in the literature review in Chapter Two. That is, the stages involve and divide into the following major activities:

- collect information to understand the nature of the problem;
- discuss and analyse the problem;
- develop options to solve the problem;
- decide on a preferred option or direction, and
- make a recommendation to implement the decision on the basis of workshop activities.

In practice, the Strategic Needs Analysis is a three-stage process:

1. Information seminar (understand the problem);
2. Workshop One (develop appropriate options to solve problem), and
3. Workshop Two (decide and recommend).

The structure is shown diagrammatically in Figure 1.

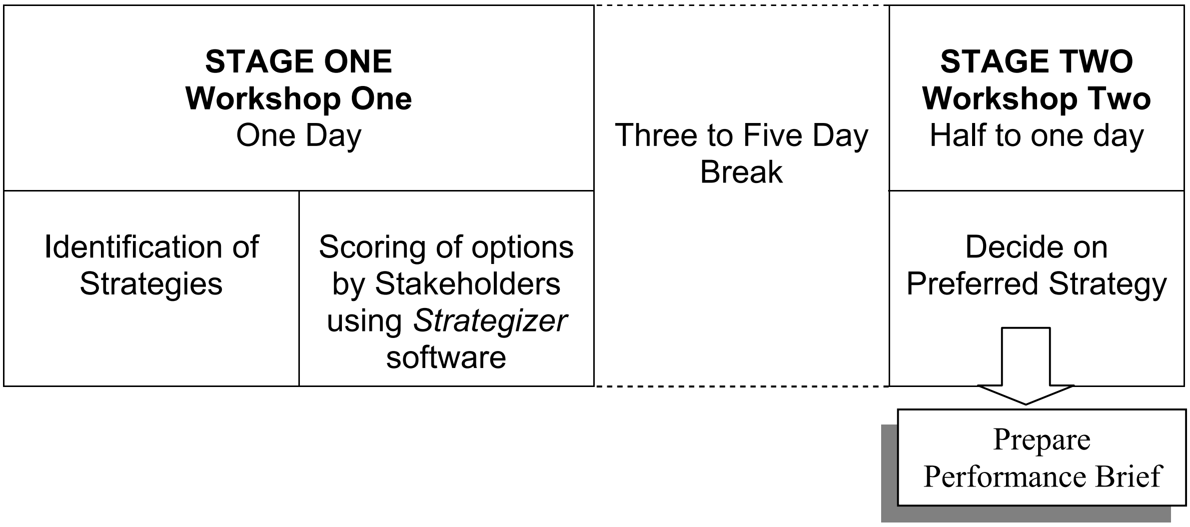

Figure 1 Strategic Needs Workshops

SNA aims to not only achieve involvement of all the stakeholders, but also to ensure senior management is committed to the process and the outcome. It is a process designed to clearly define the problem that needs to be solved by the design team, and so provide a solid base for the project to succeed (Smith *et al*, 1998). It should create a suitably defined project (for this early stage) that suits the stakeholder's needs whilst ensuring client and stakeholder satisfaction.

1.5 Outcome

The aim of the workshops is to create an outcome that becomes the agreed strategy. The agreed strategy should satisfy the organisation's strategic requirements and should result in a decision to proceed with the project. This strategy in most cases is a built facility, in which case a performance brief will be prepared by the stakeholders to guide the design team. For an organisational arrangement strategy a detailed statement of its requirements is developed that will consider the financial, human resources, social and other implications of its implementation.

Since a built facility is the most likely chosen strategy, a performance brief will document decisions in performance terms, stating the outcomes required, rather than a prescriptive way of *how to do it.* The designer will have to develop the project within the parameters defined in the brief, which will guide, but should not inhibit the actual built solution.

2.0 The Six Studies

SNA was used on six studies during the project inception (pre-design stages) where guidance was needed to assist the client and stakeholders in defining the strategic direction for the organization or in the provision of new facilities. In fact, reviewing the types of problem in each of the studies in Table 1 shows a broad range of perspectives in each one. The types of study range from the truly strategic (College and Yacht club) to a strategic content within proposed facilities (Youth Training, Faculty Relocation and council) to almost macro-strategic within an identified project (Lighting Lab).

Nonetheless, in each of these studies, SNA, was able to inform, guide, define options and decide.

Case Study	Problem	No at Workshop	% Return
1. Lighting Lab	University property division and school making decisions on the type of teaching and research space to be planned and provided	15	73
2. College	Tertiary institution considering its strategic plan in relation to the type and need for educational facilities	42	86
3. Youth Training	Government design group and juvenile justice department reviewing its master planning for a new facility within its present system	10	80
4. Faculty Relocation	A University property division organizing a faculty transferring to a new campus with a review of the type and form of facilities to be provided	11	45
5. Yacht Club	Identification and selection of suitable options for the future development of the marina facilities in a sensitive area of city redevelopment.	8	63
6. Council	Preparation of a performance brief for a new site for the redeveloped library facilities in a shopping precinct including identifying potential joint uses in the new facility.	15	60
TOTALS		**78**	**77%**

Table 1 Case Studies

For each of these studies a survey of stakeholders was carried out immediately following the final workshop and the numbers and response rate is also given in Table 1. The survey collected views and opinions from participants on the effectiveness of the structure of the process (information seminar, workshops one and two, timing), the software, workshop decisions and general comments on the process.

A further survey some weeks after the completion of the study elicited participant views on a number of key attributes forming the basis of this research. The six broad categories of interest in this research into the project inception stages of a project were:

A. Management Commitment (Strategic)
B. Stakeholder participation
C. Group dynamics
D. Workshop organisation
E. Tools
F. Process (problem-solving)

These six broad categories were further sub-divided into individual attributes under each category and these were used to compare and analyse participant response. Termed, *Decision Making Attributes Assessment*, the framework, which was tested, using a questionnaire survey, attempted to integrate the theoretical concepts from the literature review with results from the practice of using SNA (Barrett and Stanley, 1999). In essence, these attributes provide the framework for assessment of this model of the project inception stage.

The final list of forty-one attributes in all six categories is summarised in Table 2.

Decision-Making Attributes Framework	
A. MANAGEMENT COMMITMENT (STRATEGIC)	**B. STAKEHOLDER PARTICIPATION**
A1.Searching/aspiring to highest possible quality decision	B1.Involvement by all potential internal representatives
A2. Support for process by senior management	B2. Involvement by all potential external representatives
A3.Ongoing commitment to workshop decisions	B3. Stakeholder commitment to process
A4. Support by capital works (assets) division	B4. Significant contributions
A5. Involvement by senior management	
C. GROUP DYNAMICS	**D. WORKSHOP ORGANISATION**
C1. Honesty (not role playing)	D1. Aim adequately defined
C2. Suspension of political agendas	D2. Process defined followed
C3. Shared vision	D3. Participation encouraged
C4. Levels of consensus	D4. Level of manipulation
C5. Success at generating ideas, new approaches	D5. A learning experience
C6. Working as a team	D6. Challenge assumptions
C7. Extent of participation	D7. Client/customer focused
	D8. Earnest organisation
	D9. Willingness to use all tools
	D10. Aim achieved
E. TOOLS	**F. PROCESS (PROBLEM-SOLVING)**
E1. Level of acceptance generally	F1. Quality of information provided
E2. Ease of understanding criteria	F2. Awareness of participants of problem context
E3. Ease of using software	F3. Problem defined
E4. Understanding output	F4. Problem discussed
E5. Contribution to personal understanding	F5. Options generated
E6. Contribution to decision	F6. Clear decision made
	F7. Decision agreed
	F8. Decision supported
	F9. Decision implemented

Table 2 Categories And Decision Making Attributes

Analysis of the survey was carried out using the SPSS statistical software package. A number of significant correlations (5) were identified between theory/practice scores, but no inferences could be clearly made from them. A larger number of significant correlations (16) were identified between theory/theory and practice/practice of attributes probably pointing towards an overlap in the attribute(s).

A regression analysis of theory scores compared with the equivalent practice scores was made. The attributes were then ranked (1 to 41) where attributes with the closest alignment between theory and practice scores (1.00 or lower) were ranked higher than attributes where the theory and practice scores were higher (over 1.00). The full list of rankings on this basis are given in Table 3.

ATTRIBUTES (1-41)	Practice/Forecast		Practice	Theory
	Index	Ranking	Ranking	Ranking
D2. The process defined must be followed	1.12	1	8	36
E6. Use of the tools must contribute to decision	1.13	=2	32	40
F5. Options generated must be realistic	1.13	=2	4	22
F4. Problem must be discussed adequately	1.14	4	16	=7
F2. Participants must be aware of problem context	1.19	5	=9	=7
D5. It should be a positive learning experience	1.20	6	11	30
B2. Involvement by all external representatives	1.21	7	=35	40
E5. Activities/ process contribute to understanding	1.23	8	=15	31
D8. Competent organization of workshops essential	1.25	9	1	7
D3. Broad participation should be encouraged	1.26	10	=5	=19
D4. There must be low levels of manipulation	1.28	=11	=31	37
F3. Problem must be properly defined	1.28	=11	7	=1
D10. Basic aim must be achieved by process	1.30	13	=13	26
F7. Important decision is agreed by participants	1.31	14	=27	=33
C3. Agreement on a shared vision is essential	1.33	15	=31	36
E3. Tools (software) must be easy to use	1.34	16	=15	12
C5. The group should generate new ideas	1.37	17	2	=5
D9. Participants must be willing to use all tools	1.41	=18	=21	27
E4. Understanding of output is essential	1.41	=18	=10	16
F6. Clear decision on final direction must be made	1.41	=18	=27	=28
E2. Easy understanding of criteria for assessment	1.43	21	19	25
C4. Reaching a high level of consensus important	1.46	22	=27	=28
D6. Participants must challenge some assumptions	1.49	23	=13	=14
C6. Participants should work effectively as a team	1.50	24	=21	24
D7. There must be clear client/customer focus	1.51	25	=21	=19
A5. Involvement by senior management	1.52	=26	=21	=19
C1. Honesty (not role playing) is important	1.53	=26	38	32
C2. Participants should suspend political agendas	1.53	28	40	=38
B1. Involvement by all internal representatives	1.56	29	12	=9
A4 Support by capital works division	1.61	=30	30	=19
B4. The opportunity for significant contributions	1.61	=30	=15	=9
F9. Decision must be implemented	1.63	32	41	=38
F1. Information provided must be appropriate	1.65	33	=3	=5
D1. Aim should be clearly defined	1.70	34	=5	3
F8. Decision must be supported by participants	1.75	35	=33	=17
B3. Stakeholder commitment to process	1.77	=36	=25	=9
C7. Extent of participation should be broad	1.77	=36	=25	=9
A3. Ongoing commitment to workshop decisions	2.02	38	39	=17
A1. Searching for highest quality decision	2.03	39	20	=1
A2. Support for the process by senior management	2.27	40	=35	4
E1. High level of acceptance of tools in process	2.32	41	=35	=33

Table 3 Best Fit for Practice/Forecast Performance Rankings

2.1 Best Performing Attributes

The top ten attributes (24% of the total 41 attributes) placed in their categories are shown in Table 4. The order of ranking on the theory/practice performance scale are shown in brackets in column 2. The proportion of attributes in each category in this top ten listing are also shown in column 3 of the table. By classifying these attributes a good impression is gained of the categories of the SNA that appear to be working effectively.

CATEGORY	ATTRIBUTE	No. out of Total in Category
A. MANAGERIAL COMMITMENT	NONE	0 of 5 (0%)
B. STAKEHOLDER PARTICIPATION	B2. Involvement by all external representatives (7)	1 of 4 (25%)
C. GROUP DYNAMICS	NONE	0 of 7 (0%)
D. WORKSHOP ORGANISATION	D2. The process defined must be followed (1) D5. It should be a positive learning experience (6) D8. Competent organization of workshops essential (9) D3. Broad participation should be encouraged (10)	4 of 10 (40%)
E. TOOLS	E6. Use of the tools must contribute to decision (2) E5. Activities/ process contribute to understanding (8)	2 of 6 (33%)
F. PROCESS	F5. Options generated must be realistic (3) F4. Problem must be discussed adequately (4) F2. Participants must be aware of problem context (5)	3 of 9 (33%)

Table 4 The Top Ten Practice/Forecast Attributes in Categories

An interesting feature of this analysis is that none of the attributes in *Management Commitment* or *Group Dynamics* is included in these top performing attributes.

In contrast, the eight clearly poorly performing attributes on the same theory/practice scale are shown in Table 5. Similarly, their rank in the 41 attributes is shown in column 2 in brackets.

CATEGORY	ATTRIBUTE	No. / Total
A. MANAGERIAL COMMITMENT	A3. Ongoing commitment to workshop decisions (38) A1. Searching for highest quality decision (39) A2. Support for the process by senior management (40)	3 of 5 (60%)
B. STAKEHOLDER PARTICIPATION	B3. Stakeholder commitment to process (36)	1 of 4 (25%)
C. GROUP DYNAMICS	C7. Extent of participation should be broad (37)	1 of 7 (14%)
D. WORKSHOP ORGANISATION	D1. Aim should be clearly defined (34)	1 of 10 (10%)
E. TOOLS	E1. High level of acceptance of tools in process (41)	1 of 6 (17%)
F. PROCESS	F8. Decision must be supported by participants (35)	1 of 9 (11%)

Table 5 The Poorest Performing Practice/Forecast Attributes in Categories

The major negative category in terms of better performance in SNA is concerned with 'Managerial Commitment' (See Table 4 above). Whilst all the other categories have one attribute on the poor performing list, the 'Managerial Commitment' category fares the worst. In addition, from the survey and participant observation, there are some features of SNA that need reinforcing or require more determined implementation, such as the 'Information Seminar'. The other feature that participants noted as making a positive contribution to 'Stakeholder Participation' and 'Group Dynamics' is the introduction of small group(s) options development teams into workshop one and accepting that this change extends this workshop by an additional half or full day.

The other feature that was recognised particularly in the final case study (Council) was the structuring of the options by the introduction of the purpose-designed software, *Situation Structuring*.

When these features are added to our basic model illustrated in Figure 1 the SNA process now takes on a structure represented in Figure 2 below. The formal addition of the 'Information Seminar' is made to the structure; the small group options development is introduced into workshop one, as is the discretionary use of the *Situation Structuring* software (Dickey, 1995) to assist in the activity of options identification.

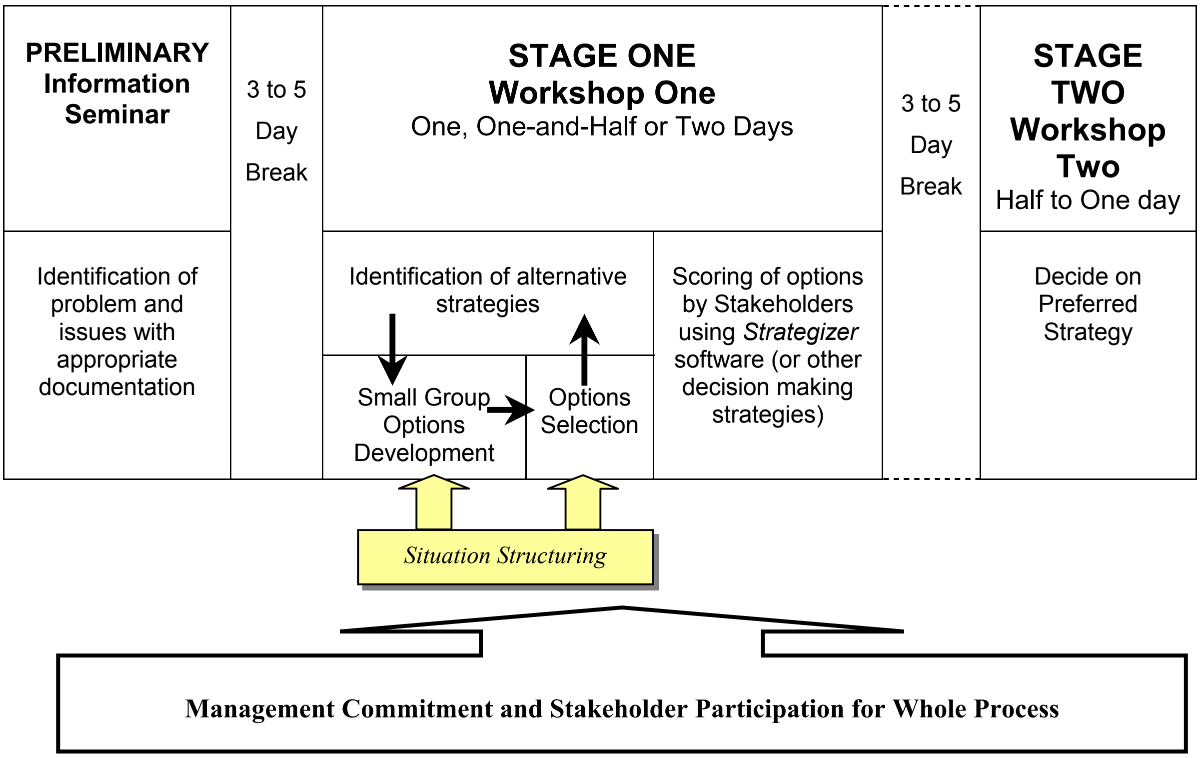

Figure 2 Restructured SNA Process

3.0 Practice Implications

However, the process cannot properly succeed unless it is sustained by a climate within the organisation that supports a strategic culture and environment that continually demands better ways of providing its core business and related activities. If the organisation is not prepared to adopt a strategic management approach linked with corporate strategy where it aims to continually improve its performance then this process is not likely to succeed. A characteristic of this strategic approach is that the organisation creatively questions and justifies its own activities at the most fundamental level. The organisation must not complacently accept that the historical way of providing services need necessarily be projected indefinitely into the future. As a consequence, a problem-solving approach combined with a demanding strategic management environment inherently involves a greater number of people (*stakeholders*) in the decision-making process and it encourages and rewards alternative solutions and methods of problem solving that are more effective.

For over two decades clients and design teams have recognised that it is during the early stages in the life of a project where most of the critical decisions are made. However, progress towards greater involvement in this stage by the various built environment disciplines has been substantial. Lack of client may be one of the major reasons why this has not occurred, but another reason may be the absence of suitable tools, techniques and approaches to assist the client team during these strategic stages of decision-making. This research proposes one methodology to enable clients, stakeholders and their design team advisers to work together. Clients need to be made aware of such approaches and it is only through use and practice that these approaches will become accepted as common practice. So, clients, project managers and design team members should work more closely to ensure that good advice is available at the project inception stages.

In parallel to these client based activities and awareness programs, the professional bodies in the built environment (architects, engineers, project managers, urban planners, facilities managers, property advisers) should identify and target project inception and the decision to build for greater definition than they presently have in their standard 'Plans of Work'. That is, decision point(s) and time lines and the potential participants should be identified, together with a recommendation about the possible techniques and approaches that could be adopted. An initial awareness program may bring this stage to the attention of clients and peak industry bodies (such as the Property Council of Australia or British Property Federation) should be encouraged to make its members aware of this stage and the assistance that can be enlisted from various sources.

However, as this research has shown, the commitment of the client group through its senior management is the critical factor in achieving a successful outcome. None of the many techniques or initiatives being developed can succeed without honest client support, commitment and interest.

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Systematic procedure for setting building flexibility targets

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Abstract: *The aim of the research was to determine: Which factors can be used to affect the flexibility of a building? How should flexibility be taken into account in decision-making concerning construction projects? In the presented method of setting flexibility goals, the modifiable flexible spaces are defined first. It is essential that project-specific flexibility goals be set for modifiable spaces, for instance, with respect to divisibility into separate rental units and flexibility of the space program. The base building is dimensioned on the basis of the definition of modifiable spaces. It includes dimensioning of the permanent frame section and permanent building services. The infill of the building's modifiable spaces is determined at later stages of the building project as the occupancies of the spaces are "fixed". The infill of various sections of the building may be attached one at a time as the project advances. In order to remain within the budget of the building project, it is important that financing is based on the most expensive combination within the limits of flexibility. The presented method suits both new construction and refurbishment.*

Keywords: Building, Programming, Flexibility, New construction, Refurbishment

Introduction

The Dutch pioneers of open building, John Habraken and Age van Randen, have since the 1960s developed the idea of dividing a building into a permanent support and a modifiable infill section. They thought of breaking up residential building construction into two independent processes. The task of the support, which is the permanent section of a building, is to provide space protected from the elements. It can be divided into individual units—of varying sizes in the ideal case—so that fluctuations in demand can be met now and in the future. The permanent support incorporates all common systems such as entrances, stair wells, lifts as well as the fixed parts of electrical, water, gas, etc. systems up to the ”front door” of each space unit. The modifiable infill serves individual spaces by providing building services, partition walls, doors, equipment, kitchen and sanitary fixtures, internal surfaces, etc. The service life of the permanent support is long compared to the modifiable infill (van Randen 1996).

The basic principle of open building is to find ways of dividing and combining subsystems so that their interdependencies are minimized. (see Fig. 1). Application of this principle allows efficient buildings as well as redesigning or renewing a subsystem to correspond to different features without redesigning and renewing the entire system (Decker & Kendall 1996).

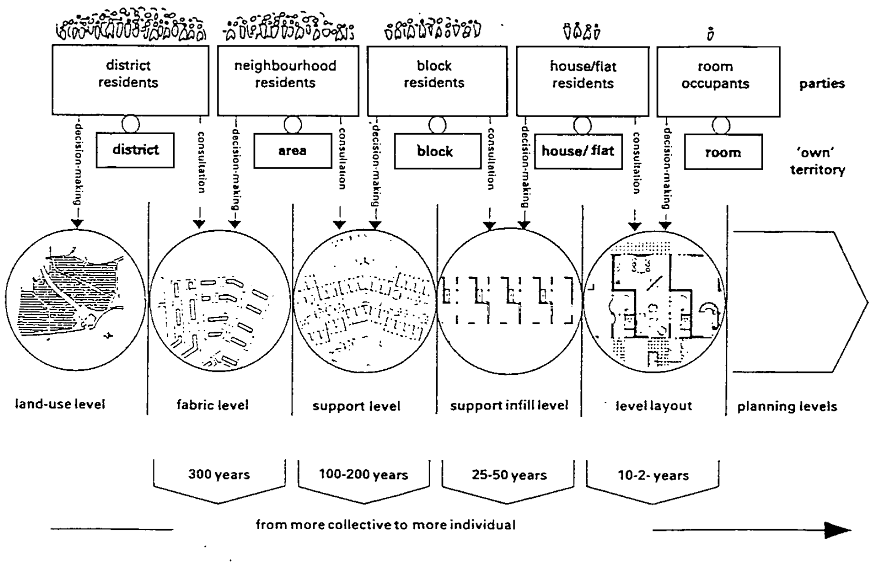

Figure1. Decision-making levels in open building (Source: Decker&Kendall 1996).

Francis Duffy and John Worthington have also emphasized that the different service lives of various parts of an office building must be considered. Already in 1972 they introduced the ”shell-scenery-set” scheme which depicts the differentiation of building sections that perform differently time-wise. The most durable parts of a building such as columns, beams, foundations, roofs and bearing walls are structural. Consequently, they are difficult to replace or redesign and rebuild. These structural components determine the location of other building parts. Thus, they must be designed so as to enable different mechanical systems and space arrangements in the future. The shortest-lived parts of a building, again, must be such that office workers themselves can control and alter them which promotes individuality and creativity.

Steward Brand developed the stratification idea of the building further. He divides the building into the following parts: site, structure, skin, services, space plan, and stuff.

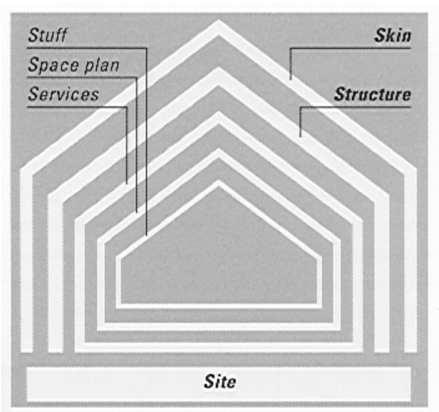

Figure 2. Building stratification by Steward Brand. Source: Duffy 1997.

In the United States and Canada, the building has been divided into three parts in office and commercial construction for at least two decades (Kendall 1996): the base building, interior construction and furnishing, fixtures and equipment.

Base buildings are designed and constructed without a space plan based on various tenants or considering furnishing, fixtures and equipment. As soon as a unit has been sold or rented, it is adapted to the user's needs. Later on, individual units are adapted to the needs of new users causing as little disturbance to other tenants as possible. In the above-mentioned countries the entire process of building and renting office and commercial space has been adapted to the described plan.

This paper presents a procedure which allows setting targets for the flexibility of buildings at the project programming phase.

Flexibility of building

User's viewpoint

The important factors from the viewpoint of users affecting flexibility are:

- Spaciousness (e. g. space per capita)
- space plan of rental unit and ease of its modification
- air change rates, cooling capacity, lighting capacity, etc.
- available common spaces and services.

The users of a rental unit are interested, especially, in the *operative use flexibility* of the unit and its facilities, which indicates how well the unit adapts to the changing needs of the user. Needs may change at intervals of a few years or, in extreme cases, of just minutes. The use flexibility of a space or unit can be affected by its universal applicability as well as its modifiability. Use flexibility is especially important to the users of a space.

Owner's viewpoint

The following features of buildings are the least adaptable to change:

- available room height
- horizontal openness of bearing frame
- load-bearing capacity of building frame
- layout and capacity of vertical traffic routes (stair wells, lift shafts, mechanical shafts and ducts).

Of course, the mentioned features of an existing building can be altered, but the related costs are extremely high. If we design a more spacious building with regard to the mentioned features, the building will be more adaptable to presently unknown occupancies.

Strategic flexibility describes how well a building adapts to possible changes after years. Such changes are required, for instance, by changes in the operations of space users, new users of spaces, a general change in the nature of work, and structural change of society.

Strategic flexibility is an important feature for the building owner who must consider, already at the investment phase, whether to invest in a more expensive and more flexible alternative. After all, the option purchased at a high price may turn out to be an unprofitable investment (no change occurs, or the change is completely different than expected). It is also possible that if the cheaper and less flexible solution was chosen, the costs (NPV) from the change are essentially larger than the price of the option.

Differences between new construction and refurbishment

In refurbishment, the starting point is an existing building of a certain shape, number of floors, frame depth, floor height, stair well system, frame system, and space plan. Thus, the building can be highly unadaptable to major changes at present and over its coming life span. It is easier to increase operative use flexibility than strategic flexibility, which the owner values more, when refurbishing existing buildings.

In new construction projects the same constraints do not apply. The strategic-flexibility features are more freely selectable than in refurbishment.

Consideration of the change cycle

Demands on buildings change over time. The demands can be met in two ways, either by:

1. altering the building physically as requirements change, or
2. by incorporating in the building versatile or universal features.

In the first instance, the costs of the change are incurred at the time the change takes place. In the second instance, hardly any costs are incurred as the need changes—the costs were incurred already at the construction phase in preparation for possible future changes.

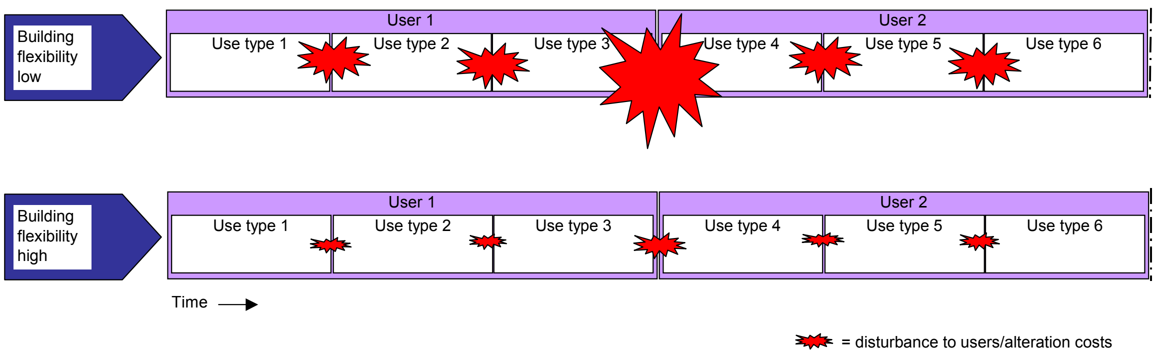

Figure 3. Investments to building flexibility decrease disturbance and alteration costs.

The cycle of change determines largely which method is more advantageous. If the cycle is long, tens of years, it is generally more economical to choose the cheaper, less adaptable option (e.g. a fixed board partition). Should the cycle be essentially shorter (a few years), the more flexible option is generally better justified (a demountable and reinstallable system wall). In the case of an extremely short cycle of a month or maybe a few hours, an essentially more flexible solution is called for (e.g. a wall that slides on tracks).

Setting of flexibility targets for a building

The programming of a building project is done at an early phase before building designs are drawn and work commences. In programming, the quantitative, qualitative, financial, and time-wise targets of the building project are set.

In order to program flexibility into the project, one must establish what kind of spatial flexibility is required of the building. Flexibility may be needed due to the fact that the users of the building are not known (construction-phase flexibility) or to allow for changes in building occupancy over its life cycle (life time flexibility).

Users of buildings are primarily interested in the spaces and their features. Thus, we should determine what kinds of spatial features a building must be able to offer immediately on its completion as well as over its life cycle. Therefore, programming starts with setting of *spatial flexibility requirements.*

The highly unadaptable parts of a building such as the bearing frame and technical routings limit changes. Thus, it is important to set *flexibility* targets already at the programming phase for the *base building* composed of the permanent parts.

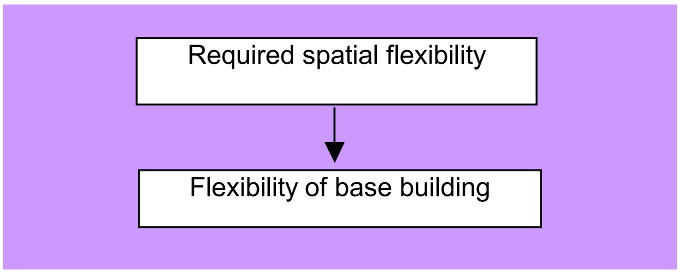

Figure 4. Programming starts with setting of spatial flexibility requirements. It is important to set flexibility targets already at the programming phase for the base building composed of the permanent parts.

Required spatial flexibility

In order to be able to define and dimension the base building, the limits of the features of the modifiable spaces must be defined.

The modifiable spaces consists of those building spaces whose occupancy or use may change. Changes may take place during the building process or the use of the building. The infill of the modifiable spaces of the building is ”fixed” at a later stage of the building project when the occupancies of spaces are finalized.

The following features of modifiable spaces are established:

Divisibility into units:
Number, size, limits, and independence of units.
Example: One should be prepared for the fact that the building may be divided into rental units of about 200 m^2 or its multiples. Walls between units cannot be bearing. The requirements apply to flexibility during construction and building use. The units must be independent. Each one must have its own entrance with a lockable door.

Space programme flexibility:
Space designations, no. of spaces, and their features
Example:

office rooms	300-1,600 m^2	/ea. 10-20 m^2 /	20-150 people
open-plan office space	0-1,000m^2	/	0-125 people
conference rooms	100-200 m^2		
close-by storage space	200-400 m^2		
toilet facilities	0-40 m^2		
total (max)	2,600 m^2		

Indoor air quality requirement class is S2. If the toilet facilities are not implemented, water and drain pipes are nevertheless laid up to the space in question. Otherwise, space requirements will become more specified as the users of spaces become known.

Permanent spaces:
Some spaces of the building need not be modifiable or are so specialized that it is not worth making them flexible.
Example:

car park	420	m^2
lobby	100	
auditorium	100	
toilets	30	
service space	60	
stair wells	130	
corridors	260	
mechanical room	200	
other mechanical space	40	
civil defence shelter	60	
Total	1,400	m^2

Flexibility of base building

The base building incorporates all the physical building parts that need not be changed or altered even if anticipated changes take place during construction and use.

The definition and dimensioning of the base building involves:

Available room height:
Example: Clear height of modifiable spaces must be at least 3.5 m. Clear height is measured from the floor surface to the underside of a bearing structure in the ceiling of the space.

Horizontal openness of bearing frame:
Example: The target gross area of the building is 4,500 m^2. It must be possible to expand the building in at least one direction (+50 %). The span of the building frame must be at least 9 m. Modifiable

spaces must not incorporate bearing partitions. Facade fenestration must accommodate different combinations of modifiable spaces.

Load-bearing capacity of building frame:
Example: Building frame must withstand a floor load of at least 5 kN/m^2.

Flexibility of technical routings:
Example: The vertical routings of the building's technical systems must be dimensioned according to maximum capacity + 50 %, and the horizontal routings are to be dimensioned according to maximum capacity +25 %..

Flexibility of technical systems:
Example: The building's max. design value for ventilation is 10.5 m^3/s and the min. value 9.5.m^3/s. The vertical and horizontal main air distribution ducts and ventilation equipment are to be dimensioned according to the max. values.

Budgeting the building project

In order to be able to prepare a sound financing plan for the project, a ceiling for the construction costs must be set. The ceiling is determined by including the most expensive modifiable infill in the budget. The budget is broken down into support and infill parts. The infill budget is revised as more is learned about the users of the building.

Example: The ceiling price for construction costs is €6.5 million euros. Project financing is based on the ceiling price. The base building's share of the ceiling price is €3.6 million which also constitutes the budget of the base building. The share of infill is €2.5-2.9 million. The infill budget is revised as the occupancy of the spaces becomes known. The ceiling price for the infill is €2.9 million.

Summary

The target setting procedure for flexibility of buildings defines initially the modifiable spaces. The essential feature is that flexibility targets for spaces are project-specific, for instance, with respect to divisibility into units and flexibility of the space programme. The base building is defined on the basis of the modifiable spaces. The infill of the modifiable spaces of the building is determined during later stages of the building project as the occupancies of spaces are finalized. The infills of various building parts can become attached piecemeal as the project proceeds. To ensure that the project stays within budget, the financing should be based on the most expensive combination within the limits of flexibility. The procedure is applicable to both new construction and refurbishment.

The presented method of programming building flexibility needs to be tested in pilot projects.

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Consolidating FM Knowledge

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Abstract: *This paper proposes that in order to consolidate high quality FM knowledge it is necessary to describe what constitutes FM knowledge. The paper describes the research methodology being developed to consider the development of FM knowledge in a local environment, Australia. The knowledge associated with FM in Australia reflects a particular approach to the profession. It is assumed this approach has elements in common with FM practice in countries around the world. However, there are local differences: the quest to globalise standard FM practices should consider these. The research methodology uses the current national standards, that is, FM competencies as a means of organising topics. The paper concludes by considering the need for a common benchmark for global FM knowledge.*

Keywords: *Facility management, knowledge, competency, research, discourse analysis*

Introduction

Background to the research

> *"Although the facility management profession has been in existence since the evolution of the office, only in recent years has it received worldwide recognition. Business entities have come to realise that maintaining a well managed and highly efficient facility is critical to success. New technologies, environmental consciousness and health concerns also have had a major impact on the importance of and need for facility professionals in organisations."*
> *(IFMA 1999a)*

Facilities management is an emerging professional discipline that derives from practice (Rondeau 1995). Because of this, there is considerable variation in the concepts of facility management practice (Alexander 1998, Park 1998, Rondeau 1995). There is variation in the approaches to facility management: strategic (Alexander 1998) and tactical or operational (Park 1998, Rondeau 1995). Further discussion has taken place regarding the concept of facility management as a profession and as an academic field (van Wagenburg 1997).

The field of facility management includes an organisational focus (Becker 1990), a facility planning focus (Brauer et al 1992, Duffy 1993/1997), an operational focus (Preiser 1988) and a maintenance focus (Brown 1996). Consequently facility managers require wide-ranging knowledge to solve a multitude of complex problems.

Associated areas which have been identified with facility management include facility briefing (Barrett 1995), environmental quality (Vischer 1989), human resource issues (Raymond 1998), strategic facility management (Binder 1992), post-occupancy evaluation (Kernouhan 1996), and property (McLennan 1999).

Facility management is an internationally practiced profession as demonstrated by the development of professional associations in the USA (IFMA), UK (BIFM), Netherlands (FMN), Australia (FMA) and Japan (JFMA). Facility management organisations delivering FM services (in Australia: Johnson Controls, Tungsten, Jones Lang la Salle, Tyco) practice internationally reflecting global business trends. New companies such as Citex (in the UK) and Multiplex Asset Management (Australia) are being formed to deliver facility management services, complementing the facility management services provided by established providers in Australia such as Haden FM (now Tyco) and Serco. Major organisations in Australia have their own facility managers (including Reserve Bank, Mayne Nickless, Optus, Vodafone, Arthur Andersen, Toyota, Deutsche Bank, American Express).

Within each of these organisations the job responsibilities vary hugely across major functional areas. As organisations become global in their FM practice the need to describe or define the FM knowledge required to implement these job responsibilities emerges. More recently, the very need for the FM profession is being challenged (Price 2002) so the need to understand what it is and how it differs from other professions is critical.

The research questions

The research project is an ongoing project that focuses on establishing the range of knowledge variables in considering the quality of provision of facilities management services to corporations.

The key research question for the first element of the research project is:
- what do facility managers need to know to support corporations through provision of facility management services *i.e. content*

To examine what it is that facilities managers need to know, one can consider for example, the following:
- the constitution of facilities management knowledge in a local environment such as Australia and hence,
- the set of elements that constitute the body of knowledge.

This paper describes the research methodology used to investigate how FM knowledge is constituted in a local environment and some preliminary findings that raise questions regarding the breadth of knowledge required by the FM profession.

To test the issue of the breadth of knowledge and to examine its relevance, in the ongoing project, the next stage of the research will ask:
- how is facility management implemented in practice *i.e. context,* and
- how does facility management add value to corporations (performance measurement?) *i.e. effectiveness.*

The subsequent stages of the research will need to review implementation of FM in practice and to consider:
- the relevance of this knowledge for facilities managers

The final objective of the research will investigate the effectiveness of facility managers by examining any link between the established body of FM knowledge and its relevance to practice. This may then establish the need for and position of the FM profession.

FM knowledge

Context for the methodology

The research methodology considers the FM discourse of the conference proceedings in terms of context, content and source (Graham 2000a). These issues evolve from discourse analysis methodology (van Dijk 1985). Discourse analysis considers language, cognition, interaction, society and culture and is a means of considering and uncovering social practices. It is being used extensively to consider practices in disciplines outside linguistics to consider particular discourse for example in the professions (Di Pietro 1982, Parker 1999).

The key concerns are the context in which the discourse is presented, the content and the source of the discourse. *Context* takes into consideration conference location and theme: this suggests preoccupations of the FM profession at a point in time. Considering *content* enables the topics of interest to be mapped and so develop a classification or field of FM knowledge. By considering topics it is potentially possible to consider changes over time, in response to growing familiarity with the concept of FM and also in terms of importance of the topic to the FM profession for example by measuring frequency of mention.

The third research issue is that of the *source* of the discourse. At local conferences such as those in Australia, the presence of overseas presenters can be assumed to reflect global preoccupations in FM. Local presenters reflect current FM concerns. The source of the discourse must have a qualification to inform, for example, by membership in an FM association, or by their experience in FM as a practitioner or service provider, or expertise in an area relevant to FM. It could be assumed that an invitation to present suggests that the source (presenter) is both valid and legitimate, that is relevant to the knowledge discipline.

Research outcomes

Expected outcomes of this research are:
- the mapping of topics by time and theme

(This should suggest both the relevance of a topic and the degree of interest over time),
- the development of categories of knowledge.

(This categorisation may support or challenge the boundaries of FM knowledge established by systems of classification such as competency and so direct future amendment), and
- the identification of appropriate sources of discourse

(The qualification of the source to inform)

A local FM environment – local discourse

The research takes as a starting point the development of FM knowledge in Australia. The formal FM discourse is constituted by the proceedings of the Facility Management Association in Australia (FMA) annual conferences. The conferences began in 1989 and were the first recordings of facility management discussion and interest in Australia. In 1992, the first FM academic programmes commenced at the University of Melbourne and the University of Sydney. In 1993, the FM magazine was launched, published commercially and in association with FMA. Commercial conference programmes in FM have been offered by organisations such as IIR Pty Ltd (Graham 1998a/2000) and IBC Conferences Pty Ltd (Graham 1996-2000).

Mapping FM knowledge

The conference themes (see Table 1) address the position that FMA seeks to establish in terms of the FM contribution to business performance for an organisation. The chosen themes reinforce strategic approaches taken by Alexander (1998), Duffy (1993/1997) and Becker (1990). Yet the topics of the keynote presentations are very focussed in scope.

Year	Conference theme	Keynote topic	Competency (FMA) alignment (by author)
1989	Not known	Not known	
1990	Not known	Not known	
1991	Not known	Responsible workplace	Improve facility performance
1992	Facilities Management means Business	Workplace transformation	Improve facility performance
1993	N/A	N/A	
1994	The competitive advantage	Workplace reform	Manage change
1995	Management of change	Office change	Manage change
1996	-	International management : The facility management challenge and the global response	Manage the delivery of services
1997	Networking+Solutions+ Practice= Global FM	Facilities Strategy: Oxymoron or Opportunity	Develop strategic facility response
1998	People and Technology	Mobility's infrastructure	Manage change
1999	The Business of Space	The Business of Space: developing facilities to carry out work in space	Use organisational understanding to manage facilities
2000	Ideaction: Challenging the Familiar	Key Facility Management Challenges of the New Economy	No match (no keyword matches)
2001	Ideaction: People Creating Value	Victoria!	No match (no keyword matches)
2002	Ideaction: Shaping the future	Communities and the Built Environment	No match (no keyword matches)

Table 1 Topic of keynote presentations

The themes can be mapped over time demonstrating the range of issues identified as of interest to FM. The research is seeking to establish that the focus of the discourse changes over time. The table shows a development from recognising the need to improve facility performance, through management of change and finally reference to the organisation as a whole from a strategic perspective, to more recently looking beyond the FM profession in particular to the general business economy.

However, Table 1 also shows that for keynote presentations the topic has changed but by aligning topics with competencies, the degree of change is not significant – the category of knowledge seems less changing. The keynote presentations 1991-1995 focus strongly on workplace change and reform – a facility planning position. The remaining keynote presentations suggest a shift to a strategic position that aligns strongly with the business and economic values. The keynote presentations were all made by overseas (USA and UK) presenters, and include those with strong links to overseas FM organisations and those who have written the established text discourse.

So are topics consistently repeated because there is new information, for example from practice or because of increasing experience? Or is it that some topics are seductive for conference presentations – because clearly FM operations topics (Rondeau 1995) might seem dry – yet the bulk of FM is in providing operational services (a FMA 1999).

1991 Conference topics	**Competency (FMA) alignment (by author)**	**2001 Conference topics**	**Competency (FMA) alignment (by FMA)**
Theme: not identified		*Theme: People creating value*	
**Responsible workplace*	*Improve facility performance*	Triple bottom line reporting	Manage financial performance
**Strategic planning*	*Develop strategic facility response*	Sydney airport	Develop a strategic facility response
Relocation	Manage change	Effective FM service delivery	Manage service delivery
Property management	Manage facility portfolio	Understanding & managing values	Manage service delivery
Cost benefits	Manage financial performance	**Facilitating work*	*Manage workplace relationships*
CAFM	Improve facility performance	Acoustics in the open-plan workplace	Improve facility performance
Energy outgoings	Manage financial performance	Pursuing a balance – setting a standard	Use organisational understanding to manage facilities
Cable management	Improve facility performance	People factor in workplace change	Manage change
Institutions	Use organisational understanding to manage facilities	Engineers in East Timor	Develop a strategic facility response
Strategy	Develop a strategic facility response	A regional focus – Amex FM	Develop a strategic facility response
**Value of services*	*Manage the delivery of services*	Keeping your best staff	Manage workplace relationships
**Building appraisal*	*Improve facility performance*	PFI project and FM	Manage projects
		Risk management	Manage risk
		Balanced workplace	Improve facility performance
		Internal benchmarking	
		**Workplace of the future*	*Improve facility performance*
		Asset management systems	Manage financial performance
** Overseas presenter*		Cost control	Manage financial performance

Table 2: Conference topics

Table 2 shows the particular topics presented in two different years and suggests that boundaries of FM are more fluid and are continuously developing. It becomes apparent that within each conference there has been opportunity to examine particular issues of a more ‘hands-on’ nature. The local presenters have particularly addressed case studies and practice experience.

The topics addressed in 1991 do align with the competencies established in 2000 (Figure 1) – which suggests that the categories of knowledge established by the competencies reflect general concerns about what facility managers should know.

Conferences 1989-1999 ➡ Accreditation ➡ Conferences 2000-2002

Figure 1: Establishment of accreditation system in Australia

Equally the topics raised in 2001 show that elements such as service delivery and risk have increased in importance. This perhaps demonstrates a better understanding of the role of the facility manager providing service within organisations or to organisations. The workplace appears to be the most talked about topic – rather than the practices supporting it! *By aligning topics to competency areas the body of knowledge required to demonstrate competency can be developed.*

Globalising FM knowledge

FM Competencies

Defining what facility managers need to know is critical: hence the development of certification/recognition/accreditation systems based on competency. Competency requires that an overview of the profession and knowledge be undertaken. Elements of competence integrate knowledge, skills, attitude and other important attributes associated with an identifiable aspect of professional performance.

<table>
<tr><th>IFMA (USA)</th><th>BIFM (UK)</th><th>FMA (AUSTRALIA)</th><th></th></tr>
<tr><td>Operations and maintenance</td><td>Understanding business organisation</td><td>Use organisational understanding to manage facilities</td><td rowspan="6">AFM1</td></tr>
<tr><td>Real estate</td><td>Managing people</td><td>Manage the delivery of services</td></tr>
<tr><td>Human and environmental factors</td><td>Managing premises</td><td>Arrange and implement procurement/sourcing</td></tr>
<tr><td>Planning and project management</td><td>Managing services</td><td>Manage projects</td></tr>
<tr><td>Facility function</td><td>Managing the working environment</td><td>Improve facility performance</td></tr>
<tr><td>Finance</td><td>Managing resources</td><td>Manage risk</td></tr>
<tr><td>Quality assessment and innovation</td><td></td><td>Manage financial performance</td><td>AFM2</td></tr>
<tr><td>Communication.</td><td></td><td>Manage change</td><td rowspan="5">AFM3</td></tr>
<tr><td></td><td></td><td>Develop strategic facility response</td></tr>
<tr><td></td><td></td><td>Manage facility portfolio</td></tr>
<tr><td></td><td></td><td>Facilitate communication</td></tr>
<tr><td></td><td></td><td>Manage workplace relationships</td></tr>
</table>

Table 3: Global competency frameworks (bIFMA 1999/cBifm 1999/FMA 2000)

Table 3 sets out the established competencies for three professional FM organisations in the USA, UK and Australia. There are differences in approach: the IFMA (USA) certification process identifies areas of knowledge; the BIFM (UK) system identifies activities and the FMA (Australia) system identifies competencies that FMers should be able to do. The FMA system also recognises that FMers work at different levels of responsibility (practice, manage, lead) and hence have different degrees of knowledge and proposes a three tier system of accreditation (AFM 1-3), encouraging lifelong learning.

This comparison suggests that there are elements in common: for example, real estate (IFMA) and facility portfolio (FMA); managing people (BIFM) and managing workplace relationships (FMA). The elements of service delivery and business organisation (BIFM/FMA) are not obviously aligned with the IFMA categories. This suggests that to achieve alignment between competencies and underpinning knowledge globally requires further analysis of keywords to uncover priorities. It may also suggest that there are local differences in how facility management is defined.

The need for a common FM knowledge framework

The local differences in the FM profession should be clearly articulated and considered. If FM is a profession practised globally, then recognition of competency is necessary to facilitate for example, employment. This is an accepted practice in other professional areas such as architecture and medicine that require local registration. While not suggesting that all FM terminology should be the same, it is evident that some alignment of FM knowledge into commonly accepted categories would be advantageous. This could firmly establish the FM profession and subsequently enable opportunities for specialisation by FM practitioners.

Conclusion

FM topics can be mapped by time and theme – further research using qualitative text analysis is required to map at a finer level of keyword to investigate intersections between topics presented and establish the degree of interest in these topics. The common elements between topics and their supporting material can be considered with respect to categories of knowledge such as those defined by competency areas.

The significance of topic and time is in future reviews of competency systems – the knowledge required by facility managers may change to meet the demands of a changing profession. This raises concerns about the boundaries of FM knowledge and the degree to which professional knowledge can be limited.

The presence of overseas presenters of discourse is critical in globalising the FM experience at a local level. The common elements of concern for FMers are highlighted - and given credence by local presentations that demonstrate the impact of the common elements on local FM practice. It is these common elements that need definition and alignment through a competency alignment framework. Indeed these suggest a starting point for consolidating FM knowledge.

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An Integrated Life Cycle Costing Database: System Proposal and Methodology

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Abstract
Life Cycle Costing (LCC) techniques are being used across a wide range of projects across different industries and have attracted considerable attention. However, LCC techniques are not widely used within the construction industry because of problems associated with LCC related processes such as data capture, reliability and certainty. Recent technological developments will undoubtedly help in resolving some of the above problems associated with LCC techniques. Salford University together With Robert Gordon University have commenced a research project, which looks into the development of innovative systems that facilitates the implementation of LCC in various design and occupancy stages. To this effect, this paper outlines the research methodology associated with the development process of an integrated LCC database, data capturing mechanisms and associated limitations with the development process.

The proposed system on which this papeis based, attempts to overcome some of the limitations associated with the use of LCC and tries to develop mechanisms which will allow the user within a VR environment to navigate inside a building retrieving all information about the building components. By creating such systems, it tries to provide opportunities to take maximum advantage of using LCC techniques and related information through out the building life cycle. This proposed system will allow LCC data to be updated continuously and thus can be used as and “asset register”.

Life Cycle Costing? What does it mean?

With occupancy costs representing up to 70% of the total cost of a building over its life time (Flanagan, 1989), Life Cycle Costing (LCC) has become a valuable concept as the pre-occupation with capital expenditure has led to designs which do not offer the client best value for money in the long term.
There are a number of definitions for LCC. CRISP Performance Theme Group adopts the definition which implies LCC as: “ the systematic consideration of all relevant costs and revenues associated with the acquisition and ownership of an asset” (Clift & Bourke, 1998). For construction, this is expected to take into account capital or procurement costs such as initial construction or major refurbishment purchase or leasing, interest and feed and other associated recurring or occupancy costs.

LCC is further defined by British Standards (1997) as: “ the process of economic analysis to assess the total cost of acquisition and ownership of a product”. Kirk and Dell’Isola (1995) describe LCC as a “methodology to identify the significant costs associated with alternatives, add groups of cost by year, discount them back to a common base and finally to select the optimum cost alternative; tempering final selection with non-economic considerations”.

Background to the study

The technique of LCC is not new and methods which facilitate LCC forecasting had been available since 1970s. However, the barriers to adopting these methods were great and they included (Osbaldiston and Aouad,2001):

- The information necessary for such analyses was simply not available, or was inaccurate;
- The resources required to obtain this information, far outstripped any perceived financial gain;
- The uncertainty inherent in forecasting future financial trends, especially over a long period (up to 60 years) was deemed unacceptable;
- Capital costs and operating expenditure were met from different budgets often by different parties, offering no incentive on behalf of those responsible for construction to reduce subsequent costs-in-use. (Ferry and Flanagan, 1991);
- The exercise itself is expensive. Estimates of between 0.2% -0.5% of the project initial cost has been tendered for a professional analysis;
- The necessity to keep construction costs within prescribed budgetary constraints; and
- The failure of designers to visualise whole life issues and to understand the impact of their designs on operating and maintenance costs.

Consequently, predictions made using LCC methods were unreliable, leading to a general distrust in the technique (Bull, 1993). Over the years, research in this field (Garnett and Owen, 1995; Al-Hajj and Horner, 1998; CPN, 1998; Aouad et al, 1998) have attempted to address these and other related issues with a view to making LCC more acceptable to practitioners.

In this context, it is critical that designers are fully aware of the impact of their design decisions on the subsequent costs-in-use of a facility. This can be difficult since the information required to make these judgements such as maintenance and operating costs may be inaccurate or may not exist in a form, which the designer can easily interpret.

Enabling Visualisation of Life Cycle Costing using OSCON

In attempting to address some of the drawbacks of applying the LCC concept as identified above, possibility of using the technology, particularly Integrated Databases and Virtual Reality, has been explored (Greening and Edards, 1995; Sun, 1998; Aouad et al, 1994; Rezgui et al, 1996). This was partially achieved using the OSCON (Open Systems for Construction) database. OSCON (Aouad et al, 1997) is a set of integrated software, which includes CAD application, and will extend the Virtual Reality Interface to allow the visualisation of life cycle costs. This system was developed with the aim to ease and actively share construction information via a central project oriented project database.

The OSCON application currently supports the functions of design, estimating and planning by allowing these phases to effectively share information dynamically and intelligently. The linage of LCC analysis tool to OSCON will increase the functionality of the system, particularly the design element and will effectively extend the scope of the OSCON suite to the occupancy stage (Osbaldiston and Aouad, 2001).

System Proposal

As apposed to the uses, benefits and limitations of LCC applications identified above, this paper introduces development phases and data capturing methodologies of a system which is aiming at developing applications of whole LCC to facilitate flexible methods of predicting total LCC of construction assets and their components. Particular emphasis is given to discuss the issues associated with the development of the framework for data collection and recording appropriate for LCC analysis.

LCC and Integrated Environments

One of the main objectives of the proposed system is to minimise the effort required to perform the LCC analyses. It combines the integrated environment together with the LCC database. LCC database provides the LCC data where as the integrated environment provides other relevant information about the proposed building. An integrated LCC environment not only simplifies the LCC analysis process, but also provides the flexibility for better consideration of the factors that have an influence on the LCC of buildings. As integrated environment has knowledge on the building model, it provides more opportunities to link to LCC component into the integrated environment. The integrated LCC environment further assists on complication and storage of LCC data for different uses. Integrated environment with LCC database, act together in prviding the opportunity for automating the LCC calculations.

Outline of the System

It is well known that the benefits to be gained from a LCC analysis are maximised by applying the concepts as early as possible during the design phase of a construction project (Kirk and Dell'Isola, 1995). It is therefore critical that designers are fully aware of the impact of their design decisions on the subsequent costs-in-use of a facility. This can be difficult since the information required to make these judgements such as maintenance and operating costs may be inaccurate or may not exist in a form, which the designer can easily interpret. The problem designers have in visualising expenditure beyond the construction phase is also a critical one. It is well known that the benefits to be gained from a LCC analysis diminish significantly if it is applied only after the design has been agreed (Kirk and Dell'Isola, 1995, Al-Hajj and Aouad, 1999). Since LCC is essentially used to facilitate a choice between possible alternatives based on economic factors, it is important that this is seen as an integral part of the design phase, not simply an ad-hoc tool that can be used to justify any chosen design (Osbaldiston and Aouad, 2001).

This research, as indicated above, aims to provide designers and clients with a tool which will enable them to visualise the implications of their design decisions on the associated Life Cycle Costs. This tool will be based on the OSCON Integrated Database and will extend the Virtual Reality Interface to allow the visualisation of life cycle costs. Figure 1 shows the architecture of the existing suite and the proposed extensions:

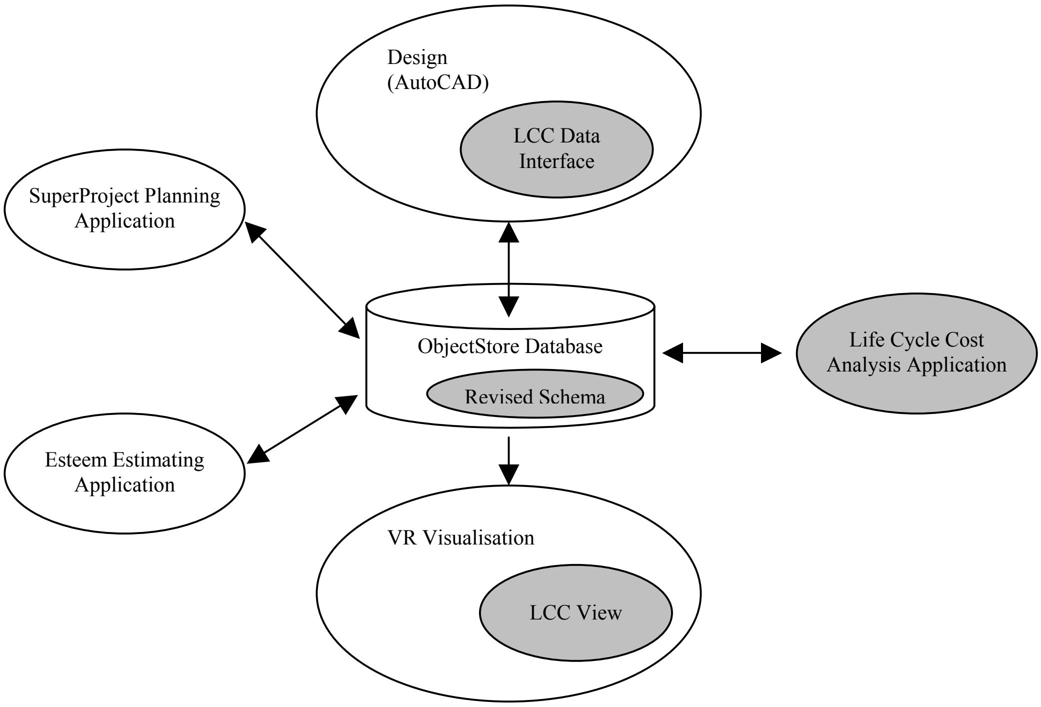


Figure 1 – OSCON Architecture and proposed extensions to accommodate LCC element (Osbaldiston and Aouad, 2001)

Development of the LCC database

A comprehensive literature review was undertaken in the areas of LCC, Integrated Construction Environments and VR visualisation. This has led to the identification of the most appropriate methodologies and technologies for use during the project. The review of the literature included an in-depth examination of the material relating to current LCC applications in general, issues relating to database development and in its IT related applications in particular. The literature review revealed the established and generally accepted facts and has enabled to identify and understand the theories or models, which have been used by previous researchers in the field. The main purpose and outcome of this was to identify important components to be addressed in the database development. Although the area of LCC is not new, the constructs are neither well established nor standardised across and even within the construction profession. There are, therefore, an abundance of areas that required further investigation.

Development of LCC has attracted little attention in the field and only a limited number of small scale databases have been developed so far (Al-Hajj & Aouad, 1999).

Following sections summarises several issues underlying the LCC databases development.

Level of granularity of LCC data

LCC data is derived at various levels of granularity with each one of them reflecting a different level in a building decomposition hierarchy. At the lowest level of granularity, that is, at the highest level of the building decomposition hierarchy, the LCC data are quite generic and are concerned with the building as a whole. At this level, most of LCC data are expressed in generic terms such as costs per building floor area per year. At the highest level of granularity and lowest level in the building decomposition hierarchy, the LCC data becomes explicit and are concerned with specific properties of building components, such as life expectancy, energy efficiency etc. Therefore, in the integrated LCC database development process, it is required to decide on which level or levels of data should be stored in the database. Should it be data only at the building and component level or should it be at each level in the building decomposition hierarchy, and which levels of building's composition hierarchy to be taken into consideration are some of the issues that needs to be decided upon.

In an integrated environment, the building decomposition hierarchy is defined by the common building model. But in a specific integrated environment which consists of specific CAD tools, levels of data required by each tool needs to be identified and needs to supports only the selection. However, attention is required in identifying a specific integrated environment if an open integrated environment and a database that can be shared across applications over the Internet needs to be achieved. A LCC database, as has been envisaged, needs to provide data at any possible level within the building decomposition hierarchy. Compilation of data for each level of building's decomposition hierarchy is a complicated process and when such data is not readily available, the database should be capable of generating such data dynamically on the basis of available data relating to lower levels of the building decomposition together with information conveyed by the building model. Of course, this type of data estimates and conversions might be fairly complex to define, might not be always feasible and might not be always accurate. However, the requirement to provide LCC data at any level in the building decomposition hierarchy remains a priority in the research and these issues were carefully analysed in developing the system, briefly described in the data capturing methodology section.

Type of database management system to be used

There are three main options available in deciding on which database management system be used: a Relational Database Management system (RDBMS), an Object Oriented Database Management System (OODBMS) or an Object Relational Database Management System (OORDMS). The choice of the system will depend on the complexity of data and the complexity of queries that the system will receive. RDBMSs are more appropriate for raw data within which many joint operations are not required. OODBMSs are more appropriate for complex data and for simple queries. The approach identified in this research for the automatic estimation of LCC data requires maintenance of interconnections between LCC data at different levels of the building decomposition hierarchy and frequent navigation between the interconnected data. If such an approach is to be followed, OODBMS will be more appropriate to play the role of LCC database. However, how the interrelationships between components are described, stored in the database and used by the system to make predictions remains as open issues to consider in the research.

Organisation of LCC data

The main purpose of the LCC database is not to provide efficient access to LCC data, but to facilitate what-if analysis to different design options in order to identify the best possible design solutions. This issue becomes even more important especially in an integrated environment where what-of analysis could be automated. As an enabler to this process, the designer or the integrated design tool needs to query the LCC database for costs of alternative components. But how can the alternative components be identified in the database? Classification of components on the basis of their functionality is one of the options available.

Storage of LCC related information

In developing a LCC database, attention is required to identify the way in which factors that influence LCC data are stored in the database and used in LCC analyses. This represents one of the major problems of using LCC data, as they are dependent upon many different factors, which are more complex and very difficult to quantify in most circumstances. Development of different sets of data and databases for different types if buildings, is a way of avoiding many problems related to the complexity and diversity of LCC data and the factors that influence them.

Handling of complexity of operations

Handling of LCC related data is fairly a complex process when different levels of decomposition within a building is considered. But, the development of a LCC database can be substantially simplified without a significant loss in the accuracy of predictions by identifying ad using only the most important components and most important factors that have an influence on these components. Figure 3 highlights components which has been identified to handle the complexity of LCC data. Al-Hajj and Horner (1998) justify this decision as they have shown that only 16% of costs collected are adequate to predict the total running costs of a building to an accuracy between 2.5% - 5% and the annual costs to an accuracy of 7%.

LCC data are very sparse – how to deal with this complexity?

If different databases for different types of buildings are used, then there should be schemes devised for sharing data, which are common to all types of buildings. Developing a shared LCC model is once again a complex task and requires considerable effort. However, it is envisaged that such a shared model will provide solutions to some of the conflicting problems of non-availability of extensive data and satisfying the requirement of reasonable accuracy of available data. The wide acceptance of the Internet and the World Wide Web provides the opportunity for developing databases that are shard by a community of users. Therefore, development of shared LCC databases could be identified as the only practical solution to the problem of providing access to a large amount of LCC data. But there will be limitations associated with such developments as certain participants within the building life cycle such as consultants, will not be willing to share their LCC data as they present them a strategic advantage. Therefore, such limitations need to be overcome by creating an awareness of the importance of sharing LCC information across the building supply chain. Further, development of such a shared database requires development of standard LCC data recording formats, which will simplify and will enable the complication of recorded data.

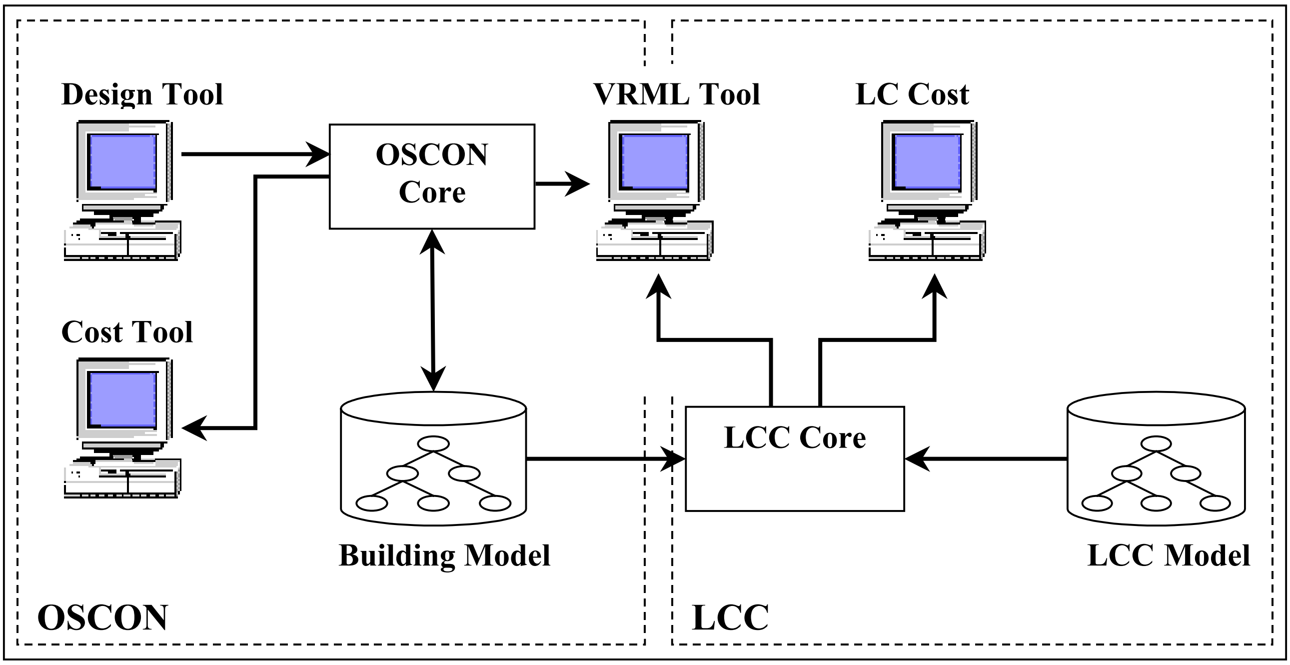


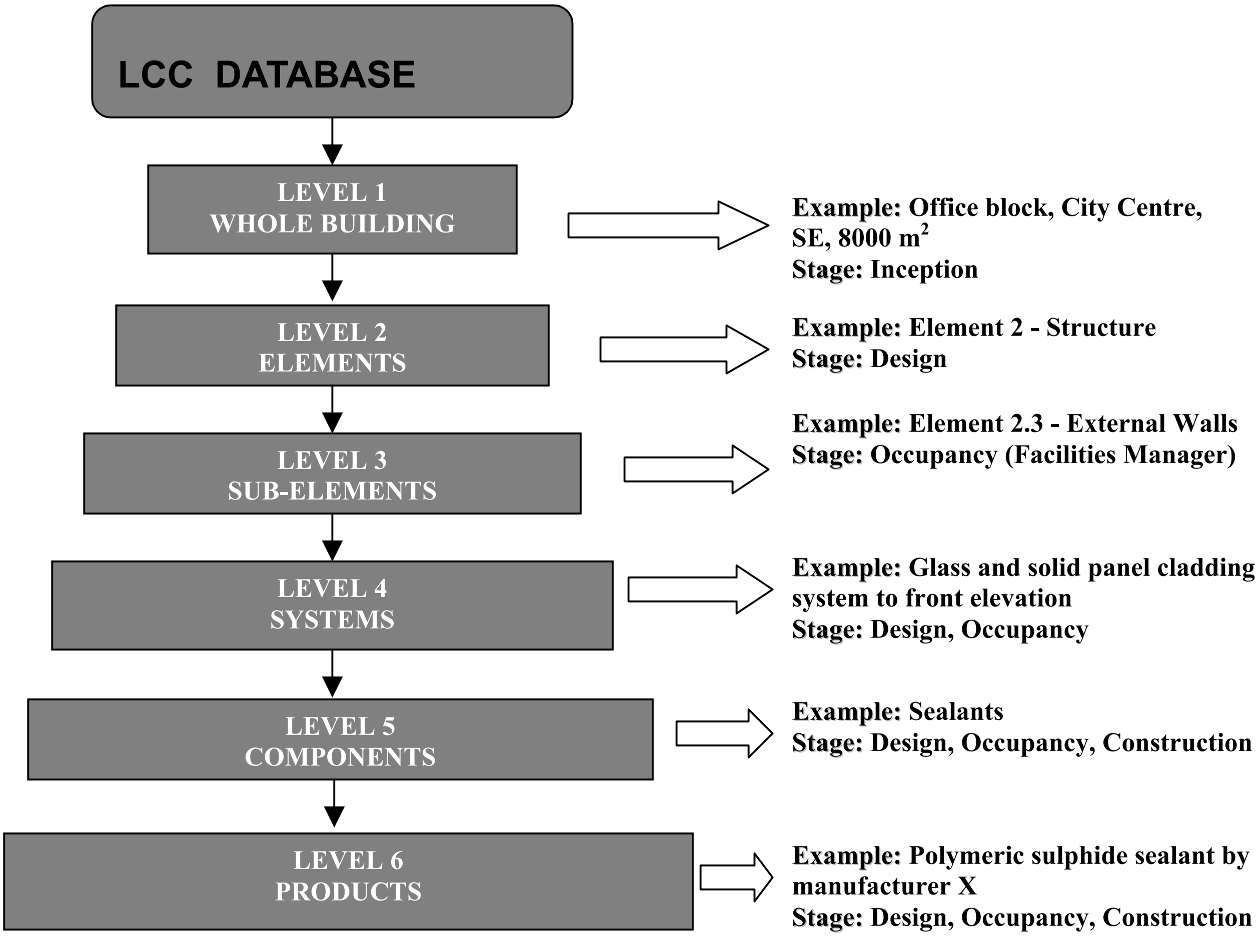
Figure 2: *The LCC system proposal*

On the basis of the issues identified through the above discussion, a framework has been proposed, as illustrated in Figure 2, for the development of the LCC database.

Data Capturing Methodology

By taking into consideration, factors discussed above, the LCC analysis will be conducted on two levels as proposed by Whyte (1999). First level of analysis is at the building, or overall asset level, and will give an indication of building performance, including such issues as energy consumption, management, cleaning, rates and insurance. Secondly, individual elements will be considered, taking into account all planned costs over the life cycle of that particular component. These costs will include acquisition, maintenance, operating, disposal and any others considered to be significant for that element. (Figure 3). Such a system will help to overcome the problems associated with lack of universal methods and standard formats for the calculation of whole life costs and the difficulty in integrating operating maintenance strategies at the design phase, as indicated by CRISP and the Technology Foresight Panel (cited in Clift and Bourke, 1998).

The models developed to facilitate this multi level LCC analysis will link to other components of the integrated environment (Figure 2). This will safeguard the integrity of the model and ensure compatibility with existing OSCON functionality. Once the functionality commences, the database will form an object oriented asset register, which will be of use not only to designers but also to Facilities Managers and others throughout the life cycle of the building.



Levels 1,2 7 3 are Building dependent and Levels 4,5 & 6 are Building independent
***Figure 3** : LCC Database – Overview*

Any LCC analysis is only as good as the input data allows, and future cost predictions, but their very nature have some uncertainty associated with them. It is therefore important that a risk analysis is performed on all input data and that the results are fed back to the user giving an indication as to the reliability of the forecast. It is anticipated that the proposed VR interface, in addition to displaying the costs will also provide a method by which the level of reliability may be visualised. Virtual Reality is considered a more natural means for interfacing with complex information (Aouad et al 1998). Using this system, anyone with an interest in the building design will have at their disposal within a single visually appealing environment, all the data necessary to make informed decisions based on Life cycle cost as well as aesthetic criteria.

In order to test the application, sufficient data will be required to enable realistic cost comparisons to be made between a number of alternative designs and between the use of different building elements. Case studies which have been used to verify previous LCC research will also be employed, in addition to a fresh case study currently being undertaken. In the first instance, tests will be restricted to certain well-defined areas of application such as internal decoration and roof design in order to validate the technique and to establish interest before extending the application industry wide.

Initially, data will be entered via forms designed specifically for the purpose, which will be accessible from within the CAD package. This will allow designers to enter data in a familiar environment, whilst being encouraged to consider the life cycle implications of their proposals at every stage (Whyte, 1999). The feasibility of retrieving data directly from existing electronic sources will be considered for future investigation.

Associated Limitations

The degree of automation of LCC data with the use of integrated environments will be largely dependent upon the degree of availability of LCC data to reflect different circumstances, as it was argued that LCC data will depend on may complex and diverse factors. Those factors, for e.g. the life expectancy of a building must be taken into account if reasonably accurate estimations are to be made. However, may of LCC associated factors are difficult to quantify in a form that can be interpreted by computer systems. Thus, experts in LCC often use their expertise and human judgement to adjust the data to use particular situations and circumstances. However, use of computer systems provides two options in dealing with LCC data: either to identify the factors that influence the data to quantify them or create a semiautomatic and interactive environment where the judgement of the LCC expertise is invited to update information. A balance between the two is often suggested, the exhaustive intervention of the LCC expertise and the automatic but less accurate operative systems must be achieved. How this is to be achieved has been an open question and attempts have taken to find answers to such questions in the research.

Conclusion

Whole life costing is a technique which could be used to facilitate effective choice between alternatives in the search of value for money. However, a lack of accurate data and a difficulty amongst design teams to visualise the impact of their decisions on occupancy costs have reduced the effectiveness of this technique.

This paper has given an overview of a project currently in progress to embed a LCC analysis tool within the design phase of an Integrated Construction Environment. Particular emphasis was given to discuss LCC database development and its associated limitations and constrains and to outlines suggestions to overcome those barriers.

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Acknowledgement

The LCC integrated system described in this paper is being developed as part of an EPSRC-funded research project, undertaken through a joint collaboration between the Robert Gordon University and the University of Salford.

Environmental issues in the property life cycle

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Abstract: *The life cycle of capital projects is affected by several significant environmental issues such as energy use and global warming, natural resources and waste and recycling, pollution and hazardous materials, internal environment and indoor air quality and planning and land use. The issues are discussed in terms of the decisions required to minimise the environmental impact of a commercial property during its life cycle. The issues are then related to a case study of a property development proposal for a sustainable building in Melbourne, Australia and then broadly compared with a similar example, that of Audubon House in New York City. Reference is made to the significant use of energy in commercial buildings, in particular the resultant greenhouse emissions.*

Keywords: Energy, environmental issues, life cycle, property and construction, resources, sustainable development.

Introduction

The purpose of this paper is to discuss environmental issues in the property life cycle. The property context is a commercial office building in Australia. The decisions required to deal with the issues are outlined and a comparison is made with a similar project in the USA.

The environment comprises the "surroundings in which an organisation operates, including air, water, land, natural resources, flora, fauna, humans, and their interrelations" (Standards Australia 1999). The context is the conduct and control of urban property within the environment and it includes the land and buildings together with the activities of the occupants. Included is the impact of the property on the environment and *vice versa* and thus ecology is subsumed. It leads to the concept of environmentally sustainable development, a concept that "stresses using resources of energy and materials in a responsible way so that future generations can benefit from them too" (Fryer, 1997, p152).

The principle of environmental sustainability "implies using natural resources in a way which does not eliminate or degrade them or otherwise decrease their usefulness to future generations, and implies using non-renewable natural resources at a rate slow enough as to ensure a high probability of an orderly societal transition to new alternatives" (Pearce *et al,* 1989, p176). The World Bank has used the phrase "development that lasts" in this context (World Bank, 1992, p34).

Management of the environmental issues is continuous throughout the life cycle of the property. The life cycle comprises "consecutive and interlinked stages of a product system, from raw material acquisition or generation of natural resources to the final disposal" (Standards Australia, 1998). In the context of property and construction, it is a time horizon, which commences with the acquisition of land, includes the design and construction of buildings, and continues with the ongoing operation of the property and ceases with the ultimate demolition or deconstruction and recycling of the property.

the stages throughout the project life cycle from inception through to disposal:

- Inception and design
- Delivery and commissioning
- Operation
- Disposal including demolition, recycling, redevelopment, renewal and upgrading.

Life cycle costing methods have been used in decisions about property and construction options for many years (Flanagan & Norman, 1984; Stone, 1980). Levels of complexity of life cycle costing have been recommended (Robinson, 1986). The more detailed technical approach is illustrated elsewhere (Robinson, 1996) in which the costs and benefits associated with a series of options is analysed including the effects of taxation, externalities and discounting and inflation.

Review

Several international case studies are now available (National Audubon Society, 1994; Treloar, 1996; Bamford *et al,* 1998; Yeang*,* 1999). The case study described in this paper comprises a property and construction project, which initially formed the subject of a collaborative research grant, sponsored by the Australian Research Council and industry partners (Bamford *et al,* 1998). One of the industry partners, the Australian Conservation Foundation (ACF), had decided to review its accommodation needs in 1997. It was then in occupation of a small old-style building (2,400 m^2) of two levels that it owned in Fitzroy, an inner suburb of Melbourne. The ACF is at the forefront of environmental matters and wished to occupy premises with a minimum impact on the environment. Several options were considered including purchase of a new property, purchase of an existing property and refurbishment, purchase of land and the construction of a new building and lease of existing premises (Aye *et al*, 2000). Although ownership of a new building proved to be the preferable option, ACF decided that it preferred to use its capital for environmental policies and campaigns so it decided to lease premises. A search for premises owned by a landlord with an environmental ethic proved to be fruitless. In the event, an ethical investment company, the Green Building Partnership, acquired an underdeveloped property with some heritage features in Carlton, another inner suburb of Melbourne, and it commissioned a building refurbishment of high environmental design (called 60L) and offered to lease to ACF part of the building on completion. Thus the case study is from the point of view of the owner and not the tenant. The decisions required to achieve an environmentally sustainable development are outlined below. Various aspects of this case study have been described in detail in Aye *et al*, 1999, 2000 & 2002. The building refurbishment is still under construction at the time of writing (mid-2002). The developer's stand is that no compromises are acceptable and this has given rise to significant design and construction delays.

This case study is briefly compared with Audubon House (National Audubon Society, 1994). The National Audubon Society (NAS) is similar to the ACF in that its mission is “to conserve and restore natural ecosystems, focussing on birds and other wildlife for the benefit of humanity and the earth’s biological diversity” (NAS, 1994, p6). The NAS decided to review its accommodation needs in 1987 and its then premises (3,500 m^2) were leased in a 30-storey skyscraper in New York City. Ownership was found to be the best option and the NAS acquired an existing eight-storey building in lower Manhattan. It was a building completed in 1891 with significant heritage elements. As for 60L, a refurbishment project of high environmental design was commissioned and it was completed in 1992. However, compromises were expected and accepted as critical for a project to proceed in the commercial world and it has been expressed as a “ninety percent solution” (NAS, 1994, p58). Moreover, the choice of materials and components was controlled by establishing a 10% limit in cost premiums.

Several key property and construction issues are identified in this study described by the author (Robinson,2002). Many of these issues relate to the acceptance of the project by the property market. They are based on a classification by the Construction Industry Research and Information Association (Fryer, *op cit,* p151):

- Energy use, global warming and climate change
- Resources, waste and recycling
- Pollution and hazardous substances
- Internal environment of buildings
- Planning, land use and conservation
- Legislation and policy issues.

Land and Planning Issues

Location

In respect of the location of the proposed accommodation, it was decided that the building should ideally be centrally located on a site with excellent public transport access. Accordingly, the search for a suitable location is concentrated in localities within walking distance (a few hundred metres) of the Melbourne underground rail loop which serves the central business district, i.e., in a city fringe locality.

Audubon House is located in lower Manhattan and it enjoys a central location.

Transport and Energy

A principle of the design of 60L was to optimise the use of public transport and minimise energy consumption and greenhouse gas emissions. Carparking is not provided on the site in an effort to encourage the building occupants to travel by public transport.

Tenure

A preference for freehold ownership has been articulated so that the ethical investor has full control of the building design, configuration and operation, and the opportunity to achieve the benefits of sustainable property development and investment. This applies in both projects.

Embodied Energy

Due to the centrality of the chosen locations, the ability to find a suitable vacant site was limited. Thus the decision was made to redevelop a site containing an existing building. This decision makes a significant statement about embodied energy and natural resources in that the recycling of (part of) an existing building would create a substantial saving in embodied energy and resource consumption. In turn, this reduced the amount of waste that would need to be deposited as landfill elsewhere.

Heritage

The design includes the preservation of a heritage building and street façade. It is to be incorporated into an office building of modern design. The building has had many alterations and additions during its lifetime and thus has low heritage significance described as remnant architectural merit. Of greater significance is the historical value of the site on which many different activities have taken place. These many past uses justify the changes currently proposed.

Audubon House has a similar history although a much greater proportion of the fabric of the building has been preserved and very few structural additions were required. In the case of 60L, well over half of the site coverage contains new building work and most of the remaining internal structure has been substantially altered.

Design Issues

Passive Design

The existing building has three levels and a fourth level is to be added in a lightweight but fully insulated structure. The subject property is constrained by boundary walls on the north and south, a frontage facing west and a rear alignment to a laneway to the east. Therefore, there is very little opportunity for natural light and to use the façade as a source of energy. The features used to provide additional light include a central atrium with solar chimneys to effect ventilation and a series of light and ventilation wells on the northern and southern boundaries to provide light to the lower floors of the building and to assist ventilation throughout. Openings equivalent to 2% of the floor area of the building in the external walls and in the roofs of the solar chimneys are required for effective operation of the passive ventilation system. These openings are to be operated in a night purge system to remove heat that has been built up during the day.

Other aspects of passive design include a reinforced concrete structure to provide thermal mass, insulation of all walls and the roof space, low emissivity double glazing, passive solar shading, high efficiency artificial lighting. Each of these measures taken alone provides a marginal improvement in comfort and energy consumption. All together, these measures should provide commercial quality comfort with a substantial reduction in energy use.

Audubon House covers the whole site and it has two street frontages, being a corner site, and therefore two walls providing natural light. An external light well forms part of the floor layout in the corner away from the windows.

Active Design

Given the setting of the property in the commercial office market, comfort conditions associated with conventional office buildings have set the design parameters. The proposed plant is an air-cooled heat pump split-system. The system is to be operated on demand when the ambient temperatures exceed the design range (19 to 26C). The control system will enable the switching over from the passive system to the active and it will be done on a multi-zone basis. In other words, zones requiring specific services are to be operated individually. The greater the number of zones, the greater the potential of energy savings consequent with comfort. The control system will also provide for pre-heating and pre-cooling as necessary.

Audubon House contains an active system based on a gas-fired chiller-heater located on the top floor. It is considered to be an energy efficient machine which reticulated chilled or heated water to individual air handling units on each floor and then via the ceiling space ducts and VAV boxes to the occupied floors with return air through the ceiling plenums.

Transportation Services

Although an elevator is provided to enable universal access, building occupants are to be encouraged to use open stairways located in the central atrium.

The configuration of Audubon House requires two lifts.

Electrical Services

Connection to the national power supply grid is required. Renewable energy is to be supplied by the retailer (at an additional 33% in price). Limited on-site photo-voltaic generation is to be included. PVA sheathed cabling is to be avoided due to its poor fire safety performance. The power density allowance is reduced to 25% of the normal allowance for a building of the type.

Hydraulic Services

It is proposed to reuse storm-water on the site but with an allowance for excess storm-water to be reticulated into the infrastructure. Grey water and black water is to be treated on the site and effluent used on landscaping in the atrium and on the roof garden.

Fire services

Environmentally sustainable features are provided in the fire services system. Photo-optical smoke detectors are to be installed instead of the usual ionization type detectors to avoid radioactive materials on the site. The backup power supply for the emergency lighting is to be fed by solar collectors. The water used in the testing of the sprinkler system is to be discharged into the grey water system.

Acoustics

It is conceded that the nature of the atrium and the light courts, together with the existing timber floors in parts of the existing building, mitigate against optimum acoustic conditions. Measures are to be put in place to minimize the acoustic impact between the occupants of the building.

Audubon House comprises a more conventional layout using a typical open plan for the office floors.

Materials

Ecologically sustainable materials are specified including high-mass masonry for the main perimeter walls and lightweight construction in the walls of the atrium and light-wells. The former are to be reinforced concrete or brickwork, some of which is existing, and the latter are to be a mixture of glazing and polycarbonate with perforated pressed metal panels and compressed sheet linings. Floors are to be a mixture of polished concrete, natural timber, carpet and vinyl. Internal partitions are to be glazed or finished in plasterboard. Suspended ceilings are minimised to gain access to the thermal mass. A materials auditing exercise was put in place to ensure an optimum outcome in terms of the origin of the materials, the environmental impact and the energy and water required during the supply chain.

A similar challenge was posed in respect of Audubon House. It was considered that the impact of the materials on the indoor air quality was the main issue. Although the upstream and downstream effects were considered important, they were secondary to indoor air quality. PVC materials and adhesives were avoided, but glues were used to reduce potentially dangerous situations such as carpet on stairs. Pure wool carpet was installed. Internal lightweight walls were constructed of a recycled gypsum core and recycled paper linings. Paint was chosen for its chemical composition, odour-free nature and avoidance of off-gassing emissions. Pressed wood was avoided where possible.

Energy and Greenhouse Gas Emissions

The building configuration and the land and planning issues and design issues establish the life cycle energy use and greenhouse gas emissions. The design details have been adopted in an attempt to optimise the sustainability issues together with the economic and financial issues.

Building Delivery Issues

Prequalification

The consultants and the building contractor have been selected on the basis of a two-stage process. The first stage consists of a public advertisement requesting expressions of interest from suitably qualified persons or firms to present credentials for consideration by the developer. The factor considered important for the first stage is previous experience, particularly in environmentally sustainable development. The second stage commences with the preparation of a short-list of potential contributors and an invitation to submit a proposal including a scope of services to be provided together with the proposed fee in the case of the consultants or the tender price in the case of the contractors. This stage includes an interview of the firms that submitted a proposal in order to meet the individuals who would be involved in the project and to assess their commitment to the nature of the project. Fee and price are not necessarily the major drivers of the selection of the successful consultants and contractors.

Similar guidelines were adopted for each project. The consultants, in particular the architect, were expected to understand the environmental imperative, to be able to work in an integrated fashion with other team members, in particular the mechanical engineers and environmental concepts experts and to be prepared to undertake research to achieve the optimum environmental outcome. It was considered particularly important to avoid a purely aesthetic approach.

Computer modelling was undertaken by both teams in order to project energy needs and internal comfort.

Construction operations

The consultants and the contractor are expected to apply sustainable practices to their professional and commercial activities. For example, the consultants are to design and document the project using electronic storage, retrieval and transfer of information. The contractor is expected to provide an environmental management process to enable sustainable site practices. An environmental superintendent is to be appointed to advise and be the final arbiter on the project during the delivery phase. The contract is based on an industry standard with the addition of special conditions to reflect the environmental ethic.

Continuous delays have been experienced during construction. Soil contamination by hydrocarbons from old underground fuel tanks and also by lead was discovered necessitating cleaning of the material prior to the continuation of construction work. Delays were caused whilst awaiting the design and manufacture of environmental systems. For example, a water recycling system allowing for the re-use of grey-water on site was initially designed with a requirement for several electric pumps to operate 24 hours a day seven days a week and which required chlorine to be regularly administered. This was unacceptable to the developer and an alternative was demanded.

Building Management Issues

Lease Terms and Building Rules

The building occupants are to be signatories to a lease document that contains requirements, including building rules, that promote environmentally sustainable practices. Tenants are expected to operate the building systems for best environmental outcomes. This includes a requirement to commute to the premises by public transport where possible thus keeping vehicular use to a minimum. As has been discussed above, car-parking spaces on the property are not provided.

Performance Monitoring

The building owners intend to monitor the building to establish that the best possible environmental practice is maintained. This will entail the measurement and recording of basic climatic data including temperature, humidity, wind speed and direction, solar radiation and rainfall. A self-contained weather station is to be installed. The building monitoring will also include the measurement and recording of internal data such as temperatures, humidity, energy use, water consumption and so on. A building automation system is to be installed together with logging devices to monitor the operation of the building.

The systems at Audubon House are monitored and the performance appears to be an improvement over standard benchmarks. An in-house recycling system is in place and close to 80% of office waste is recycled. The system was a substantial part of the building refurbishment with four chutes and several bins into which waste is sorted.

Conclusion

The Audubon House refurbishment was completed in 1992 and some environmental outcomes are available. However, the Green Building (60L) is not yet complete and it needs to be monitored in order to discover the environmental outcomes. The Australian experience is that the holistic nature of environmentally sustainable development is not well understood by the property and construction industry. Many operators in the industry tend to concentrate on a component of environmental sustainability. Energy use and heritage conservation have been popular proxies for environmental sustainability for some years. In very recent times, it has become fashionable to market or advertise a proposed building as being environmentally sustainable if it includes a design feature such as a façade containing photo-voltaic cells. The use of environmental marketing occurs even if the building itself breaks most of the environmental sustainability rules in terms of its configuration, materials and services.

Building design and the delivery process is critical to the environmental performance of buildings. In Australia, buildings are responsible for 30% of all raw materials used by society and they consume more than 40% of all energy produced causing more than 40% of all air emissions. It is expected that the commercial building sector will double its greenhouse emissions over the next decade. It has been shown that 250 m^2 of forest is required to absorb the carbon emissions created by 1 m^2 of a commercial office building (Aye *et al,* 2002). It has been noted that the annual energy consumption of office buildings in Australia can vary from 350 MJ per m^2 to 4,000 MJ per m^2 (BOMA, 1996). So there is a significant opportunity to establish some environmental sustainability benchmarks.

Further Research

A research project has been proposed to examine, in the first instance, the differences between buildings incorporating some energy efficient measures to those that have none at all. It will also investigate how the occupants of these buildings relate to the environmentally sustainable issues such as energy efficient measures (or lack of them). The recording of the attitudes of building occupants has not been dealt with in the Australian property and construction industry. There is a growing body of evidence, both research based and anecdotal, that shows productivity and satisfaction gains can be realised by providing better built environments that are more efficient. Productivity gains of up to 25% through increases in process rates and reductions in absenteeism have been suggested (Rocky Mountains Institute, 1998). Thus the project intends to survey commercial office building occupants to establish a measure of these gains.

This research will assist in the new triple bottom line accounting culture in which the notion of reporting on an entity's environmental and social performance, in addition to its economic and financial performance, is directly tied to the concept of sustainable development.

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Acknowledgement

The author acknowledges the contribution of the Australian Research Council, the industry partners, colleagues at the University of Melbourne and consultants advising on the Australian project outlined in the case study.

Best Value Through Whole Life Performance

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Abstract
When construction clients seek best value, they seek a whole range of things from their buildings, Such things, may themselves be seen as attributes where in effect the building's whole life performance can be expressed as a bundle of performance attributes which in turn make it up.

Whole Life Performance is, however, a highly condensed construct, which requires to be decomposed into more easily recognisable components of whole life performances. Here, components of such wholelife performances may be secured through in-house provision, or bought-in services.

It is suggested that both whole life performance and whole life cost are two sides of the same coin. In other words, it is not buildings that incur cost, but rather those decisions relating to the building's performance in use. Whole Life Cost is defined in the paper, where it believed that wholelife costing itself refers to the decision support framework for securing the best outcome, consistent with the construction clients' requirements or commitment to acquire, operate and dispose of a built facility.

The paper proposes a composition for a decision support framework and a perceived client's commitment towards a best value implicit in such a framework. It concludes by suggesting that unless the bundle of performance attributes from the built facility over a defined service life, is clearly defined and supported by protected funding, the client is unlikely to achieve best value.

Keywords: Whole life performance, whole life costs, replacement cycles, performance attributes, sinking fund

INTRODUCTION

All 'parties' that come together during construction or facility procurement or post commissioning of a building have a legitimate interest or stake in wholelife performance. Nevertheless, if value based performance and wholelife is to develop as a discipline the stakeholder interest though different needs to be both understood and considered.

What might be more helpful is to determine the performance nature of both the building as an asset and those attributes for the facility or space that secure those operability levels defined. Here, the adoption of performance life based audits, would contribute to the client's understanding of the implications of managing existing or modified designs. Especially through a project driven performance framework.

The performance approach is, in essence, the practice of thinking and working in terms of outcomes or ends, (Ang & Wyatt 2001) rather than inputs or means. Instead of describing, specifying and procuring the building parts, the performance approach concentrates on building attributes. In doing so, it provides a way for wholelife thinking, and above all whole-building performance auditing.

In practice most designs are inevitably a mixture of prescriptive and performance specifications. So care is needed in evolving to a wholelife practice. Likewise, the whole life cost should address service loss and the risk of non-use of the facility.

WHOLE LIFE PERFORMANCE

The pursuit of whole life performance is expressed in different ways, depending on the stage throughout the life of the building and its 'moments of risk' (Ang & Wyatt 1998).
A pathway already established (ISO 15686 2002), encourages tracking of performance over time against some defined parameter(s). As one phase rolls into the next phase, the challenge is how value, wholelife performance and wholelife cost come together to deliver best value.

Essentially, the whole-life cost of meeting the stated performance standard requires careful consideration. (Meacham 2001). Such performance standards should form the basis of the replacement strategy in order to secure the life time benefits.

It remains, however, to establish precisely what the lifetime benefits are, and how they are to be expressed in order to make a proper evaluation against the cost of achieving them and performances that can be identified and secured (Huovila 2001). Service life planning is concerned with the performance and functional requirements of the constructed works, as well as securing the reliability of the elements, or systems. In short, there is a need for a conceptual framework, which goes further than just talking about how whole life performance

WHOLE LIFE COSTS

When seeking a definition of whole life cost, consideration must be given to the changing economic conditions organisational requirements which determines the rate of replacement, major changes in use and final decommissioning and disposal of the building.

Whole life costing should not be equated life cycle costing, which employs present value (PV) and annual equivalent (AE) methods. The purpose of these techniques is to enable evaluations of alternatives to be made, based on their time equivalent cash flows.

Whilst such techniques have their role, they are seen as peripheral to whole life performance and whole-life costing. Whole life performance is about implementing the decisions to conform to agreed performance standards.
A clear agreement is however needed as to what is meant by whole life costs.
Whilst whole life cost has variously been defined as:

'the total resources required assembling, equipping, sustaining, operating and disposing of a specified asset as detailed in the plan at defined levels of readiness, reliability, performance and safety (BS 7000-5 2001)

Through life costs are seen as:

'those costs incurred in the constructed facility or works lifetime and assume significance against its range of service life, reliability requirements and serviceability set against the performance level used.

In consequence, WLC is defined here as:

'the total costs anticipated, or incurred constructing, operating, or maintaining a facility, in terms of its performance and functional levels through out its' in service life' and where considered the disposal less any net recovery attributed to carbon based accounting' (Wyatt 2002)

The appropriate technique for such commitment implied in the above definition is the annual sinking fund (ASF), which constitutes the whole life cost plan.

VALUE

The focus is now on economic value in a wider sense, encouraged by the need to manage the retention of embodied energy within a carbon based credit system. In consequence pursuit of value for money (VFM) requires a focus on the life-time approach. In order to ensure that clients obtain value for money (VFM) from their buildings, it is not enough to know just the purpose of the building, the budget and time constraints. What is required is a coherent framework of what constitutes VFM.

The concept of value for money (VFM) is built on three aspects of delivering a service, known as the three Es (Butt &Palmer 1985). These three Es are *economy*, *efficiency* and *effectiveness. Economy* was to do with the cost and quality of resources, *efficiency* is the ratio of output gained for the amount of resource used, and *effectiveness* is the extent to which the actual results matched the desired results. The question how benefits are to be determined and more importantly how they are weighed against cost is a challenging prospect and can only be judged by the client. In that sense, the language of VFM, *effectiveness* would be a measure of the extent to which the realised benefits matched the required benefits. But it is through and whole-life cost decision making, that the issue of performance over time and value needs to be addressed. This focus upon 'wholelife costs' is seen as a recognised outcome, in order to facilitate performance life based decision-making especially at a project or strategic level.

BUILDINGS: BUNDLES OF ATTRIBUTES

The constructed work's may at its simplest level, be seen as comprising space, elements and systems. In turn, these may be made up of other systems and components but all have varying service lives. Best value is therefore obtained when the lifetime benefits derived from the building exceed its whole-life cost.

Given the overall performance of a building involves a balance of specific requirements, it is necessary to express the requirements into the language of performance criteria. To do this, however, it is necessary to have a clear statement and structure of the attributes requiring performance evaluation, including environmental performance. (Bartlett & Edwards 2001). An appropriate approach for this kind of problem is one that employs multiple criteria decision making.

Multiple Criteria Decision Making (MCDM)

MCDM is a generic description of a range of techniques for handling decisions, involving multiple criteria and which cannot be evaluated by just one form of measurement. A number of approaches to structuring MCDM problems (Malczewski 1999) have been adopted, resulting in terms being used interchangeably. This paper adopts a version of the simple mult-attrubute rating technique (SMART) based on the work by Edwards (1977) and developed by Green (1992) in the area of value management. It does this on the grounds, in line with Green (1992), that the assumptions of undistorted utility functions associated with multi-attribute utility theory (MAUT) cannot be justified.

To ensure clarity and consistency, the following terms have been adopted in this paper:

> *Multiple Criteria Decision Making (MCDM)* refers to the whole aspect of decision making involving multiple conflicting criteria
>
> *alternatives, options, course of action, strategies* – will be treated as referring to options open to the decision-maker.
>
> *objective* – indicates the direction in which an action is set and which points towards an overall goal, objective or aim. For complex problems, objectives are hierarchical in nature.
>
> *goal* – In some cases *goal* is defined as synonymous with *objective* in others it is defined as an *overall objective* as in goal programming
>
> *attribute* - a characteristic of the option being evaluated in relation to an objective, against some measurable yardstick
>
> *criterion* – required level of attribute (performance standard) by which an alternative is judged.
>
> *Outcome* – the consequence of an alternative in relation to an objective and expressed in the related attribute.
>
> *weight* – value assigned to an evaluation criterion to indicate its relative importance.

In MCDM, outcomes are not only judged by the degree to which they meet the criteria, but are weighted according to their relative importance. The relationship between the various elements of a MCDA is shown in Figure 1.

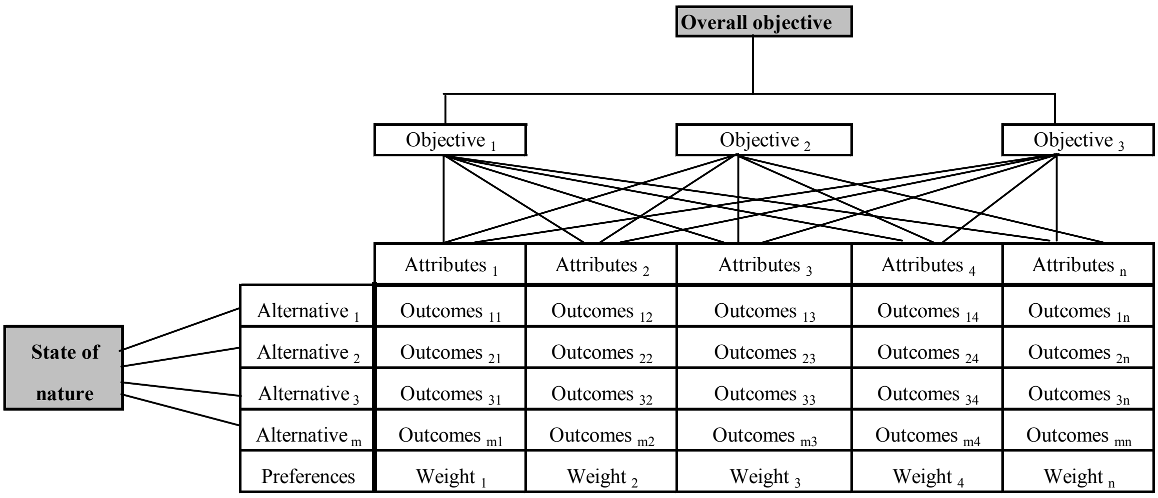

Figure 1 Framework for Multi-criteria decision analysis (based on Malczewski 1999)

Having established a clear statement of the overall objective, it should be possible to generate more specific objectives and their corresponding attributes. The attributes are characterised by indicating, through some measurement, the degree to which the objective can be met. The prescribed measure required from the attribute constitutes the performance criteria. Performance criteria, in this context, only become operational when assigned appropriate attributes.

To ensure the appropriate attributes are selected Keeney and Raiffa (1993) have proposed that they should be:

- *Comprehensive.* From the known level of attribute, it should be possible to know the extent to which the associated objective is achieved, In other words it should be relevant to a particular course of action.

- *Measurable.* It should be possible to relate the client's requirements to particular levels of an attribute. This being so a judgement can be made regarding the extent to which an aspect of the requirement is met.

- *Complete*. A set of attributes is complete if it covers all relevant aspects of a decision problem. Given each attribute is *comprehensive*, they should indicate the degree to which the overall objective is met.

- *Operational.* It should be possible for the decision maker to know the full consequences of the various alternatives. Further the decision maker must be aware of the non-technical problems that render the set of attributes non operational such as existing policy.

- *Decomposable*. It is sometimes necessary to simplify the decision by disaggregating the problem into parts of smaller dimension. This becomes necessary when dealing with environmental issues where, the attributes describing air pollution can be grouped in terms of contributing to global warming and a threat to human health.

- *Non-redundant*. An outcome may be scored in terms of energy consumed and cost, clearly cost is a proxy for the energy used and should not be included in addition to the level of resource.

Given client requirements are characterised by objectives with attributes containing the above properties, it should be possible to evaluate the outcome of the corresponding decision and to take appropriate action in the event of failing to meet the standards implied by those attributes.

SCORES AND WEGHTS

Where it is not possible to assign measurable attributes to any of the requirements, it is necessary to resort assign some index of preference. The options can then be evaluated by assigning scores and weights.

Each outcome, with respect to an alternative, is given a score according to how close it meets the performance criterion. The criterion is assigned a weight, which reflects its relative importance. The combination of weights and scores is known as the weighted score technique (WST). The WST consists of establishing an arbitrary scale of say 0-10 to measure the performance of an attribute of each alternative. A total score is then obtained for each alternative by multiplying the weights assigned to each attribute by the scaled value given to that attribute. The alternative with the highest overall score is the most preferred. For example, the initial criteria for conference centre were given as follows:

- Attractiveness of locality
- Quality of accommodation
- Quality of catering
- Ease of access
- Costs ease of organisation

As the criteria were too general, it was necessary to break them down into more detailed (lower level) criteria. The more specific the end criteria the easier it is to evaluate options and to rank them. Where possible the end criteria should be sufficiently detailed to assign attributes to them.

In Table 1, the overall evaluation is specified in terms of criteria, each which contributes to the overall evaluation. The first level criteria contribute directly towards the overall evaluation. Lower level criteria in turn contribute towards the first level criteria. All other criteria contribute to the ones immediately above known as the parent criteria.

Where the overall evaluation (V_1) is equivalent to alternative (a_i) and the score of option *i* on criterion *j* (v_{ij}) is equivalent to the score of the alternative *i* with respect to the attribute *j* (x_{ij}),

Based on subjective ratings on a scale 0-100 (local scale), the five possible sites for a built facility (alternatives) are given a score for each of the criteria. In order to establish overall evaluation therefore, weights in column W3 have been assigned to each of the criteria and multiplied by each of the respective scores as shown in the Table below.

Table 1 Evaluation of proposal

	Weightings			sites				
Venue	W1	W2	W3	A	B	C	D	E
Location	0.30		0.30	0	60	100	30	30
Accommodation	0.20							
Personal		0.15	0.03	100	80	50	0	100
Lectures		0.15	0.03	10	100	0	60	60
Social		0.15	0.03	30	80	100	10	0
Proximity		0.15	0.03	100	90	100	50	0
Catering		0.25	0.05	30	90	100	0	30
Access		0.15	0.03	100	30	0	50	50
		1.00						
Costs	0.20		0.20	0	30	30	100	50
Organisation (ease)	0.30							
Experienced staff		0.60	0.18	0	80	30	100	20
Flexibility		0.40	0.12	10	50	40	100	0
	1.00	1.00	1.00	12.90	60.30	58.70	64.10	30.40

The final weights in column W3 have been derived by multiplying the weights in column W2 by their parent weight in columnW1 according to the chosen scores and weights, Conference site D is the preferred choice.

Whilst the example given was for the selection of a suitable site for a built facility, many of the criteria are relevant to end-user requirements of buildings. From the provider perspective, practically all the criteria would be relevant. The question of the performance standards and weightings however, would be a matter of marketing such facilities and their whole-life costs.

For other types of organisations, the nature and conditions of the built facility could have a significant impact on performance of the business, where the operations are highly sensitive to the internal environment. In such circumstances, the relevant attributes would need to be given the corresponding weightings.

WHOLE LIFE COST PLAN THROUGH A SINKING FUND

Client commitment to maintain their required standard throughout the operational life of the building, a whole-life cost plan should be undertaken. Here, Table 2 intimates the planned replacement expenditures for a building with a target operational life of sixty years. Given the client intended to provide for these expenditures by means of a sinking fund, it is possible to show the amount of funding necessary to meet the replacement bills when they are due.

Table 2 Planned replacement expenditures for a building with a Target life 60 years

Terminal year for funding 55	ASF rate 2.5%					
Replacements every fifteen years (equals three replacements)	Replacement cost £,000	Replacement at year	ASF factor	Annual sinking fund £,000	Cumulative ASF £,000	Funding period
Roof coverings	300					
Windows	250					
Wall and ceiling						
Finishes	140	45	0.0123	13.98	13.98	1 - 45
Mechanical services	450	30	0.0228	25.97	39.95	1 - 30
	1140	15	0.0558	63.57	103.53	1 - 15
				103.53		
Replacements every ten years						
equals five replacements						
Internal doors	40	50	0.0103	5.33	5.33	1 - 50
Fittings	80	40	0.0148	7.71	13.05	1 - 40
Electrical services	350	30	0.0228	11.84	24.89	1 - 30
Lifts	50	20	0.0391	20.36	45.25	1 - 20
	520	10	0.0893	46.41	91.66	1 - 10
				91.66		
Eleven replacements						
every five years:		55	0.0087	2.16	2.16	1 - 55
Floor finishes	250	50	0.0103	2.56	4.73	1- 50
		45	0.0123	3.07	7.79	1 - 45
		40	0.0148	3.71	11.50	1 - 40
		35	0.0182	4.55	16.06	1 - 35
		30	0.0228	5.69	21.75	1 - 30
		25	0.0293	7.32	29.07	1 - 25
		20	0.0391	9.79	38.86	1 - 20
		15	0.0558	13.94	52.80	1 - 15
		10	0.0893	22.31	75.11	1 - 10
	250	5	0.1902	47.56	122.67	1 - 5
				122.67		

Since the timing cash flows of the required expenditures will vary, the true level of commitment can be expressed in terms of the funding necessary to meet the periodic expenditures, in addition to the projected annual expenditures.

It is convenient to group the different replacement cycles and estimate the annual sinking fund (ASF) for each group of replacements as shown in figures 2, 3 and 4. The ASF is based on the assumption that the client commences the replacement funding at the beginning of the operational life of the building. The timing, however, can be altered to smooth out the funding, or relate it to the overall cash flow of the business.

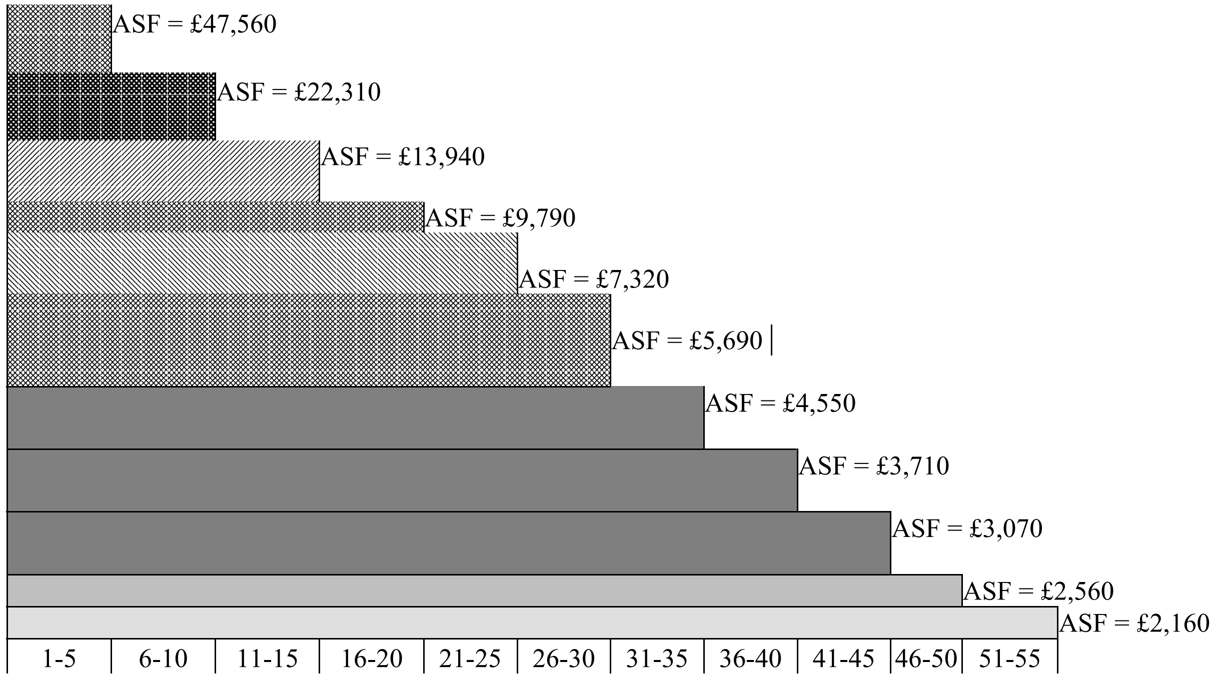

Figure 2 Replacement every five years

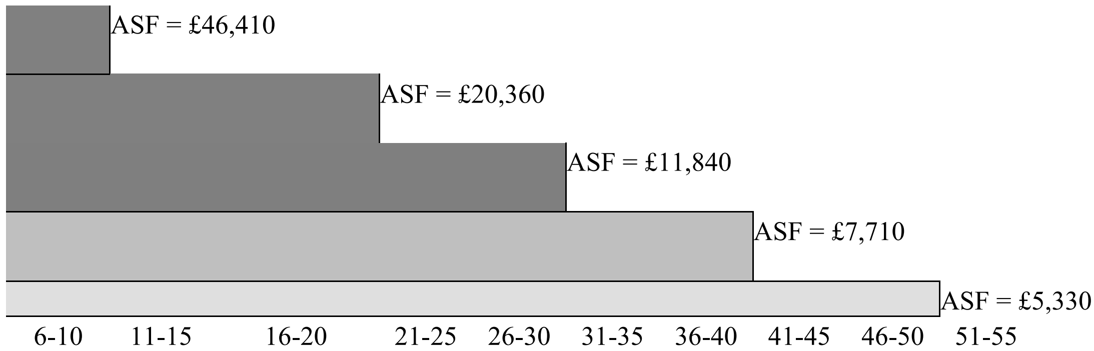

Figure 3 Replacement every ten years

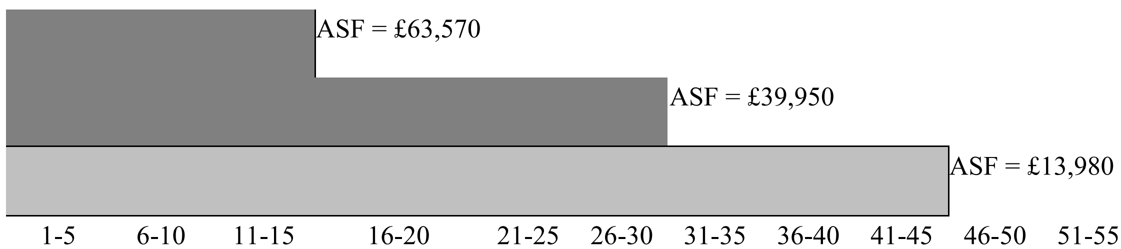

Figure 4 Replacement every fifteen years

Table 3 below provides a summary of the replacement groups. By adding the annual occupancy cost of the building, a total annual budget for each funding period can be computed.

Table 3 Annual budget summary for replacements/ annual expenditures

Funding period	Every five years £,000	Every ten years £,000	Every fifteen years £,000	Total ASF £,000	Annual occupancy costs £,000	Annual budget £,000
1 - 5	122.67	91.66	103.53	317.86	300	617.86
1 - 10	75.11	91.66	103.53	270.30	300	570.30
1 - 15	52.80	45.25	103.53	201.57	300	501.57
1 - 20	38.86	45.25	39.95	124.06	300	424.06
1 - 25	29.07	24.89	39.95	93.91	300	393.91
1 - 30	21.75	24.89	39.95	86.59	300	386.59
1 - 35	16.06	13.05	13.98	43.09	300	343.09
1 - 40	11.50	13.05	13.98	38.54	300	338.54
1 - 45	7.79	5.33	13.98	27.11	300	327.11
1 - 50	4.73	5.33		10.06	300	310.06
1 - 55	2.16			2.16	300	302.16

Model of whole life cost management

Figure 5 provides a model of whole life cost management by linking the client requirements expressed through a balance of performance attributes and the funding necessary to maintain the attributes throughout a defined period of time.

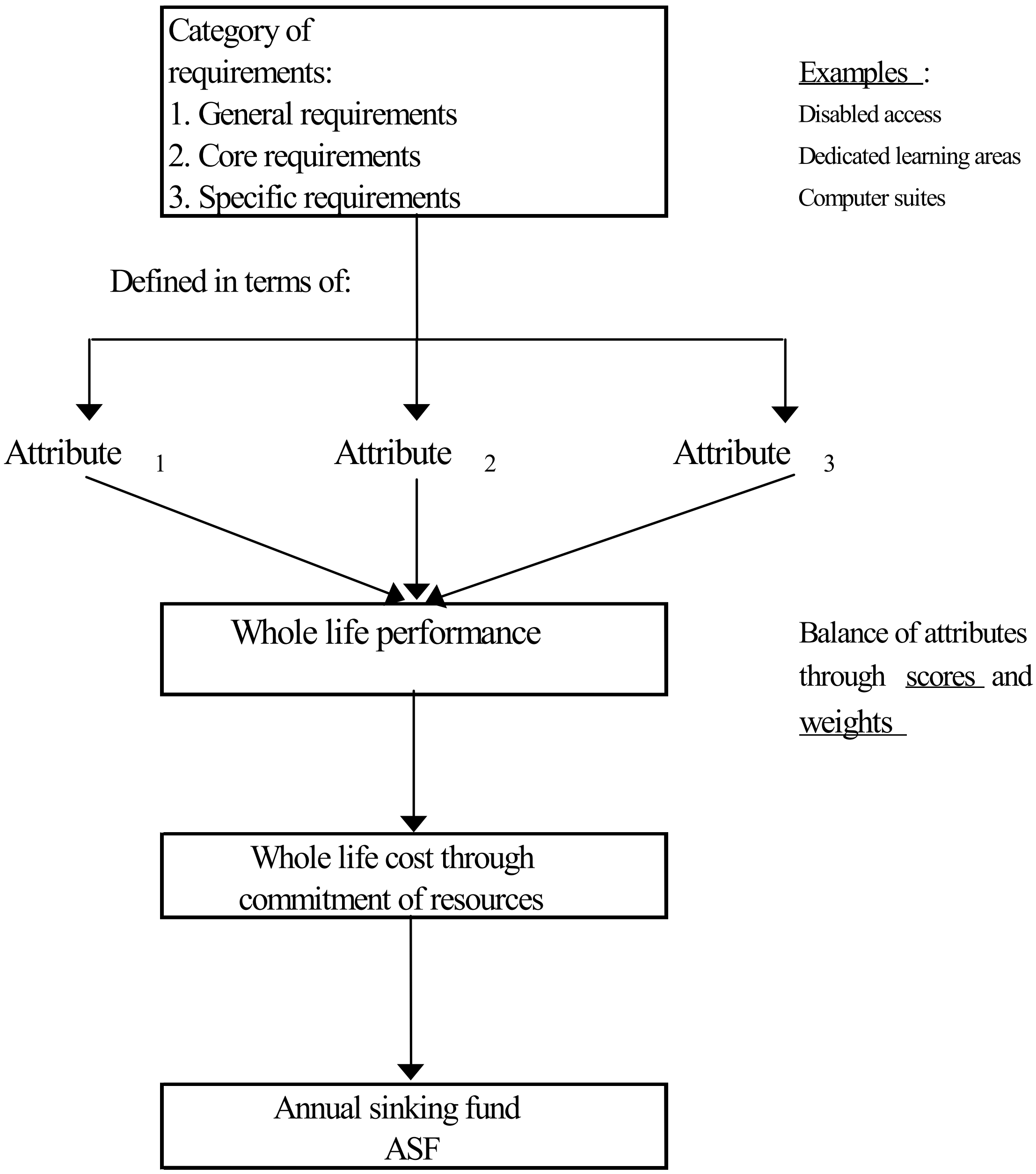

Figure 5 Whole life cost management: the response to whole life performance

The true commitment to whole-life performance is ultimately expressed in the form of funding commitment necessary to secure the agreed standards throughout the target life of the building. It is necessary therefore, to show how the funding is reached in terms of explicit requirements and how the funding is to be arranged.

CONCLUSION

Whole life performance and whole life cost are two side of the same coin. When buildings are seen as bundles of performance attributes, the need to consider appropriate attributes becomes apparent. Further the decision problem needs to be set in a multi-criteria decision framework that can be understood and debated by interested parties of the client organisation.

Through this framework an agreed set of criteria can be reached and the consequences, not least those of cost, are fully examined. Since many of the requirements are complex at the higher level, they need to be decomposed into lower level ones with appropriate and measurable attributes assigned to them.

Where no natural set of attributes is available, an index of preferences can be established through score and weights.

The decision framework provides, not only a strategy for design, but also a link between design decisions and the consequential cost to client organisation throughout the whole-life of the building. Once an agreed set of whole-life performance criteria is established, the whole-life cost, in terms of the funding requirement, can be determined. It is this balance set of requirements secured on the best funding arrangement that will secure best value for the client organisation. To that end, service life planning (BS/ISO 15686 2000) should be seen as a significant part of future best value within a whole life cost decision framework. What is required, therefore, is a responsive building industry (Kendal 2001), That is, one that operates within a whole life cost management discipline and which matches clients' sinking funds based on performance attributes

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Moving towards an integrated facilities management tool to evaluate facilities for service performance in local government

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Abstract
Appraisal of facility performance has of late concentrated heavily on the strategic evaluation of facility performance - that is the alignment of the real estate function with the organization's overall strategic aims. This paper presents a refined model for the measurement, management and benchmarking of facilities in relation to their ability to enable service delivery. Developed specifically for the context of local government, the Logometrix model is the outcome of a collaborative research project with eight local government authorities (LGAs) in Victoria (Australia), with research by Swinburne University (Australia) and UNITEC Institute of Technology (New Zealand). Logometrix allows LGAs to measure the performance of their community facilities strategically and to benchmark with like councils over the Internet using a browser interface. The model incorporates financial and non-financial indicators, and balances the demands of service delivery with those of maintenance, preservation of asset value, and financial performance. This is essential to support the view of the facility as the nexus of service provision, physical building substance and the community using the facility.

Keywords: Integrated facility management, benchmarking, service delivery, public sector

Introduction

At the CIB W70 2000 conference in Brisbane a model for a balanced approach of measuring facility performance that incorporated financial as well as non-financial measures was presented – the Service Balanced Scorecard (SBS) (Brackertz & Kenley 2000). At that time the research was in its pilot phase.[1] Now, almost two years later the authors report the results of the ongoing pilot study and also to present a refined version of the original SBS. Since its humble beginnings as a performance measurement tool implemented with only one Victorian Local Government Authority (LGA) the project has expanded significantly. It is now a collaborative project with eight local government partners, a software developer, a law firm, the Institute for Social Research (Swinburne University of Technology, Hawthorn, Victoria Australia) and UNITEC Institute of Technology, Auckland, NZ.[2]

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[1] The City of Port Phillip, Melbourne, Australia began using the SBS pilot in 1999 and continues to do so.

[2] Refer to Appendix I for a history of the project.

This collaborative project, known as Logometrix (Local Government Facilities – Strategic Performance Measurement) also has significantly expanded the project brief of the original SBS.

Research question

The general question underlying the research for both, the SBS and Logometrix, is "How do facilities support the processes that allow an organisation to fulfil its strategic aims?" And more specifically, in the case of local government, "In a non-profit driven environment, how can facilities be evaluated in relation to the strategic aim of service delivery?"

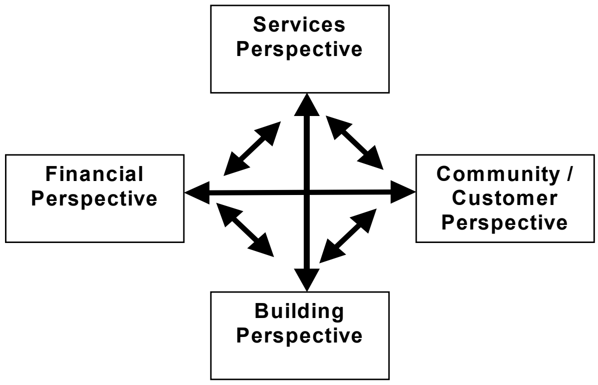

Figure 1: The Service Balanced Scorecard

In answering these questions, the initial project, the SBS, took a stakeholder approach and balanced four perspectives of facility performance, namely community, services, building and financial performance (Fig. 1), collecting tangible and intangible data. Crucial to the concept of the SBS was that data was not provided by facilities management only, but that other stakeholders (service managers and the community) also contributed information. The focus of performance evaluation was on service provision as a return on investment, with particular regard to the LGA's key result areas (Brackertz & Kenley 2002a).

Aims

Logometrix builds on the insights gained from the SBS pilot study and provides a tool that can be used by multiple councils, thereby enabling them to benchmark facilities performance. Using a balanced approach,[3] Logometrix allows a number of council stakeholders (asset and facility managers as well as service managers) to provide tangible and intangible data about facilities. Logometrix has three distinct desired outcomes.

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[3] Refer Kaplan & Norton (1992). Applications of the Balanced Scorecard have also been variously discussed in the literature on facility performance e.g. (Amaratunga, Baldry & Sarshar 2000; Apgar & Bellew 1995; Apgar 1995a; Apgar 1995b).

1. Performance indicators
   Develop a uniform set of criteria and performance indicators that are generally applicable to local government facilities; i.e. facility performance indicators that don't have to be customised for either the type of facility to which they are applied, or to the particular council using them.
2. Benchmarking
   Facilitate benchmarking within individual councils as well as benchmarking of facilities between councils.
3. Logometrix software application
   Develop software solutions for a central database that allows participating councils to enter data and conduct evaluation and benchmarking of facilities over the Internet using a browser-based interface. (Fig.2)

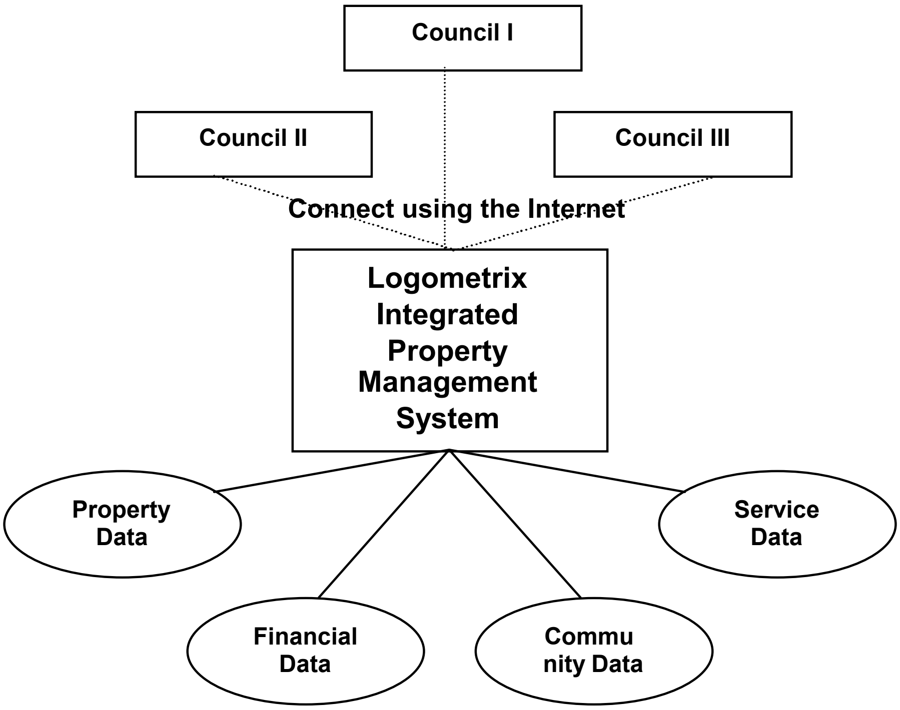

Figure 2: Centralised database with access for multiple councils

This paper provides an overview of the research process and methodology used. In discussing the underlying concepts the measurement of facilities' service performance and benchmarking are emphasised.

Methodology

Logometrix used a collaborative action research approach, which means that the participants in the research are also the main stakeholders. In this 'ground-up' approach, the issues raised during the research process drive the research. An action research methodology was chosen because the study is based around the needs of participating industry partners. Logometrix aims to transform the process of data collection and property values in LGAs through a process of critical inquiry. In doing so the knowledge and expertise of council staff are utilised to inform the development of the model at every stage of the research. At the same time, the close interaction between researchers and council staff is a way for participants to learn about the Logometrix tool and is also a vehicle to foster cultural change within the organisation.

A combination of focus groups, a modified Delphi technique, face to face interviews and a workshop were used to elicit responses and on the ground knowledge from research participants. In all instances participants were targeted selectively on the basis of their expertise and knowledge about facilities, service delivery and council decision making processes.

Research began with a series of focus groups designed to identify councils' strategic objectives. Focus groups were analysed to identify councils' needs in relation to measuring facility performance. This needs analysis was the basis for the Logometrix model. Because researchers felt that additional information was required about certain aspects, a workshop with facility and asset managers was conducted to collect supplementary data. The Logometrix model was then fed back to councils using a Delphi questionnaire. Responses from the Delphi enabled the construction of the final Logometrix model. Simultaneously, researchers worked with software developer to develop the Logometrix software application.

Identifying strategic needs

The development of Logometrix strategic performance indicators was grounded in a detailed analysis of the information needs of participating LGAs regarding the strategic management of their facilities. Building on the insights from the SBS, a series of focus groups was conducted with stakeholders in council facilities.

Focus group participants were selected from industry partner councils and were chosen on the basis of their key knowledge about council facilities. Three main stakeholder groups with an interest in facility decision-making were identified: facilities / asset managers, service managers and councillors.[4] A total of seven focus groups were conducted: two with asset and facilities managers; four with managers of councils services (aged care and disability managers, library managers, community services managers, parks and recreation managers); and one with councillors, who are the elected representatives of the community and decision makers within council.[5] The intention was that each focus group should be composed of one person from each of the eight councils. However, due to scheduling and participant availability this was not always possible. Where persons with key knowledge about council facilities were unable to attend focus groups, one-on-one interviews were conducted using the focus group questions.

Focus groups identified the strategic objectives and information needs of stakeholders in relation to facility performance, how they interpreted their respective LGAs' strategic missions, priorities, and what they thought should be measured about facility performance. The questioning route was derived according to the process

[4] For a detailed description and rationale of stakeholder group identification refer Brackertz & Kenley 2002a: 130.

[5] For a detailed description of the focus group process and its results, refer to Brackertz & Kenley 2002b.

suggested by Morgan and Kruger (1998) to: test existing assumptions; allow discussion to reveal and explore any further assumptions and issues; be general, so as not to limit the input to a narrow area; and elicit responses on the same issues from different perspectives.

The focus group interviews were recorded onto audio tape to ensure comprehensive data capture. Tapes were transcribed verbatim, omitting only participants' names and any identifying characteristics to preserve anonymity. Transcripts were then imported into QSR NUD*IST (a software application that allows for qualitative data analysis using coding techniques) and coded according to emerging themes. In a second coding pass, codes were reviewed and refined to identify major themes relevant to the research brief.

Focus groups provided detailed insights about councils' information needs, as well as contextual insights about facility management and decision making processes. The results of the needs analysis were related back to industry partners by way of a commercial in confidence report that contained detailed findings (Brackertz & Pontikis 2000).

Focus group results

Focus groups confirmed the approach taken for the SBS pilot study: the centrality of facilities in enabling effective service delivery to the community and the necessity of balancing services and facilities data to capture this.

It was found that in line with councils' strategic aims, facility performance can be measured as a combination of effective service delivery, satisfaction of community needs, physical viability and financial sustainability. Each of these four perspectives represents a dimension of facilities' ability to enable effective service delivery. Hence, Logometrix adopts a balanced approach to performance measurement that incorporates each of these four perspectives and uses tangible and intangible data about facility performance. This differs from traditional approaches in facilities management, which are primarily concerned with ratios of space (m2), cost and number of employees.

Focus groups also highlighted the need for a new and commonly understood definition of 'facility'. During the focus group process, participants had used the term 'facility' with varying meanings, sometimes referring to the building, sometimes to the service provided, and sometimes to a combination of the two. In local government, the facility physically represents the place where service provision and the building intersect (Fig.3) and can be defined as follows:

Building refers to the physical structure and fit out of that structure used to house a service;

Service refers to the service or program (human element) provided from the building; and

Facility refers to the combination of the service and building where the two are inextricably linked, as they are in reality

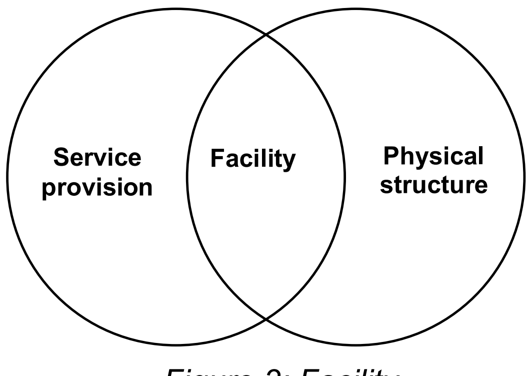

Figure 3: Facility

and includes the land, space, environment and communications that allow a particular service to be delivered from a location.

The strategic objectives identified by the Logometrix needs analysis in the Stage 1 Report (Brackertz & Pontikis 2000) confirmed the concept underlying the SBS. This proved that the SBS model is not restricted to one particular LGA and can be transferred to multiple councils. In addition, focus groups added significant contextual insights about councils' information needs as regards the management of their facilities. These provided the base data for the construction of a refined model of facilities performance measurement with wider applicability and the added ability to benchmark across councils.

After establishing councils' strategic objectives and information needs the next step was to develop a framework for data gathering and a set of indicators that would capture strategic outcomes and could be applied to a range of facilities in multiple councils. While the Stage 1 Report included preliminary suggestions for performance indicators (Brackertz & Pontikis 2000: 41-65), these were merely intended as *examples* for readers of the report and did not represent a completed outcome.

The preliminary model of the Logometrix performance measurement tool aimed to marry the theoretical foundations of strategic balanced performance measurement within a stakeholder context and provide a standardised interface for data collection applicable to different types of facilities and across multiple councils.

In order to facilitate this, data from focus groups was restructured and re-evaluated to create a pilot model of the Logometrix integrated facility management tool. A detailed review of the performance management literature was undertaken, as was an analysis of the strengths and weaknesses of other commercially available strategic facility performance measurement and management tools.[6] In order to gain additional insights on areas which researchers felt had not yet been fully explored, an additional half-day workshop was conducted with representatives from the facility and assent management areas of each participating council. The insights thus gained were used to generate a template for a working model of Logometrix. The model was then tested using a modified Delphi technique before the final version of Logometrix was created for development into a software application.

Modified Delphi

It was decided that the best way to confirm the validity of the Logometrix pilot and to test its useability was to ask the intended end-users to review the model. Ideally, end-users would have been asked to assess the Logometrix model in the form of a software application, as this would be the way the tool will be finally presented to them. However, because of the cost of developing software using incomplete

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[6] Eg. Hinks & McNay (1999), have developed a *management-by-variance* tool that assesses the effectiveness of the facility management function by linking to its (internal) clients' requirements. The Organisation of Higher Education Facilities Officers has developed SAM (*Strategic Assessment Model*) which is built around The Malcolm Baldridge Criteria for Performance Excellence and the *balanced scorecard* (Givens 2000; http://www.appa.org). The International Centre for Facilities (http://www.icf-cebe.com) has developed a method called *Serviceability Tools & Methods* (ST&M). This works at the macro level, with a method that matches demand (occupant requirements) to supply (serviceability of buildings) in relation to the facility's ability to support/impede the strategy of the business or the functioning of its occupants.

specifications, it was decided to pre-test the Logometrix model using a paper-based questionnaire In keeping with the principles of action research, a modified Delphi technique seemed appropriate for this purpose.

The Delphi method is a way of structuring group communication so that is effective in allowing a group of individuals, as a whole, to deal with complex problems using written responses. Delphi is an iterative process and is able to accommodate diverging opinions. The success of the Delphi depends of the input of experts, their knowledge and practical engagement with the issues and their capacity and willingness to contribute to the exploration of the problem and along with this assurance that sufficient time will be dedicated to the Delphi exercise (Adler & Ziglio 1996).

Based on these criteria, and to allow for continuity in the research, Delphi experts were selected from focus group participants. Where focus group participants were not willing, or available, or had left their positions within council, persons with similar background to the original focus group participants were recruited.

Delphi participants were provided with a paper-based model of the Logometrix management tool. This was designed to resemble as closely as possible – in form and content – the Logometrix software application that was being developed in parallel. This necessitated that each of the questionnaire pages was designed to visually resemble a data input screen.

Delphi experts were asked to evaluate the Logometrix model in light of two questions, namely the *validity* of the model and the *useability* of the interface.

Delphi experts were encouraged to comment on any aspect of the Logometrix model, to ask for clarifications, or argue in favour or against issues. Experts were also asked to identify items they deemed superfluous or suggest the addition of items they felt had been omitted.

All in all, 37 questionnaires were sent out to 8 councils. Of these, 23 questionnaires were returned (a response of 62.2%), of these 21 were valid replies (56.7%).

It was the intention to conduct a full Delphi process. However, after implementing the first Delphi questionnaire it was found that the time and effort required to set up the Delphi procedure was not warranted by the information gained from the responses. In addition it was considered inappropriate to ask respondents to volunteer a significant amount of their time for the outcomes this provided. However, the responses to the Delphi questionnaire were largely positive and proved to be constructive in the generation of the final Logometrix model. It is intended that the Logometrix model be reviewed and revised if necessary after its implementation with councils in late 2002.

From a methodological point of view the results of the research process are still considered to be valid. Focus groups posed the research question in broad terms and elicited information about facility performance and councils' strategic aims. The Stage 1 Report reported back the complex issues and ideals generated, and structured feedback on the model was gathered using the paper-based questionnaire. This provides a solid foundation and justification for the model presented here.

The Logometrix model

The original SBS comprised four Perspectives of facility performance, namely the services, building, community and financial perspectives (Fig. 1). Focus groups and the workshop with facilities and asset managers showed that *utilisation* was considered a crucial aspect of facility performance and warranted consideration in its own right. Consequently, utilisation was 'promoted' from being a subset of the Service Perspective to being a Perspective in its own right. This decision was supported by evidence from the SBS pilot study, which had shown utilisation to be a significant and useful indicator of facility performance. Especially in the not-for-profit context of local government, capital and maintenance expenditure on facilities are considered a worthwhile expenses if they are balanced by high levels of service use, as expressed through utilisation.

Evaluation of the Delphi questionnaire brought about another change to the Logometrix Perspectives. Initially the Building Perspective had included a sub-set of data called Energy Efficiency. However, responses to the Delphi showed that many councils now manage according to the principles of the triple bottom line, which includes economic, social and environmental outcomes. Respondents felt that assessing facilities in relation to energy efficiency was insufficient and that the approach should be broadened to encompass other environmental factors, such as water and waste management, recycling, and the use of environmentally friendly building materials and methods. Consequently, the Environmental Perspective became the sixth perspective and accommodates experts' suggestions.

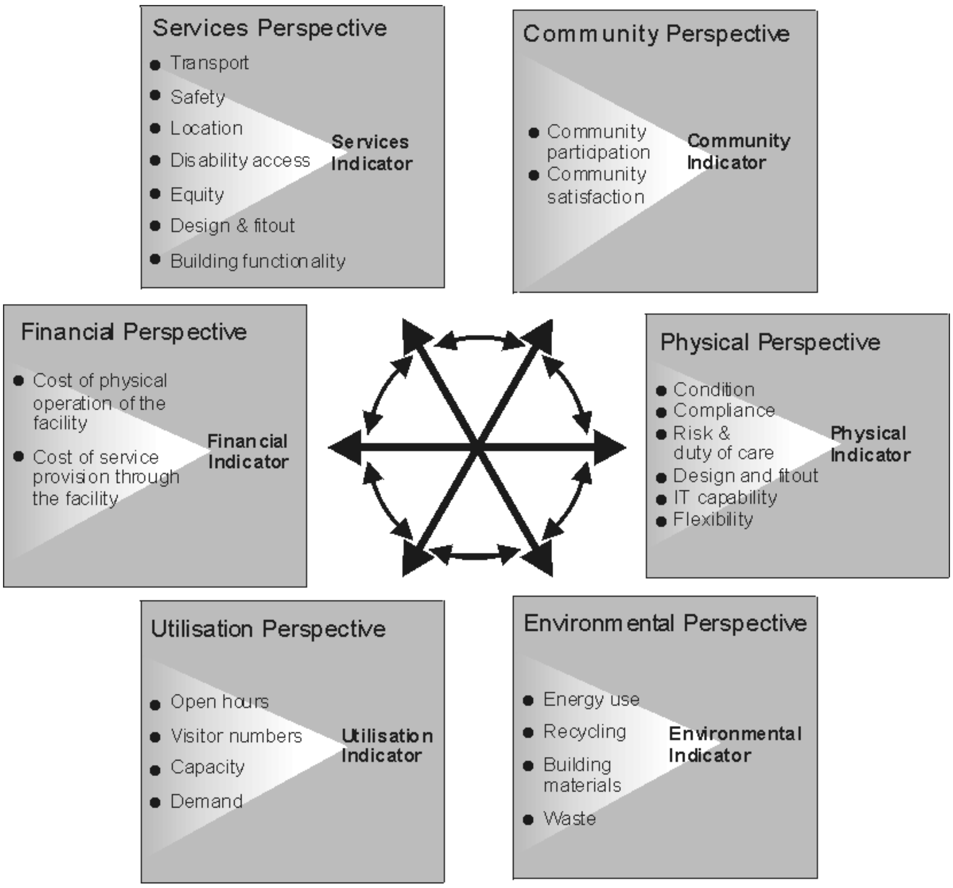

Figure 4: The six Logometrix Perspectives

The final Logometrix model balances the following six Perspectives, each of which is made up of an number of elements:

- Service Perspective
  Objective: Council aims to provide facilities that enable the effective delivery of services that are appropriate and meet the needs of the community.
  Elements: transport accessibility, safety, location, disability access, equity of access, design and fitout, building functionality
- Physical Perspective[7]
  Objective: Council aims to provide buildings that are fit for the purpose for which they are being used.
  Elements: building condition, maintenance, compliance, risk and duty of care, IT capability, flexibility
- Community Perspective
  Objective: Council aims to provide facilities that support and facilitate the delivery of services that meet the needs of the community.
- Elements: community satisfaction, community participation
- Financial Perspective
  Objective: Council aims to provide facilities that are economically sustainable and are affordable to the community.
  Elements: service cost, building cost
- Utilisation Perspective
  Objective: Council aims to provide facilities that are available to the community at times of demand and that are well utilised.
  Elements: opening hours, user numbers, capacity, demand
- Environmental Perspective
  Objective: Council aims to provide facilities that are environmentally sustainable.
  Elements: Australian Building Greenhouse Rating Scheme, energy management, recycling, waste management, building materials

Performance Indicators

Each of the Logometrix Perspectives is represented by a Key Performance Indicator (KPI). These are the top-level indicators used to determine how well council facilities are performing according to the agreed upon strategic goals.

Underlying each Key Performance Indicator is a set of Element Scores. These lower level indicators capture aspects of performance that are prerequisite to the achievement of strategic goals. Each Element in turn is derived from a set of raw data about the facility. Together these three tiers of data and indicators are a powerful tool for evaluation facility performance.

Beginning with the broad overview provided by the KPIs, councils can ‘drill down’ to the next level of data, the Element Scores, to obtain more detailed information about facilities’ strengths and weaknesses. Raw data, finally, can pinpoint specific reasons for a facility’s success or failure.

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[7] The name of the Building Perspective was changed to Physical Perspective to avoid confusion.

The Service Indicator

The issue of collecting standardised data on facility performance for the Service Perspective proved to be a particular challenge. Data about facilities' service function is often of an intangible nature and cannot be expressed in dollars and meters. In order to capture this intangible data a set of statements was developed that described each aspect of a facility that was considered vital to enabling service delivery in line with strategic objectives. In other words, each statement described one *criterion* of a facility that was important for effective service delivery. The idea was that facilities could then be scored against these criteria to see whether they supported or hindered service delivery.

However, different services, such as kindergartens and libraries, for example, have different requirements of their facilities and are not easily comparable. Thus not every criterion for service enablement is relevant to every type of facility. So how can a uniform set of performance criteria be applied to a diverse range of facilities? The solution is to score each criterion twice; first in relation to whether or not the criterion is *required* for service enablement, and then in relation to its *actual performance*.

As stated previously, it is councils' objective to provide facilities that enable the effective delivery of services that are appropriate and meet the needs of the community.

This objective is circumscribed by seven Elements that describe how the facility must enable service delivery in order for the strategic objective to be achieved.

- Transport accessibility (Council's objective is to provide facilities that are physically accessible the community using appropriate modes of transport)
- Safety (Council's are responsible for providing facilities that feel and are safe for employees and the community)
- Location (Council strives to locate facilities in such a way that provides added benefits for users
- Disability access (Council aims to provide facilities that area accessible to community members if all abilities)
- Equity (Council strives to provide facilities that promote equity within the community)
- Design and fit-out (Council aims to provide facilities that are well designed and fitted out for the intended uses)
- Building functionality (Council aims to provide buildings that meet the requirements of users and that are fit for the purpose for which they are intended)

Each of these Elements is defined by a number of C*riteria* that are described in a series of statements.

		Functional Requirement	Actual Performance
	The facility has adequate car parking.	1 2 3 4 5	1 2 3 4 5
	The parking times are adequate and appropriate for the activities undertaken by the users of the facility.	1 2 3 4 5	1 2 3 4 5
	During opening hours access to the facility by public transport is adequate.	1 2 3 4 5	1 2 3 4 5
	The facility is adequately serviced by community transport (eg community bus).	1 2 3 4 5	1 2 3 4 5
	Safety of bicycle access to the facility is adequate.	1 2 3 4 5	1 2 3 4 5
	The facility has adequate bicycle parking.	1 2 3 4 5	1 2 3 4 5
	The facility is close enough to the target groups it serves and the types of transport they use.	1 2 3 4 5	1 2 3 4 5
	Overall, the facility's accessibility by transport is appropriate to the needs of the target groups.	1 2 3 4 5	1 2 3 4 5

Figure 5: Service Perspective – Transport accessibility screen

1. Scoring the *Functional Requirement*
   The relevance of each individual criterion for the service is determined, that is whether or not the criterion is needed for the service to function effectively. This *Functional Requirement* is scored by the user on a Likert-scale from 1 = Not needed to 5=Essential.
2. Scoring the *Actual Performance*
   In a second step the facility is assessed in relation to its *actual performance* on the criterion. A five point Likert-scale from 1 = Doesn't meet to 5 = Exceeds is used.

Note that the *Functional Requirement* and the *Actual Performance* scales are independent of one another.

3. Calculating the *Element Score*
   The *functional requirement* is used to identify which of the standard set of Logometrix criteria are needed to enable effective service delivery to the community. Only criteria rated 3 to 5 on the Likert-scale ("desirable", "needed" or "essential") are considered important in this respect. Functional requirements are then collapsed into two categories:
   - Not Important (scores 1=not needed, 2=optional) – indicates that the criterion is not required to enable service delivery
   - Important (scores 3=desirable, 4=needed, 5=essential) – indicates that the criterion is required to enable service delivery

   Any criteria rated "not important" are not considered in further calculations, as these criteria are not important for the particular service being assessed.

   Scores for criteria rated "important" on the Functional Requirement scale are summed and divided by the number of items. This results in a value between 1 and 5, the *Element Score*. The Element Score reflects how well the facility succeeds in supporting the strategic objective of the particular service Element (eg transport, safety, etc).

Criteria for other Service Perspective Elements are scored in the same way.

4. Calculating the *Service Indicator Score*
Results for all Element Scores are summed and divided by the number of Element Scores. The resulting *Service Indicator Scor*e gives a general overview of the facility's service performance. The Service Indicator Score can then be evaluated in relation to councils' objective of providing facilities that enable the effective delivery of services that meet the needs of the community:

    1 = Poor Service Enablement
    The building is not suited to the service's needs and service delivery is restricted because of building-related impediments.

    2 = Insufficient service enablement
    The delivery of community services is not facilitated and supported to the extent needed and in some instance service delivery may be hampered due to building related impediments.

    3 = Partial Service Enablement
    The delivery of community services is not supported and facilitated to the full extent required, but service delivery is not significantly hampered.

    4 = Adequate service enablement
    Service delivery is facilitated and supported to a satisfactory level.

    5 = Excellent service enablement
    The delivery of community services is facilitated and supported beyond the basic requirements and has added benefits for users and staff of the facility.

Note that the process of averaging leads to a loss in meaningfulness of the resultant value due to the multiple effect of collapsing data and using relative data. Consequently the Service Indicator Score should not be read in isolation, but has to be considered in context. Any interpretation of service performance that goes beyond a general overview must consider the Element Scores to backtrack and find specific areas of concern.

Benchmarking

Benchmarking is done by scoring each individual facility out of a total score of 100. This provides a snapshot of overall performance and allows facilities to be ranked against other facilities of their type, and across facility types. The benchmarking process is best illustrated by way of an example.

Perspective Indicator	Weighting
Service Perspective	25
Community Perspective	20
Building Perspective	18
Utilisation Perspective	17
Environmental Perspective	10
Financial Perspective	10
Total	100

Fig. 6: Weighting Perspectives

1. Each Perspective is assigned a weighting according to its strategic importance. The individual councils undertake this weighting process. In this example (Fig. 6), the Council of Sharing Caring has decided that its main aim is to provide services that meet community needs. Service provision and community satisfaction are considered the most important objectives, while the cost of running the facility is the least important aspect.
2. *Perspective Indicators* for each facility are calculated using the Logometrix tool.
3. A category average for each Perspective Indicator is taken.
4. Perspective Indicators for the individual facility are then compared to the average of all facilities of its type. If the individual facility performs at or above the category average, it is awarded the weighting score is assigned according to the table. If the facility performs lower than the category average, a weighting score of 0 is recorded.
5. The weighted scores are then added up for each facility, thereby providing the overall weighted facility indicator score out of 100.
6. Facilities may then be ranked against other facilities of that type, or cross facility type comparisons may be made.

Conclusion

The integrated facilities management tool developed for this study allows LGAs to evaluate facilities in relation to strategic aims. Logometrix differs from traditional approaches to facility performance measurement in that it balances tangible and intangible data and relates facility performance to the strategic goal of service delivery. Logometrix accounts not only for facility cost, but also for functionality. This approach is particularly valuable in the case of local government where profitability is not considered as important as service delivery to the community.

In addition, Logometrix provides a benchmarking system that allows councils to weight strategic areas of facility performance and to rank facilities according to their achievement of strategic goals. In this way Logometrix facilitates comparison between facilities that are of like type, as well as facilities that are of from different categories.

Benchmarking in conjunction with the three tiers of data and indicators provided by Logometrix (performance criteria, Element scores and Perspective KPIs) empower councils to make informed strategic decisions about facilities.

Further Research

Logometrix has been designed to meet the needs of LGAs and was developed for a not-for-profit environment. There is, however, considerable scope to apply Logometrix to a corporate environment. While the private sector is more focussed on bottom-line performance, corporate organisations, too, can benefit from evaluating their real estate assets in relation to their contribution to strategic outcomes.

Acknowledgement

The authors would like to acknowledge the support of the following organizations: Bass Coast Shire Council, City of Darebin, City of Glen Eira, City of Greater Shepparton, City of Maribyrnong, City of Melbourne, City of Port Phillip, City of Stonnington, Xpedite Professional Services. The ongoing support of the Australian Research Council is also gratefully acknowledged.

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Appendix I - Timeline

June to December 1999 – Service Balanced Scorecard Pilot
The City of Port Phillip (Melbourne, Victoria, Australia) approached United Consultants and the Corporate Real Estate and Asset Management Research Group (CREAM) at the University of Melbourne, with a brief to develop a set of indicators for its community facilities. Indicators were to reflect the facilities' ability to deliver services to the community. The Service Balanced Scorecard (SBS) was the result of this research and provided the critical connection between the role physical facilities and the delivery of public services in a local government setting. The SBS was implemented with the City of Port Phillip in late 1999 (refer Brackertz & Kenley 2000; Brackertz & Kenley 2002).

January to June 2000 – Collaborative Logometrix Research Project is formed
The successful implementation of the SBS generated considerable interest from other LGAs in Victoria. Consequently a collaborative research arrangement was set up with the cities of Stonnington, Melbourne, Maribyrnong, Glen Eira, Darebin, Greater Shepparton, Bass Coast and Port Phillip. A software developer, Xpedite Professional Services and the law fir Maddocks, also joined; the Victorian Department of Infrastructure - Office of Local Government supported the project. The research was to be conducted CREAM at the University of Melbourne. The result of this collaboration is Logometrix (Local Government Facilities – Strategic Performance Measurement).

Collaborators applied for a SPIRT Grant (Strategic Partnerships with Industry – Research and Training Scheme) from the Australian Research Council (ARC). These grants support academic research and provide matching funds for contributions by Industry Partners to facilitate projects that are relevant to Industry and beneficial to the wider Australian community. The grant was submitted to the ARC in September 2000.

July to December 2000 – Logometrix Stage 1

Because of the uncertainty of whether the grant would be awarded, Logometrix was initially funded independently by the Industry Partners and commenced research in July 2000.

Logometrix Stage 1 was an analysis of LGAs information needs in relation to the strategic measurement of facility performance. The results of this research are published in a confidential report to participating councils (Brackertz & Pontikis 2000).

January 2001 – December 2002 – Logometrix Stage 2

The ARC grant was awarded and the research on Logometrix Stage 2 commenced. It was decided to shift the research from the University of Melbourne to the Institute for Social Research at Swinburne University of Technology, Hawthorn, Australia, as the Institute has an extensive and distinguished record of research with LGAs and was considered a fertile environment for the Logometrix to flourish. Here the final Logometrix tool is currently being developed.

AN INTEGRATED APPROACH TO ASSESS FACILITIES PERFORMANCE

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Abstract
Formulation of tools, which assess 'Facility Performance' in terms of quality, cost and effectiveness, is cardinal for 'Organisational' and 'Facilities Management' advancements. In the view of addressing the emerging assessment needs in the domain of facilities management, 'Integrated Facilities Performance' (IFP) concept is proposed. IFP aims to formulate a holistic measure that amalgamates building performance indicators and business/organisational performance domain. Stakeholder systems perspective employed to conceptualise IFP had identified four crucial stakeholders, namely customers, employees, experts and organisation. Transformed into four distinct models, these systems constitute the base for IFP assessment. Decomposition of each independent model into various subsystems of 'mandates', 'limits' and 'terms' capture the real meaning of IFP. Customer, employee and organisational models propose weighted approach to modelling, while expert model explores the application of probability approach to modelling. Ultimately, IFP framework integrates various individual attribute scores into a single performance score. Nevertheless, flexibility to obtain scores according to organisation's necessities is possible.

Keywords: Integrated facilities performance; organisational effectiveness; stakeholder perspective; systems approach

INTRODUCTION

The environment created for the occupants of a building[1] influences the performance of the activities (Then, 1999) carried out in a building. Therefore, organisations, in general, desire facilities[2] that are comfortable to occupy, cost-effective and efficient to run, and for those facilities to remain as added value assets (Douglas, 1996). Meanwhile, property professionals pay more attention to resources other than property because those resources are believed to have greater impact on the achievement on the organisational goals (Walters, 1999). Thus, facilities and organisational management domains had only marginal interactions in the past, and also performance assessment methods from both these domains had continued to neglect the other perspective in their measurement until now, when complex business environment urges for an intensive dialogue between them. This enabled the emergence of 'Integrated Facilities Performance' (IFP) concept.

[1] Building only refers to the physical object and its components
[2] Facility is a physical setting to serve a specific purpose. That is facility incorporates the physical environment and its use.

Establishing The Need

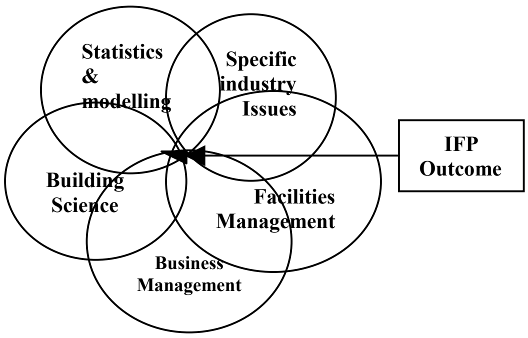

Figure 1 Multi-disciplinary approach of the concept.

'What performance really means' and 'to be able to measure it' are the most crucial aspects to be understood to embark on a performance measurement exercise. Therefore, key components of a performance measurement system are the 'conceptual definition of performance' and 'the method of measurement' (Williams, 1993). Numerous and different approaches to performance measurement are found with different goals and measurement methods which treat building as a physical object, as a facility or as an investment (Bruhns & Isaacs, 1993). However, a serious criticism raised by much of the work is that the existing building assessment methodologies generally failed to make any connection between the performance of buildings and work organisation as a context to grasp the holistic overall performance measures (Alexander, 1997). Specific standards of measurement matrices are essential to identify performance gaps, however, isolated matrices do not reflect the overall performance of the business, and that as a consequence may not revel the significance of facilities decision on overall success, until a more holistic approach is applied (Massheder and Finch, 1998).

Business associated performance/quality measurement tools are predominantly financial related, while only a few of the tools incorporate environmental issues in a very broad sense (SERVQUAL *Parasuraman et al. 1988;* SERPFRF *Cronin et al. 1992;* Balance score card *Kaplan & Norton 1992*). They neither are substantially detailed nor yield adequate information for a facilities/property manager to act upon. However, these tools are conceptually well embedded with multiple perspectives to performance. Thus, assessment of facilities performance in an integrated manner requires a tie between facilities data and business/organisational data that cross-links the physical, spatial and environmental databases describing the facility characteristics, with information concerning the operational behaviour of management and users, and financial consequences overall (Bev Nutt 1993).

This paper intends to couple the concepts of 'Building Performance' and 'Organisational performance' into 'Integrated Facilities performance' (IFP), a holistic perspective, to assess factors influencing organisational success. Furthermore, a methodology is proposed to operationalise IFP score.

Definitions Of Concepts

Prieser *et al*. (1988) defines performance as "the ability of an environment to support occupant requirements as described by evaluation criteria". In a simple term, performance is 'achievement against intention'. Moreover, Standard terminology of definitions from ASTM 1992 for '*Building performance'* and '*Facility performance'*, suggests that former embraces pure technical perspective with respect to total or components of building, whereas the latter extends beyond by affiliating human interaction with the building. However, by definition 'Facilities Performance' does not account organisational or business realm in its essence.

Terzovski (1999) measures "*Organisational Performance*" by employee relations, customer satisfaction, operational performance (quality & productivity) and business performance (profitability). *Business* and *Operational Performances* are concerned with the contribution towards financial and marketing objectives. However, organisational effectiveness measure depends on the perspective of the person selecting the criteria, ultimately leading to a value judgement. This paper measures '*Organisational Performance*' in terms of employee performance, customer service performance, operational performance and financial performance.

"***Integrated Facilities performance***" (IFP) is defined as 'the hybrid domain integrating the core business performance measures and measures associated with the behaviour of the facility in achieving organisational effectiveness'. IFP will attempt to focus on commingling variables pertaining to performance of building and organisation into a new taxonomy with systems approach. IFP is multi-disciplinary in nature, as indicated in Figure 1, encompassing many areas of study.

RELEVANCE OF THE 'BUILT-ENVIRONMENT' TO 'BUSINESS PERFORMANCE'

Environmental Influence on Organisational Performance

Studies on the relevance of environment to human performance can be traced back to 1920's (Meharabian *et al.* 1974). Very eminent management theories that had considered the effect of environment on human performance are worth noting. Although, Vroom (1964, p203) constructed 'Performance' as a function of 'Ability x motivation', preceding researches insisted on many other influences on performance. However, eventually, the 'working conditions' and 'environment' (Peters *et al*. 1980) began to capture prominence in motivational research. Hawthorne experiment, which is a landmark study, as part, studied the effect of lighting environment on workload (Mayo 1949). Moreover, Maslow's theory of 'hierarchy of needs' and writings of Herzberg, a psychologist, included the environment in his taxonomy of work related to factors affecting job satisfaction. In the early years the field of Human Engineering attempted to relate work efficiency to physical stimuli (Mehrabian *et al*. 1974). With time, research on environmental effects and performance were carried out in the management domain, in isolated research efforts with little reference to organisation as a whole, and in fields such as environmental psychology, human performance, human ecology, human behaviour, applied psychology, consumer behaviour etc.

Environmental Differentiation: A source of Competitive Advantage

For firms to survive, it has become necessary to keep ahead of competitors. In the recent past researchers and writers of business management, stressed on sustaining competitive advantage as a means for business success (Porter, 1985; Douglas 1996; Bharadwaj *et al.*, 1993; Bell, 1999). Effective building environmental differentiation can add perceived/actual value or uniqueness in the mind of the customer with regards to an offering and can contribute for competitive edge.

Critical Success Factors[3] (CSF) is one approach for gaining competitive advantage and this helps managers to ensure that resources under their authority are directed towards important areas. It is intended that outcomes of IFP assessment should yield CSF's which are helpful to gain business success. Nevertheless, CSF approach gains criticism over the difficulty in application, validity against the analyst-manager biases and difficulty in dealing with true causality. Therefore, a sound theoretical and analytical approach is adopted in conceptualising and applying IFP assessment rather than the original approach suggested in identifying CSF's. Prior to constructing a scientific model to assess IFP, a holistic conceptual framework showing various connections of issues and links to built environmental assessment in a real world sense is mandatory.

A HOLISTIC PERFORMANCE APPRAISAL

Systems approach is proposed to conceptualise and measure IFP holistically. Since, systems can be developed with different perspectives, formulation of a perspective that captures the 'constructs' and 'attributes' with most sense is a challenging exercise. This paper categorises a new taxonomy, through stakeholder - systems perspective, for measuring 'Integrated Facilities Performance' which ensures holism.

Systems Approach to IFP

Generally in the definitions of holism, the parts of an organisation do not receive consideration, and the characteristics of the whole of the organisation should be the subject of attention. Term 'holism' must take into account that the components of complex systems are so connected, and that taking account of these connections and taking a total view of situations can only discover knowledge and understanding of their behaviour (Mason 1997). Therefore, first step to execute holism is to identify all the systems connected and classifying them in a sensible manner. "A system can be characterised as a pattern of elements in mutual interaction, where the boundaries that delimit it are dependent on the activity under consideration" (Krippner and Combs 1998, p81). Exploration of the meaning of 'system' only needs identifiable entities and connections between them (Mason 1997). Classifications of sub systems and their properties would form a comprehensive and unified base that permits levels of decomposition, or construction of higher levels with compatibility satisfying requirements for holism. However, a brief overview of the existing performance concepts would shed some light into the systems that needs to be considered for a holistic Built Environmental Assessment.

Performance in Perspective

Performance is based on the practice of thinking and working in-terms of goals (ends) rather than means (Douglas 1996; Alexander 1997). Performance of the building is dictated by the way in which building users interact with its physical, business and work environments. Buildings, despite their relatively low-tech makeup,

[3] CSF are the "limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organisation" (Rockart, 1979, p 85), while " … those managerial or enterprise areas … must be given special and continual attention to bring high performance" (Boynton *et. al.*, 1984, p. 17).

are a complex arrangement of systems and sub-systems. Like any such entities, for each, the whole is more than the sum of its parts. Further, stages of the building production and building consumption have been constructed to clarify key conceptual differences (Alexander 1997). Complexity increases further when the buildings are products itself for consumption and offer/or a base for offering services in another sense. One way to interpret it is with the 'Consumption system' approach (Mittal *et al*. 1999). The selection of performance criteria has to be done therefore within the context of the property concerned and based on the needs of the client (Douglas 1996). Needs of the client may capture more complex systems and sub systems in concepts such as "total quality management' and 'sustainable development' which lead business towards a wider holistic approach to their activities (Walter 1998). A holistic perspective means that performance should not be defined only for a single 'stakeholder', but from organisation's key relationships in an all 'inclusive' approach (RSA 1995).

A 'STAKEHOLDER-SYSTEM APPROACH' TO PERFORMANCE ASSESSMENT

Although the term 'building performance', the way in which users interact with physical, business and work environment, may sound simple, different taxonomy of 'actors' involved with widely differing interests and requirements make this definition more complex (Cole, 1998). Stakeholders are all those claimants inside and outside the firm who have vested interest in a problem, and when they are in a position through the resources under their control, they can influence the way the problem is formulated and solved. Otherwise stakeholders may be mainly affecting a problem or being mainly affected by it or both (Banville *et al*., 1998). Goals that are actually pursued will depend in the power of that stakeholder, compared to other stakeholders in the organisation and the environment. Identification of stakeholders is situation dependent, and factors such as characteristics of the situation, the time constraint or the physical proximity may have impact on the stakeholders' involvement in decision-making process. "One must remember that these are no more than heuristics that can help but that can never guarantee the appropriateness of the selection" (Banville *et al*. 1998, p28). Most stakeholders' taxonomy is not mutually exclusive.

Literature screening and subsequent analysis distinguished four active stakeholders, with respect to facility assessment, in a general business set-up, and they are ***Customers, Employees, Government/legal/ experts*** and ***Organisational-management/Owners*** (whereas others are dim or silent stakeholders). Relationships of stakeholders to organisations will be decided on their relative importance. Customers have the bargaining power (assuming perfect competition); employees have union power; government bodies and special interest groups (such as environmentalists) have their goals met either by legislation or political pressure. These are some examples to indicate the kind of powers and controls exercised by the stakeholders. However, the relative importance of each stakeholder may also differ across companies. Some companies feel their main assets are the customers (Kaplan & Norton 1992), whereas for some it is the employees (Walters 1999). However, although, this classification is comprehensive for general set-up, a more detailed classification may be needed to represent some of the complex businesses.

A CONCEPTUAL FRAMEWORK FOR ASSESSMENT OF BUILT ENVIRONMENT

Boundary management in the creation of IFP concept is very crucial, not only in terms of addressing definite network connections, but also during the application. Due to its interdisciplinary nature, IFP concept may create friction with other disciplines and may refrain them from co-operating with Facilities managers, if IFP sphere penetrates deep into other domains. Figure 2 explains graphical illustration of the encompassing spheres of IFP concept.

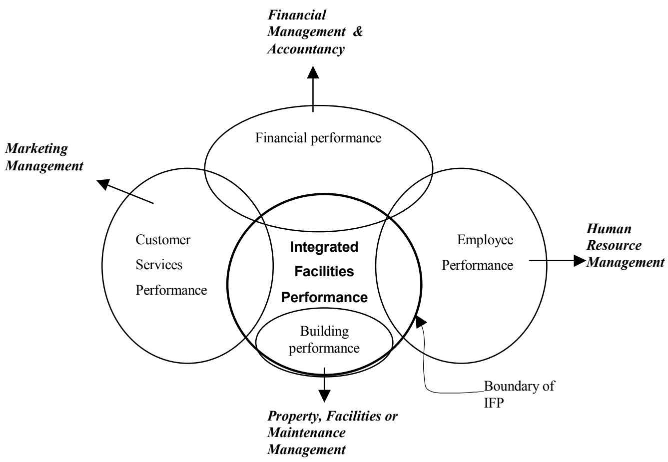

Figure 2 - Interaction of various disciplines related to IFP.

Generally, research narrowing down only to a 'survey definition' level, a simple list of attributes with finite number of elements, excludes all the yet unexplored areas of the field, and is therefore inadequate. Social science research constitutes a complex of variables, objects, buildings, or combinations of persons and physical settings; thus, relating a particular behavioural change to a specific environmental stimulus is an arduous task, if not impossible. Nevertheless, a conceptual framework must be constructed with concepts and logical reasoning or/and focused research findings.

Developed into greater detail from Figure 2, Figure 3 expands organisations' environmental domain in attaining sustainable business. This broad theoretical framework encompasses the selected stakeholders, towards sustainable business by constructing paradigm connections through past research evidence from various backgrounds rather than basing on heuristics. Main purpose of this framework is to derive a model to assess IFP in a strategic set-up and to help formulating appropriate future strategies through identifying important factors affecting organisational performance.

APPROACHES TO ASSESSMENTS

Three major approaches found in literature for measuring building related assessment are by Vischer (1989), Hartkopf *et al.* (1986) and Preiser *et al*. (1997). Vischer (1989) identifies four categories of problem analysis, application of standards and codes, satisfaction of users, reductionist approach and environmental determinism. Each category has is own merits and demerits. In brief, the reductionist approach attempts to isolate units of environment experience, and to decompose units to small parts that can be observed and possibly measured and then all these parts are composed to constitute environmental quality.

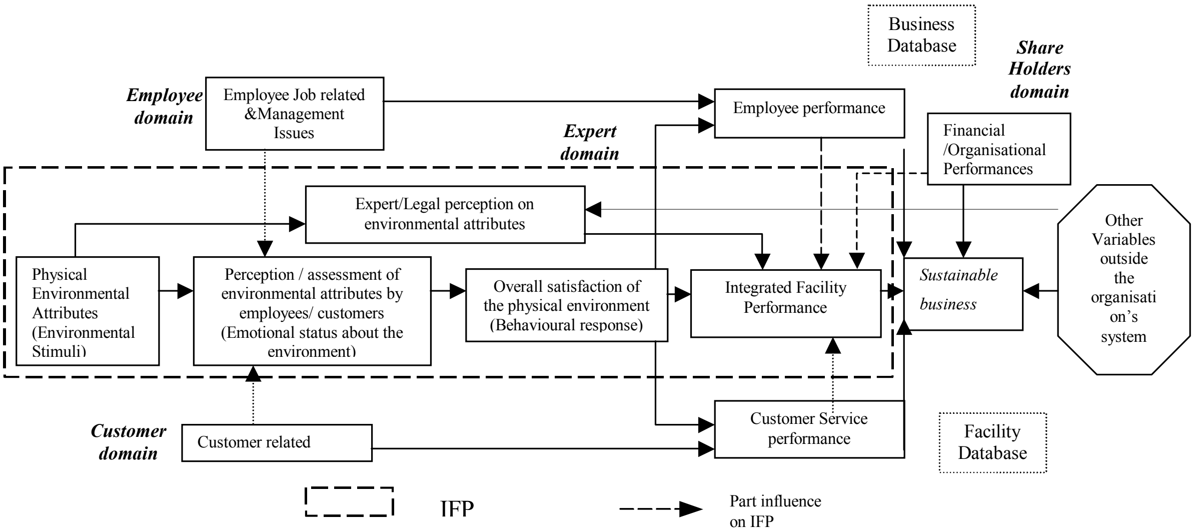

Figure 3 – A holistic conceptual framework for performance assessment of built environment.

Another approach constructed by Hartkopf *et al*. (1986) based on 'Building diagnostic' concept, approaches building performance by establishing 'Performance Mandates', 'Limits of acceptability' and 'Terms of Evaluation'. Preiser (1988) defined the performance under four major classifications: technical, functional, economical and behavioural. However, Post Occupancy Evaluation habitability framework (Preiser 1997) attempts to suppress the above four classification into a three levels of performance, namely, Health/Safety/security level, Functionality/efficiency/work factors and Social/psychological /cultural level of performance including aesthetics.

Section below takes an 'analytical scientist' approach, in moulding the IFP assessment conception from the conceptual framework in Figure 3, characterising well defined, precise, self-consistent, explanatory, analytical framework with accuracy, reliability, and objectivity.

THE CONCEPTUAL FOUNDATION AND ANALYTICAL FRAMEWORK FOR IFP

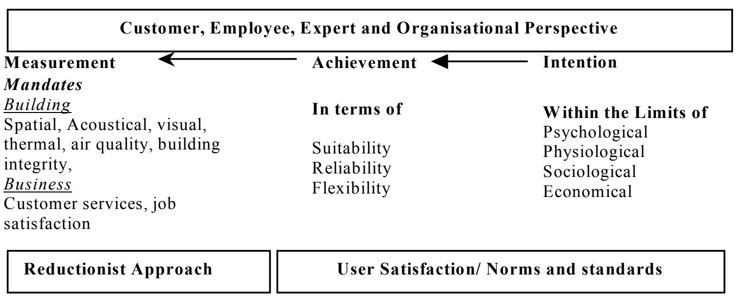

Figure 4 - Foundation for assessment.

IFP assessment foundation in Figure 4, is a complex of various views, systems and approaches, and has endorsed the whole of building performance and part of the business performance attributes from the network connections showed in Figure 3. Further, Reductionist approach is viewed as the most suitable to account the IFP, since it enables decomposition, measurement, and then composition of this complex phenomenon.

Mandates of Assessment	Technique of data collection	Goals	Parameters	Instrument	Measurement in terms of	Relevant Limits	Application
Indoor Air Quality	Occupants Survey	Comfort		Questionnaire	Suitability	Psychological/ Sociological	Customer & Employee model
	Complex Instrumentation	Health	CO_2	Bruel & Kjare multi gas monitor type 1302 and Innova multi point sampler type 1309 and Innova software 7300		Physiological	Expert model
			CO				
			TVOC				
			Formaldehyde				
	Simple instrumentation		Dust count	Dust monitor – Grimm Seris 1:1000			
			Bacteria and Fungi	Anderson Centrifugal Air Sampler			
	Expert Judgement	Efficiency of the operations and economics		Expert Knowledge	Flexibility Reliability	Economical	

Table 1 - IFP assessment framework for IAQ mandate.

Foundation for measurement in Figure 4 is transformed into a model to measure IFP as shown in Figure 5. Further, Figure 5 is translated to a framework as shown in Table 1 to operationalise the IFP measure. As an example, consider the measure of '*acceptability and adequacy of air quality*', under the 'Indoor air quality' (IAQ) mandate. Widespread approach to measure this attribute is the occupant satisfaction level or an engineer's opinion. Will these approaches ensure holism? Satisfaction measure accounts only the psychological and part of physiological issues. On the other hand expert opinion accounts part of physiological issues based on the comparison of standards guidelines, and part of economic issues. Since IFP assessment approach intends to capture this measure holistically and accurately, application of stakeholder system perspective decomposed of psychological, physiological, sociological and economical limits in terms of suitability, reliability and flexibility, will be the most decisive way. These Facilities Performance Indicators (FPI) scores from employee ($FPI\text{-}_{Em}$), customer ($FPI\text{-}_{Cu}$), expert ($FPI\text{-}_{Ex}$) and organisational ($FPI\text{-}_{Or}$) perspectives may differ from each other, and this forms a complete, holistic perspective.

IFP framework suggested is general and can be adapted to almost all sections of business. However, in application, development of attributes from this framework needs fine tunings specific to the organisation in question especially on job attributes, customer services attributes and organisational performance attributes. Physical environmental attributes may remain same irrespective of business, but may differ for industrial applications. Table 1 illustrates IAQ attributes relevant to IFP assessment.

MEASUREMENTS AND ANALYSIS TECHNIQUES FOR IFP

Customer, Employee and Organisational Models

Customer and employee models will make use of subjective responses from customers and employees respectively for various attributes, and 'weighted average' concept is proposed to integrate these scores. Proposed organisation model would use recorded management data and employ weighted approach to modelling. Weighting remains controversial aspect of building performance assessment due to the absence of an agreed theoretical and non-subjective basis for deriving weighting factors. However, weight usage is regarded as an avenue to improve most decision-making practices, and therefore weights criterion is proposed. With reference to the

IFP model in Figure 5, weights γ^{ijk} at level R, needs to be generated for Customer (i=1), Employee (i=2) and organisation (i=3) models. Weights at R level are generated from the 'importance' scale data from the customers, employees and shareholder/manager for respective models. Each model will generate weights independent from other models. Although the accuracy of this subjective approach to generate weights is generally questioned, as the Employee and Customer models would mostly account the limits of physiological and sociological (refer Table 1) aspects, this approach is regarded to be the most appropriate. However, validation of weights generated by various methods should be tested during calibration of the model. This involves statistical tests such as reliability analysis, multivariate analysis of variance, factor analysis and multiple regression.

Expert Model

As Expert domain looks at physiological perspective, if weighted approach to be adopted, it requires a more objective kind of weight generating process. Levin (1997) (cf. Cole 1998) proposes some broader ideas to develop weights system with objectivity. Those criteria require detailed measured records of impacts due to hazards, exposure etc. The time frame and cost involved in such an exercise will be enormous. Moreover, whether a clear-cut validation of those weights is possible or not is also a question. Thus, an alternative of a *probability approach* (Ranasinghe 1998) is viewed suitable to model the expert's domain. Expert model will make use of mostly instrumental measurement and subjective expert opinions, and it intends to integrate those individual scales with probability model.

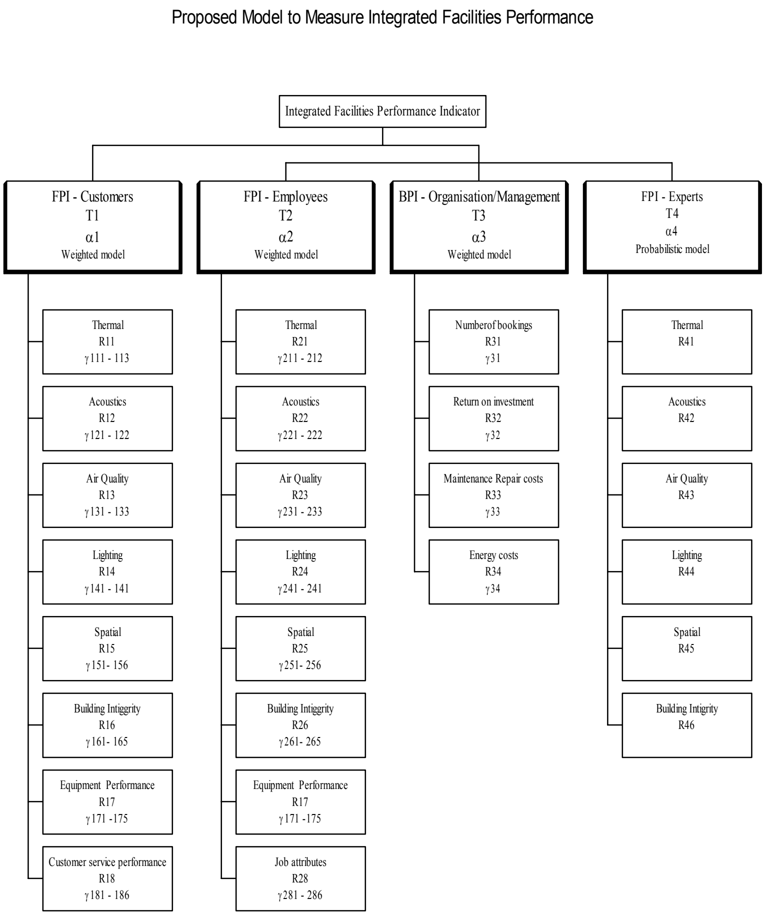

Figure 5 - Model to measure the IFP.

Integrated score

Although, specific standards of measurement matrices, as mentioned above, are essential for ensuring a common understanding of performance and to identify performance gaps (Massheder *et al.*, 1998), combining multiple matrices into a single index is an excellent way of aggregating and simplifying performance reporting (Brown, 1996). However, since this may not show the trend on individual performance, individual scores that were aggregated are available for detailed analysis. Thus, individual scores that were used to aggregate must be constructed in a meaningful way.

Integrating the individual four FPI $_{(Cu,\ Em,\ Ex,\ Or)}$ scores into IFP score is proposed by use of weights (using, $\alpha_{I,\ i=1,2,3,4}$). These weights are organisation specific and generating it in a general sense may be misleading as organisational values and objectives may differ. It is advised that these weights are generated with Delphi technique involving the strategic level executives of the organisation. However, if an industry level comparison is required, a standard or general norm could be established with consensus of all relevant interest groups. Integrated scores are generally subject to the notion of 'labelling', which is often used in conjunction with environmental assessment as a logical outcome. The labels currently used in environmental assessments are typically a classification of the performance into descriptive categories such as Excellent, Very Good, Good, or Fair (Cole, 1998). It is proposed that IFP to adopt labelling as Excellent, Very Good, Good, Bad and Worse with it's integrated scores.

APPLICATIONS AND BENEFITS OF THE IFP TOOL

Despite the relative infancy of this performance model it has a great potential as a valuable tool for decision making at both strategic and operational levels. The applications are as follows:

- Primarily this can be used as a tool to measure the implication of strategic changes resulting from any strategic business units and to focus on continuous improvements. IFP can support TQM[4] process significantly.
- To detect early warnings of obsolescence in a building, which enables timely and appropriate property portfolio reviews, acquisition or disposal decisions.
- To assess the degree to which a building meets the legal requirement set for it by authorities and standards bodies.
- To evaluate implication for the building's owners, occupants and users due to any existing or incipient deficiencies in buildings. This is to improve customer and employee satisfaction and to assess the degree to which each individual requirement is being met.
- To highlight where a facility is lacking in performance or deficient so that building owners can identify priorities for future administration measures, building retrofits (to sustain competitive advantage) by prioritising maintenance or remodelling works.
- To assist in achieving value-for-money from building assets by aiding identification of performance achievements as well as failures.
- To offer a means of structuring environmental information for new building designs and major renovations.
- To gather and organise detailed information of the building, which itself benefits the building management (reduces operation costs, insurance etc.) and formulation of Computer Aided Facilities Management systems.

[4] TQM practice is a management philosophy that integrates strategy, management practice and organisational outcomes to create a quality organisation that continuously improves and sustains performance (Terzovski, 1999). TQM is practice involves strong customer focuses, senior management leadership, and commitment to employee training, empowerment, involvement and the palliation of systematic fact-finding and decision-making process.

IFP assessment would benefit an organisation by enhancing the decision making at operational, tactical and strategic levels. Focused maintenance with limited budget, improvement of productivity/performance of business, quick decision making with first hand information, energy management with un-compromised user satisfaction are some of the benefits. Further this can help decision making on organisational issues such as rewarding system, stress management of employees and maintaining loyal and satisfied customers.

SUMMARY

The need for a holistic facilities assessment methodology is established. The relevance of the facilities performance to organisational success is illustrated based on environmental differentiation as a source of competitive advantage and environmental influence on human/organisational performance. Thereafter, it is suggested that a holistic stakeholder system perspective is most appropriate to be adopted to assess IFP. Four crucial stakeholders, namely, customers, employees, legal-bodies/experts and organisation are identified, and from those perspectives, a holistic framework to assess facilities performance is constructed. Framework encompasses customer, job, financial and physical related attributes among others. IFP concept decomposes into various attributes and then into intentions within the Physiological, Psychological, Sociological and Economical limits. Finally, measures are viewed in terms of suitability, reliability and flexibility. This assessment approach exploits both subjective and objective measurements while experimenting the fitness of the proposed 'weighted' and 'probabilistic' approaches to obtain an integrated single score to represent IFP.

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Multiple Criteria Analysis in Facilities Management

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Abstract. *The research's object of this paper is facilities management process, interested parties striving to attain their goals and micro and macro environment that make up an integral whole. A comprehensive research into the above object required the development of new methods of multiple criteria analysis enabling to thoroughly assess variable micro (labour skill level, innovation, software, expert and decision support systems, education and training, types of contracts, etc.) and macro (technological, legislative, political, social, economic and other aspects) environment of a facilities management sector. All these variable factors can be optimised. In order to demonstrate the optimisation of the above variable factors a determination of rational housing investment instruments is considered in this paper as an example.*

Keywords: Facilities Management, Multiple Criteria Analysis, Micro and Macro Environment.

1. FACILITIES MANAGEMENT IN DIFFERENT ECONOMIES

Facilities management has different priorities in different countries. It is not surprising that there are divergent views and interpretations among various countries, with marked differences between countries with developed market economies, those with transition economies and developing countries. Not all countries with one of the three development levels, in practice uses facilities management in the same way and so have different strategies. Legislative, political, social, economic, technological, culture, traditions and other reasons determine these different strategies. As an example, further on we shall briefly discuss some of the above factors.

New workplaces are emerging in the world and are driven by organizational change, information and Internet technology. Companies are experimenting with workplace innovation that involves moving workplaces out of the office into homes or a client's office. Management of these "virtual workers" is based on trust rather than on control. Trust is largely determined by culture and traditions, etc.

Duffy (1992) points out that the way the office market is organized heavily influences the type of office building built in a country. In his opinion, user dominated markets, as in Northern Europe, tend to provide office buildings of higher standards rather than developer dominated markets.

A survey by Andersen (1995) among a group of large European corporations showed that the attitude to real estate varies from country to country. For example, facilities management in Central and Eastern Europe that are facing so many problems, there is hardly any will to invest time and money in to the professional management of a workplace.

As Steiner (1995) describes, Scandinavian architects tend to be more user-orientated by creating comfortable, healthy workplaces and architects of some other countries tend to be more art-orientated by creating aesthetic buildings.

Generally, in all countries, economic information on facilities management includes the finances and depreciation, taxes, insurances and large maintenance and administrative works, etc. These economic indicators are related to a country's economical and political situation. The relationship of economy and politics in developing countries is usually connected. Poor economic conditions of a country may lead to political changes; on the other hand, a politically unstable country is usually related to a severe economic condition. Such situations could affect the efficiency of facilities management activities. The major, factors of economic impacts in developing countries are inflation, interest rate variations, currency revaluation and devaluation, differences between escalation clauses and current market prices and other conditions that could affect facilities management. Forecasting these economic indicators require great attention and is particularly useful for planning facilities management.

At present, in transition countries some low-income group inhabitants (i.e. pensioners, unemployed and large families) cannot afford the payment of bills for heating their premises. The thermal renovation of a building would reduce heating costs and save state expenditures on social allowances. In addition, the political party in power that cannot solve this urgent problem in a rational way will not be selected in the coming elections. Therefore, the problem appears to be not only a social one but also a political one.

A successful strategy for facilities management should be more-or-less compatible with legislative, political, social, economic, culture, technical, technological and other factors. A varied spectrum of strategies can be launched, while keeping in mind that the mix of influencing factors and relative emphasis is on one or other of those factors and overall will depend on local conditions.

2. EFFECT OF CHANGING THE BUSINESS ENVIRONMENT ON THE EFFICIENCY OF FACILITIES MANAGEMENT SECTOR

One of the major tasks of facilities management organizations is to carry out its activities under the most favourable micro and macro-level conditions. Efforts are made to ensure that the structure, goals, output, efficiency and quality of services of the facilities management organization will be at maximum conformity with the existing business environmental conditions. The pursuit of impracticable goals, for instance, trying to realize projects which surpass the organization's capabilities or the environment (economical, social, legal, political, competitive, technical and technological conditions) is adverse and may cause undesirable consequences.

In order to assure the efficiency of facilities management activities, it should be executed within certain boundaries that are determined by micro and macro-level factors.

2.1. Macro Efficiency Level Factors

The highest level at which efficiency factors may be considered are the macro efficiency level factors. The level of efficiency and the scope of activities of the facilities management sector depend on the following macro-level variable factors:

- Key economic indicators for the country as a whole,
- Legislation,
- Demand and supply,
- Market,
- Culture,
- Intervention of government,
- Politics,
- Interest rates,
- Environment issues,
- Unemployment,
- Wage levels,
- Insurance,
- Inflation,
- Climate,
- Unofficial economy, etc.

The efficiency level will, therefore, vary depending on the aggregate effect of these macro level factors.

As an example, further on we shall briefly discuss some of the above mentioned macro efficiency level factors.

Buildings may be private, state-owned or rented and determine whether the users are interested in effective facilities management or not. Another aspect of legislation that influences facilities management is regulations on an employee’ s participation. According to Duffy (1992), in northern Europe workers’ councils and labour unions have greater power and this is reflected by extremely high standards of space, amenity and comfort for office workers.

Hofstede (1996) describes how, in the hierarchy of culture, such as France, Italy and Germany relations between a position in the hierarchy and his /her workplace is well illustrated by the workplace’s allocation. In Central and Eastern Europe countries people at the top of the company will have workplaces with more space, better view and more privacy.

The demand for a facilities management sector to a large extent depends on the overall rate of a country. The demand for facilities management sector tends to fluctuate particularly according to the state of the government’s economy and the social and economic policies, with consequent effects on facilities management services.

Also, social problems affect facilities management and some facilities management problems go beyond the physical structure of buildings. The problems in various districts are those of street crime, burglary, vandalism, unemployment and lack of education.

Natural conditions in terms of location and climate affect facilities management. The facilities manager should investigate the climate conditions related to solar radiation, temperature, humidity, rainfall, wind, dust storms, changing ground water level and permafrost.

The government or local authorities stimulate the interest of some private companies that invest in some particular areas. The financial assistance may be in the form of subsidies, grants, benefits and preferential credits, government guarantees of a loan. This economical States policy is aimed at reducing unemployment, and restoring, developing or improving certain buildings and districts, etc.

The government by changing taxation as well as the structure and volume of its own expenditure (expanding of town reconstruction programmes, housing subsidies and benefits etc.), affects the demand for construction and facilities management, inflation and other factors. An increase in taxation and a curtailment of government expenditure usually tends to lower the demand for construction and facilities management, and vice versa. Often measures of both types i.e. taxes and government expenditure go hand-in-hand, so, the efficiency of the facilities management relies on the Government’s fiscal and monetary policy.

Many countries have a policy of subsidizing various forms of energy conservation measures in buildings, through grants and tax incentives. In Hillebrandt’s (1988) opinion, the social cost or costs to the community of consuming energy (too rapid consumption of non-replaceable energy reserves, that affect future generations but not indirectly the existing householders; the adverse effect on the balance of payments of large oil imports or a reduction in the amount available for export and the high capital costs of investment to increase energy availability) are higher than the private costs of doing the same.

2.2. Micro Efficiency Level Factors

The second level of factors may be considered as the micro level and these depend on those at the macro level. The level of efficiency and the scope of activities of the facilities management sector depend on the following micro variable factors:

- Infrastructure,
- Labour skill’s level,
- Innovation,
- Sources of company finance,
- Software, expert and decision support systems,
- Facilities management associations,
- Education and training,
- Types of contracts,
- Equipment, etc.

Some of the above factors depend on the influence of the macro level factors. For instance, the system of taxation that is set at the macro level (following the fiscal policy of the government) exerts a direct influence on wages and salaries (and thereby disposable incomes) and on prices of services at the micro level. The standpoint of the State (various laws and decrees, working of State institutions, etc.) regarding certain activities exerts considerable influence on the organizations efficiency. The law directly governs relations of the various interested parties, for instance, between occupier and owner.

As an example, further on we will briefly discuss some of the mentioned micro efficiency level factors.

A number of interested parties to a various extent are involved in the facilities management process of buildings. Some of the interested parties directly take part in the facilities management process while others belong to the category of users. Still others are “spiritually” affected by the outward qualities of a building. Architectural, aesthetic, and urban aspects of the building generate different feelings in the owner, his/her associates, neighbours, tourists and regular passers-by. The interested parties pursue different aims and objectives such as:

- The building owner invests, takes financial risks, develops capital assets and charges capital cost;
- The facilities manager lets built space, provide services, optimizes space use, maintains facilities and, provides technical competence;
- The user/tenant formulates space and service requirements, pays rent, acquires and maintains production equipment, etc.

Efforts are taken to gain a maximum at a minimum cost.

Goals of employees and employers not always coincide. Employees want to receive a higher salary while employers try to save money by seeking to increase viability and profit for the facilities management firm. Nevertheless, there are many common interests. Facilities management sector becomes more mechanized and technically complicated and qualifications of the staff have to grow. Therefore, firms need to employ highly skilled, reliable workers, which understand modern and techniques and are able to work with the latest equipment. Salaries of employees, the possibility of permanent employment greatly depend on the effective performance of the facilities management firm; therefore the majority of workers are interested in constructive collaboration with employers.

Insufficient personnel skills may adversely affect the utility of a facilities management process. Resources are lost on personnel training and workers have to use this additional time to complete their work. Trained employees work more effectively and because of this they themselves will earn more and the firm will obtain a greater profit. Lack of skills increase costs of performed works and the difficulties with the implementation of new techniques will reduce the facilities management’s quality. Firms offering higher salaries encourage workers to improve their skills. But higher salaries increase prices and the demand for work performed by the firm tends to decrease. With an increase in salaries a supply of skilled labour increases, after a reduction of salaries the best workers leave the firm and the competitive possibilities of the firm decrease. Therefore, it is feasible to discuss the possibilities of employing personnel with various skill levels and to train them.

A facilities management firm having selected a concrete market and nomenclature for its offered services has to analyze how to organize its work effectively. This depends on the decisions made on services, personnel and equipment. A firm's competitive level depends greatly on the decisions taken.

3. DETERMINATION OF RATIONAL FACILITIES MANAGEMENT PROCESSES

3.1. Determination of Rational Facilities Management Processes

A facilities management process consists of closely interrelated stages: i.e. consultation, planning, procurement, implementation and monitoring. A facilities management process may have many alternative versions. These variants are based on alternative consultation, planning, procurement, implementation and controlling stages and their constituent parts. The above solutions and processes will be considered in more detail later. For instance, alternative space management variants can be developed by varying its space organisation, removals, inventory compilation/updating and main services solutions (building security, reception, telephone switchboard, cleaning, snow-clearing service, upkeep of outdoor facilities, garden care, plant care in the building, post room, travel office, office service, central secretariat, canteen management, removals service, central archive, courier services, office supplies and safety specialist). Therefore, thousands of facilities management process alternative versions can be obtained. The diversity of available solutions contribute to a more accurate evaluation of climatic conditions, risk exposure, maintenance services, as well as making the project cheaper and results in a better way of satisfying a client's aesthetic, comfort, technological and other requirements. This also leads to a better satisfaction of the needs of all the involved parties in the facilities management process.

Various interested parties (e.g. users, owners, and facilities managers, etc.) are involved in the facilities management process, and trying to satisfy their needs and affecting its efficiency.

The above needs or objectives include the expected cost of facilities management services, occupier, owner and building support, building inspection, budgeting, cost optimization, coordination of services; accounting; It also includes contract management; leasing management; technical operations management; maintenance, inspection and, repair of equipment and systems (gas, water, wastewater, heating, ventilation, cooling, electrical systems, lifts, warehousing systems, automatic door and gate, communication, cable and network, security, laundry and dry-cleaning systems, general building equipment, other equipment and systems), etc. Facilities management companies should be able to offer a range of services that can be flexibly extended or reduced.

The problem is how to define an efficient facilities management process when many various parties are involved because the alternative versions come to thousands and the efficiency changes with the alterations in the business environment conditions and the constituent parts of the process. Moreover, the realization of some objectives seems more rational from the economic perspective though from other perspectives (i.e. technological, comfort, space, administrative, technical, etc.) they have various significances. Therefore, it is considered that the efficiency of a facilities management process depends on the rationality of its stages as well as on the ability to satisfy the needs of the interested parties and the rational character of micro and macro-level environment conditions.

A formalized presentation of the research shows how changes in the business environment and the extent to which the goals pursued by various interested parties are satisfied, cause corresponding changes in the value and utility degree of the facilities management process. With this in mind, it is possible to solve the problem of optimisation concerning the satisfaction of the needs with reasonable expenditures. This requires an analysis of the facilities management process versions allowing one to find an optimal combination of pursued goals and available finances.

The determination of the utility degree and value of the facilities management alternatives under investigation and an establishment of the priority order for its implementation does not present much difficulty if the criteria numerical values and weights have been obtained and the multiple criteria decision making methods are used.

By way of an illustration, we provide a short analysis of a criteria system of some facilities management constituent parts. They include computer-aided facilities management systems, service of a facility, and equipment.

Cormier (2000) described the process and elements for comparison and the selection when considering various computer-aided facilities management systems. Cormier (2000) considered the following criteria system: modules and tools (lease management, move management, strategic space planning, maintenance management, accounting/charge-back, communication/cable management, personnel management, etc.) the also considered cost information (cost of software, cost of training, cost and ease of software integration, cost of software maintenance, and after-sale support) technical information (platform, network access, native database support, database connectivity, user interface, security, reports, file formats, and interoperability) and key features.

The service of a facility can be evaluated as: operational productivity, aesthetic value or public image, comfort (noise, colour, air quality, thermal comfort, working conditions) flexibility, and cost (design, construction, indirect expenses, operating and maintenance expenses, renovation costs, the interest paid on loan).

Effectiveness of equipment can be evaluated by the following criteria system:

- Price,
- Expenses for use,
- Expenses for repair (maintenance, capital),
- Capacity,
- Number of operations performed,
- Reliability,
- Comfort,
- Physical and technical durability,
- Weight.

One of the main tasks of the efficient implementation of facilities management is multiple criteria optimisation of its life cycle process with the aim of maximum purpose satisfaction of all interested parties in the process. The interested parties and their aspired goals make up one entity. However, there are some potential conflicts among interested parties: e.g. speed versus waste, cost versus quality, capital cost now versus after operational efficiency, aesthetics and comfort versus cost, environment versus user needs, etc. The greater the scope of the realization of pursued goals (taking into account their significance) the greater (in the opinion of interested parties) the total efficiency of the project. In other words, the total efficiency of a project is directly proportional to the entity of its realized goals.

The level of efficiency and the scope of activities of the facilities management sector depend on the many micro and macro-level variable factors. All these variable factors can be optimised. In order to demonstrate the optimisation of the above variable factors a determination of rational housing investment instruments will be considered below as a an example.

3.2. Determining Rational Housing Investment Instruments

Medium and long-term credits are used for housing investment and certain factors and interested parties have an impact on the efficiency of alternatives of housing investment instruments.

3.2.1. Factors and interested parties affecting the efficiency of housing investment instruments

A great number of effective housing investment instruments have been developed and successfully used in advanced industrial economies. The economic, legislative, political, social, technical and cultural situations and traditions are different in every country. Also market economies have been developed in a variety of levels. Often the efforts to introduce housing investment instruments, which proved to be efficient in some countries, were not successful in others.

The same housing investment instruments when applied to various economies yield various results as far as efficiency is concerned. Researchers and practical workers use diverse criteria when analysing the efficiency of housing investment instruments. Based on the above mentioned expertise, the efficiency of housing investment instruments may be approached. Efficiency of housing investment instruments also depends on interested parties (see Fig. 1).

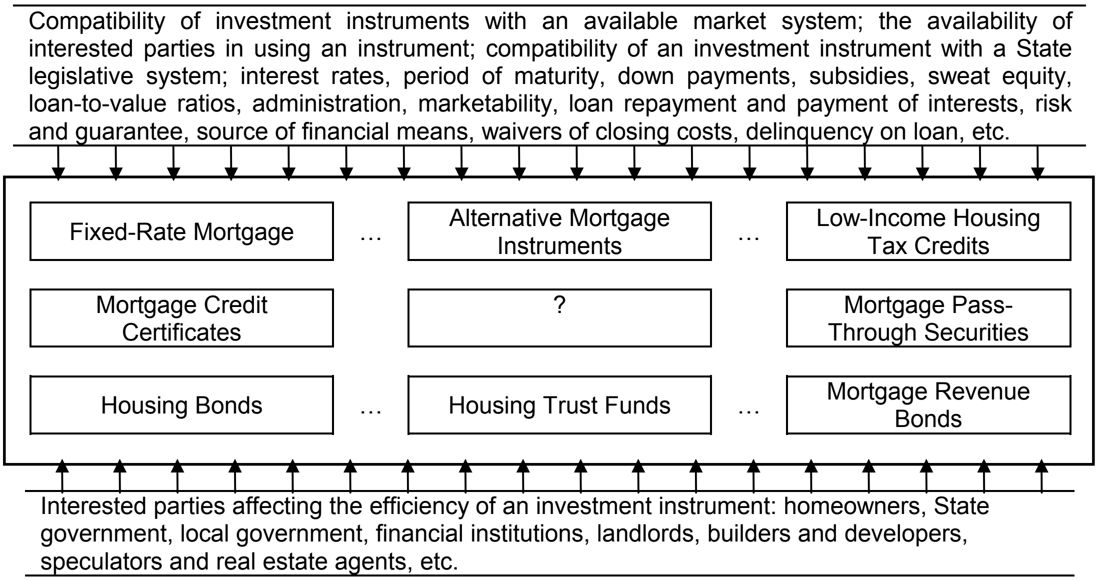

Fig. 1. Some factors and interested parties affecting the efficiency of housing investment instruments

3.2.2. Development of quantitative and conceptual databases of housing investment instruments

In order to find the most efficient housing investment instruments for a particular country, the country's exhaustive conceptual and quantitative description should formed. The data then obtained should be subject to multiple criteria analysis, so as to help to choose the most rational variants.

Conceptual descriptions of an investment instrument life cycle presents textual, graphical, numerical, mathematical and other forms of information about the investment instruments. The criteria used for their definition, as well as giving the reason for the choice of this particular system of criteria, their values and weight is also essential. Conceptual information is needed to make a complete and accurate evaluation of the alternatives considered. More useful information and the development a system and subsystems of criteria and defining their values and weight (see Fig. 2) illustrates the development of a conceptual database fragment containing the information on housing investment instruments.

Quantitative information is based on the criteria systems and subsystems, units of measure, values and initial weight. The determination of the utility degree and value of the investment instruments and the establishment of the priority order for its implementation does not present much difficulty if the criteria numerical values and weight are obtained and the multiple criteria decision making methods are used.

The process of determining the above the system of criteria, qualitative criteria initial weight and numerical values of the investment instruments under investigation is based on the use of various expert methods, on the Internet, etc. Quantitative criteria numerical values are obtained by analysing the data on investment instruments and different documents, Internet, etc. The magnitude of weight indicates how many times one criterion is more/less significant than another in the multiple criteria evaluation of investment instruments. The results of the comparative analysis of the investment instruments are presented as a grouped decision, forming matrix where columns contain *n* alternative investment instruments, while all quantitative information pertaining to them is found in *m* lines.

Housing Trust Funds. Housing trust funds are distinct accounts, typically established by city, county, or state governments, with dedicated ongoing revenue committed exclusively to support housing affordable to lower-income households.

…

Low-Income Housing Tax Credits. Low-Income Housing Tax Credits are provided through the tax code to investors in the construction and renovation of low-income rental housing.

Criteria describing the investment instruments	Signi-ficance	Measu-ring units	Alternative investment instruments					
			$\boxed{a_1}$	a_2	…	$\boxed{a_j}$	…	a_n
Interest rates	q_1	m_1	x_{11}	x_{12}	…	x_{1j}	…	x_{1n}
Period of maturity	q_2	m_2	x_{21}	x_{22}	…	x_{2j}	…	x_{2n}
...	...	...	...	...	…	...	…	...
Down payments	q_i	m_i	x_{i1}	x_{i2}	…	x_{ij}	…	x_{in}
...	...	...	...	...	…	...	…	...
Loan repayment and payment of interest	q_t	m_t	x_{t1}	x_{t2}	…	x_{tj}	…	x_{tn}
Source of the financial means	q_{t+1}	m_{t+1}	$\boxed{x_{t+1\,1}}$	$x_{t+1\,2}$	…	$x_{t+1\,j}$	…	$x_{t+1\,n}$
Subsidies	q_{t+2}	m_{t+2}	$x_{t+2\,1}$	$\boxed{x_{t+2\,2}}$	…	$x_{t+2\,j}$	…	$x_{t+2\,n}$
...	...	...	...	...	…	...	…	...
Risk and guarantee	q_i	m_i	x_{i1}	x_{i2}	…	x_{ij}	…	x_{in}
...	...	...	...	...	…	...	…	...
Delinquency on loan	q_m	m_m	x_{m1}	x_{m2}	…	x_{mj}	…	x_{mn}

The key characteristic of a housing trust fund is that it receives ongoing revenues from dedicated sources of funding, such as property taxes, sale of county-owned land, fees, loan repayments, etc.

…

The program provides a 10-year tax credit to loan investors for eligible loans in which units are set aside for at least 15 years of use by low-income households.
A developer can use tax credits for many types of low-income rental housing, including constructing new units, renovating units he or she already owns, and acquiring and renovating existing properties.

Fig. 2. A fragment of developing housing investment instruments conceptual database.

Criteria describing the investment instruments	Signi-ficance	Measu-ring units	Compared investment instruments					
			a_1	a_2	…	a_j	…	a_n
Interest rates	q_1	m_1	x_{11}	x_{12}	…	x_{1j}	…	x_{1n}
Period of maturity	q_2	m_2	x_{21}	x_{22}	…	x_{2j}	…	x_{2n}
...	...	...	...	...	…	...	…	...
Down payments	q_i	m_i	x_{i1}	x_{i2}	…	x_{ij}	…	x_{in}
...	...	...	...	...	…	...	…	...
Loan repayment and payment of interest	q_t	m_t	x_{t1}	x_{t2}	…	x_{tj}	…	x_{tn}
Source of finance	q_{t+1}	m_{t+1}	$x_{t+1\,1}$	$x_{t+1\,2}$	…	$x_{t+1\,j}$	…	$x_{t+1\,n}$
Subsidies	q_{t+2}	m_{t+2}	$x_{t+2\,1}$	$x_{t+2\,2}$	…	$x_{t+2\,j}$	…	$x_{t+2\,n}$
...	...	...	...	...	…	...	…	...
Risk and guarantee	q_i	m_i	x_{i1}	x_{i2}	…	x_{ij}	…	x_{in}
...	...	...	...	...	…	...	…	...
Delinquency on loan	q_m	m_m	x_{m1}	x_{m2}	…	x_{mj}	…	x_{mn}
Utility degree of alternatives			N_1	N_2	…	N_j	…	N_n
Priority of investment instruments			Q_1	Q_2	…	Q_j	…	Q_n

Table 1 A fragment of developing housing investment instruments quantitative database

3.2.3. Search for rational housing investment instruments

The quantitative and conceptual databases, which are being developed now, give an exhaustive description of housing investment instruments and allow for their multiple criteria analysis. This helps to determine the investment instruments efficiency of the country in question. Moreover, the databases and multiple criteria analysis offered could be used in the search for efficient lenders.

Since the efficiency of alternatives of a housing investment instrument is determined by taking into account much varied information, a multiple criteria analysis should include methods enabling a decision maker to implement a comprehensive analysis of the variants, leading to and making a proper choice.

The following methods developed by authors are aimed at performing this function:

- Method for determining the initial weight of the criteria (using experts' methods),
- Method for the criteria weight establishment,
- Method for multiple criteria analysis and setting priorities,
- Method for determining alternatives utility degree.

4. Conclusions

Facilities management companies should be well informed of the micro and macro environment levels in which the companies operate. A business environment can create or eliminate opportunities and threats. Facilities management companies analyse the micro and macro environment levels and distribute the company resources to take advantage of opportunities and to minimize threats to the company's activities. Micro and macro level factors can be optimised. These questions have been analysed in this paper.

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Performance Measurement in Facilities Management Organisations: Transition from Measurement to Management

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***Abstract**: "Facilities" create environments for occupants to work effectively within organisations and the performance of these environments influence the activities that are carried out. Formulation of techniques that are capable of assessing "facilities performance" in terms of quality, cost and effectiveness, is critical for "Organisational" and "Facilities Management" advancements. In order to address the emerging assessment needs in the field of facilities management (FM), "The Balanced Scorecard," concept is proposed in this paper. This paper speculates that BSC formulates a holistic performance measurement system that amalgamates facilities management performance indicators and business/organisational performance domains. A framework for facilities management performance measurement is offered based on the case studies carried out, and sets of propositions are suggested which might form a basis for future research in the field.*

***Keywords**: facilities management, performance measurement, performance management, Balanced Scorecard*

Background

Atkin & Brooks (2000) define Facilities Management (FM) as, "an integrated approach to operating, maintaining, improving and adapting the buildings and infrastructure of an organisation in order to create an environment that strongly supports the primary objectives of that organisation". Thus, FM is viewed as a "….hybrid management discipline that combines people, property and process management expertise to provide vital services in support of the organisation (Then, 1999). FM is defined in various ways, whilst the emphasis remains the same: the management of interaction between the physical environment and humans to enhance the organisational effectiveness (Gagendran,2000).

The environment created for the occupants of a facility influence the performance of the activities carried out in that facility (Gagendran, 2000). Hence, organisations in general desire facilities that are comfortable to occupy, cost effective and efficient to run, and those facilities to remain as added value assets (Douglas, 1996). Surveys by Debenham Tewson Research (1992). Graham Bannock & Partners (1994), Workplace Management (1996) and Arthur Anderson (1995) reveal that only on rare occasions do facilities receives explicit attention, and facilities are generally viewed as more of a cost rather than a strategic resource (cited in Then (1999)). This has resulted in facilities managers missing the opportunity to manage the environment in which they operate for competitive advantage. Therefore, any attempt that can show a connection between quality, cost and productivity, offers a useful lever in advancing the facilities performance and the facilities management discipline (Leifer, 1998) (cited in Gagendran, 2000). If organisations are able to measure the performance outcomes of their facilities they will be convinced to pay more attention to facilities related resources.

Facilities and organisational management

Facilities and organisational management domains have only marginal interactions in the past, and performance measurement methods from both these domains have continued to neglect the other perspective in their measurement, until the complex business environment urges an intensive dialogue between them (Gagendran, 2000). To this effect, research reported in this paper attempts to conceptualise a performance measurement system which would integrate both the business and facilities domain, and which intends to develop a method for meaningfully measuring facilities performance. As suggested by Gagendran (2000), this will enable improved utilisation of resources by organisations and optimum use of the facility to gain competitive advantage.

Performance measurement in FM: current thinking

It is worth noting that there is no universal agreement on the definition of “performance” (Avkiran, 1997). However, Hronec (1993) defines performance measurement as: “a quantification of how well the activities within a process or the outputs of a process achieve a specified goal”. In simple terms, performance is achievement against intention (Gagendran, 2000). Hronec (1993) lists four potential benefits that can arise as a result of having an appropriate performance measurement system: satisfying customers; monitoring progress; benchmarking processes and activities; and driving change. The emphasis on promoting customer satisfaction and driving change in accordance with the response to external pressures from an increasingly global competitive marketplace, while the emphasis on monitoring progress and benchmarking is a clear reflection of the culture promoting continuous improvement, driven from both within and outside the organisation (Then, 1996). The development of performance measurement within the context of business management is important in that it sets the background against which senior management within organisations will evaluate the current performance and contribution of their facilities services in fulfilling corporate objectives.

Even in FM environments, where performance measurement was not adequately addressed, the acceptance of performance measurement is growing. As Grimshaw and Keeffe (1992) stated: “A link exists between the physical environment and the operational efficiency of the organisation”. The need for FM performance measurement systems has already been emphasised by identifying FM as a business resource (Hinks and Hanson,1998; Alexander, 1996a; Then, 1999; Madeley, 1996; Amaratunga and Baldry, 2000). Today’s organisations constantly review the composition of their core business and the way it operates (Royal Institution of Chartered Surveyors, 1993). Therefore, clear attention must be paid both to the effective maintenance of support systems and the culture of the organisation. Tranfield and Akhlaghi, (1995) emphasised that FM is an important emerging business sector with an annual size well into tens of billions of pounds in the UK. The FM budget of an organisation can often require thirty to forty per cent of total organisational expenditure, second only in cost to payroll (Williams, 1994). Therefore, good performance in FM is essential.

In the research described in this paper, it was found out that FM managers no longer reject FM performance measurement and further acknowledge the benefits of their various measurement procedures.

Application of the Balanced Scorecard in the Facilities Management Domain

"What performance really means" and "to be able to measure it" are the most crucial things to be understood to embark on a performance measurement exercise (Gagendran, 2000). Numerous and different approaches to facilities performance measurement have been developed:

- Operating costs and Benchmarking (cited in Featherstone, 1999);
- BIFM measurement protocol (BIFM, 1997);
- Post-Occupancy Evaluation (Preiser et al, 1988);
- Hierarchical system of performance indicators (Belcher, 1997);
- Input versus output based performance measurement (Heavisides & Price, 2001).

Although many facilities performance measurement techniques are available, the focus of most of these is primarily on either technical or financial aspects. Amaratunga and Baldry (2002) comment that most of the facilities related measurement tools are either lead to a great deal of confusion about the reasons for performance indices and performance measures or that there are too many performance indices (especially in terms of cost) in the FM market, looking only at wider issues, which fail to link core business issues with those of facilities. They further argued that performance measurement techniques available in general management literature haven't been fully transformed into FM literature, emphasising the research need in performance measurement in FM.

This illustrates the present state of complexity in measuring facilities performance meaningfully. Assessment of facilities performance in an integrated manner requires a tie between facilities data and business related data that links physical, spatial and environmental issues describing the facilities' characteristics, with information concerning the operational behaviour of management and users, and financial consequences overall (Nutt, 1992). Further, enduring optimism towards facilities as a means of organisational effectiveness through enhancing facilities performance in a dynamic environment requires a dependable framework for the assessment of facilities performance, as supported by Gagendran (2000). Therefore, a broader framework that links and assesses the facilities indicators with business performance indicators is propelled in the research reported in this paper, to enhance organisational effectiveness and success.

In this context, can business performance measurement tools be an alternative to currently available facilities performance measurement tools? Amaratunga et al (2000) speculated that business performance measurement concepts such as the Balanced Scorecard (BSC) would be a valuable tool in the facilities domain. "The BSC integrates traditional financial measures with operational and softer customer and staff issues, which are vital to growth and long term competitiveness", comments

Newing (1995). This management system was developed by Kaplan and Norton (1996), and proposes a system which integrates measures of customer satisfaction, process performance, product and service innovation and finance.

The BSC measures are built around the following four perspectives (Kaplan and Norton, 1996):

- **Customer** – what do existing and new customers value from us?
- **Internal processes** – what processes must we excel at to achieve our financial and customer perspective?
- **Learning and growth** – can we continue to improve and create future value?
- **Financial** – how do we create value for our shareholders?

The four perspectives of the scorecard permit a balance between short-tem and long-term objectives, between desired outcomes and the performance drivers of those outcomes, and between the objective measures and softer, more subjective measures. While the multiplicity of measures on a BSC seems confusing to some people, properly constructed scorecards contain a unity of purpose since all the measures are directed towards achieving an integrated strategy.

Linking measurements to organisational strategy

Business performance measurement in general, and in particular: SMART pyramid (Ghalayini and Noble, 1996); the performance prism (Kennerley and Neely, 2000); EFQM (EFQM, 1999); time based performance measurement (Barker,2000); Measuring service quality (Black et al,2000); integrated performance measurement (Medori and Steeple, 2000) and the BSC (Kaplan and Norton, 1996; 2000) attempt to address a key management issue: that organisations often fail to turn strategy into action. The fact is that a clear, action oriented understanding of an organisation's strategy could significantly influence that organisation's success.

The primary focus of the BSC is on translating the organisation's strategy into measurable goals (Letza, 1996). Having understood what is important for the business, performance measures are designed to monitor performance and targets are set up for improvement. This is illustrated in Figure 1. These must then be clearly communicated to all levels within the business. This enables the organisation to understand how their own efforts can impact on the targets set in respect of each perspective.

Although offering a sample template, Kaplan and Norton (1996;2000) acknowledged that the precise format of the BSc is an organisation-specific issue. A major task facing an organisation in attempting to introduce a BSC is how to devise a set of measures explicitly linked to its strategy? (Kaplan and Norton,1996; 2000). Underlying this need is the essential condition that the strategy is widely understood and accepted within the organisation, as emphasised by Kaplan and Norton (1996; 2000).

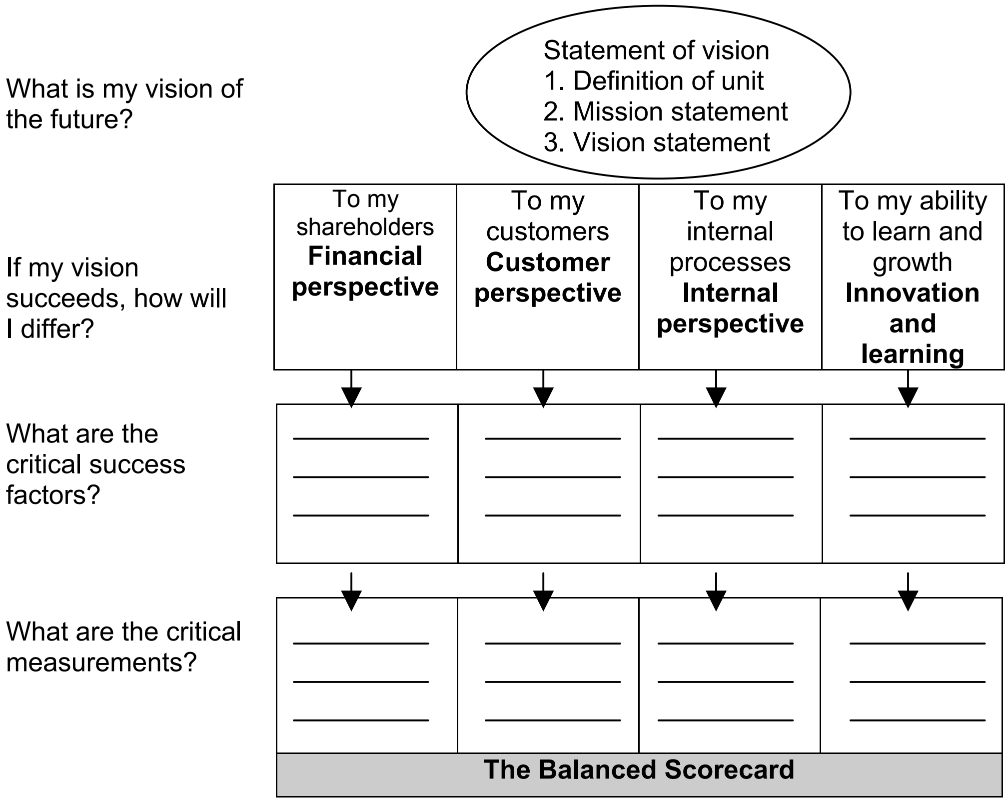

***Figure 1** – Linking measurement to strategy*
(Source: Kaplan and Norton, 1993)

Only by combining, measuring and thinking in terms of all four perspectives can managers prevent improvements being made in one area at the expense of another. The BSC forces managers to focus on some really important non-financial factors which impact on long-term profitability and which might otherwise be neglected (Newing, 1995).

However, there is no clear agreement among FM researchers (e.g. Gagendran, 2000) about whether the BSC technique is appropriate for assessing facilities performance if it is to consider as an isolated function from the rest of the organisation. Amaratunga (2001) argues that if facilities performance measures are to be effective, then facilities strategy needs to be aligned with the core business/organisational strategy.

Given the characteristics of the FM environment, recognising and satisfying the needs of the core business is vital for long term survival (Hinks, 2002). To ensure satisfaction of various customer needs, it is essential that FM identifies, focuses on, and monitors key performance indicators. The remainder of this paper reports findings of an approach investigating the suitability of the BSC to FM as a method of linking performance measurement to business strategies.

Research methodology

The purpose of the research being reported on is an attempt to devise a BSC for FM and to facilitate learning about performance assessment and the outcomes. In this context a detailed review of critical methodological issues is undertaken.

Review of the literature was the initial step and this included an in-depth examination of literature relating to performance measurement in organisations in general and performance measurement in FM organisations in particular. The main purpose and outcome of this was to identify theoretical gaps in the literature relating to performance measurement in FM. Although the area of performance measurement is not new, this concept is neither well established or standardised across and even within FM organisations.

A pilot case was conducted before the field data collection was initialised (see Amaratunga and Baldry (2000a)). The conduct of a pilot case is seen as a crucial step in order to improve the quality of the research, especially concerning the data collection phase (Miles and Huberman, 1994; Easterby-Smith et al, 1991; Yin, 1994). The pilot case was chosen on the basis that it supported the criteria mentioned above, that is, it was FM intensive.

From the conclusions of the literature review and the pilot study findings, the research objectives and research strategy were derived. In this context, the researcher decided to investigate the following key questions with respect to the practice and theory of performance measurement in FM: “How could a performance measurement framework be created based on the BSC concept in FM organisations in order to effectively transfer modern performance measurement principles in FM practice, thereby to demonstrate the links that exist between the prime organisational goal and the FM support mechanism?”

Having identified the questions to which answers need to be found, it is then important to describe the research strategy. The literature review on research methods revealed a wide variation in the classification of research approaches. Esterby-Smith et al (1991) provide a simple classification of research by outcomes that are assumed to emerge: pure, applied and action research. According to Yin (1994), a research strategy should be chosen as a function of the research situation. Each research strategy has its own specific approach to collect and analyse empirical data, and therefore each strategy has its own advantages and disadvantages. As mentioned elsewhere, there was a strong need to understand how the BSC concept will apply as a performance measurement tool to enable the achievement of optimum results within the FM context. In this context, authors agreed the “case study” is the research strategy that matches better with these characteristics. The preference of the case study strategy derives from the fact that the main research question in this work is in the form of “how”, and the case studies provide the ability to examine contemporary events – the development of performance measurement theory in FM by dealing with a wide range of evidence, documents, interviews, and observations - where the relevant behavioural aspects cannot be manipulated (adapted from Yin, 1994). This allowed an in-depth investigation of the concepts of performance measurement issues in FM in its real life context. The criteria to select the cases were a matter of discretion and judgement, convenience, access and to be those which were FM sensitive for the purpose of this research, as described by Yin (1994). For the purpose of this research, an important criterion was the presence of some sort of performance measurement procedures within the FM organisation. This emphasis on measurement principles made it unnecessary to consider in the selection criteria organisational characteristics such as the organisational size or type as also indicated by Pacitti (1998). The level of FM practice was another criterion for choosing the host organisations as it was intended to compare the “best practices” of the “best FM organisations” to ensure fair comparisons (Yin, 1994). In this work, a multiple case study design was adopted in order to add confidence and achieve more robust conclusions. Thus, by looking at a range of similar and contrasting cases it was expected to strengthen the precision, validity, and the stability of the findings of the research as described by Miles and Huberman (1994).

There are arguments on number of case studies to be used in research. Yin (1993) presents the view that considered case methodology “microscopic” because it “lacked a sufficient number” of cases. Hamel et al (1993) and Yin (1993) forcefully argue that the relative size of the sample whether 2,10 or 100 cases are used, does not transform a multiple case into a macroscopic study. The selection of number of cases for literal and theoretical replication is discretionary and judgemental, depending of the level of certainty that is wanted about the results (Yin, 1994). Overall, the number of cases is conditioned by the scarcity of time and other available resources, and explained by the tension that arises when the following two opposing criteria are applied to this limitation: case studies versus depth of study.

A multiple case study demands a formulation of a protocol for data collection that reduces the chances of missing important data and, thus, facilitates subsequent analysis (Robinson, 1993; Yin, 1994). In this research, the developed protocol for data collection followed the structure illustrated in Figure 2:

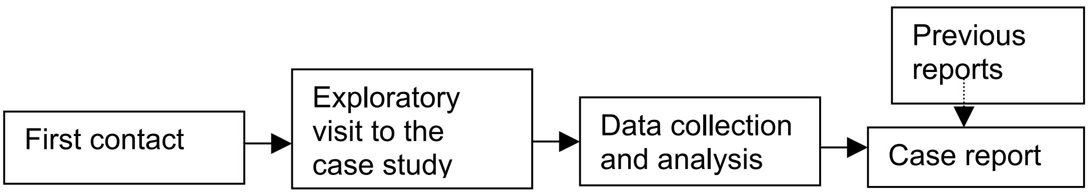

***Figure 2**: Protocol for Data Collection (adapted from Santos, 1999)*

As indicated in Figure 2 above, each case study organisation received a report containing the main findings of the case study observations and a summary of data collected. The findings presented in the report included the outcome of interviews with the senior and middle management and operational staff. Their contribution was acknowledged although specific names were avoided throughout the text following an agreement about the confidentiality of information. (See Amaratunga (2001) for more information on case study outcomes) Most of the organisations provided feedback on the practical validity of case study findings. This feedback was incorporated into the final research report, on which this paper is based (see Amaratnga, 2001) and was the basis for theory development in performance measurement applications for FM using the BSC as the theoretical framework.

Table 1 outlines the eight case studies, which were investigated (it is worthwhile to note that the abbreviations listed in the following table were used to refer to the relevant case studies due to confidentiality of information associated with the case studies):

Organisation	Industry sector
CABO FM	Public sector – Health
CAMA FM	Public sector - Health
CACE FM	Public sector - Health
CASU FM	Public sector – Higher Education
CASA FM	Public sector – Higher Education
CALA FM	Public sector – Higher Education
CAAB FM	Financial sector
CALO FM	Semi government sector

Table 1: *Summary of case study organisations*

Due to space limitations, information relating to above organisations is not presented within this paper. {See Amaratunga (2001) for more information on individual case study organisations} A multi-dimensional case study survey across a number of sectors as identified in Table 1 above was carried out. This selection was influenced by evidence from the literature survey that management perceptions of the role of facilities can vary considerably according to the type of business and the environment of the particular business sector (Then, 1996). There is also the possibility that by confining the study to a particular sector not enough cases would be found to develop theory, as emphasised by Pacitti (1998). The decision to extend the study to cover multi sector case study applications is also influenced by the fact that the process will strengthen external validity (Amaratunga & Baldry, 2000b).

Data analysis and the Balanced Scorecard Development

The aspect of data analysis of the case study methodology is the least developed and hence the most difficult (Tellis, 1997). Data analysis consists of examining, categorising, tabulating, or otherwise recombining the evidence to address the initial propositions of a study (Yin, 1994). Miles and Huberman (1994) suggested analytic techniques such as re-arranging the arrays, placing the evidence in a matrix of categories, creating flowcharts or data displays, tabulating the frequency of different events, using means, variances and cross tabulations to examine the relationships between variables, and other such techniques to facilitate analysis.

Data analysis

For case study analysis one of the most desirable strategies is to use a pattern-matching logic (Yin, 1994). Trochim (1989) considers pattern matching as one of the most desirable strategies for analysis. Such logic compares an empirically based pattern with a predicted one. Campbell (1975) described pattern matching as a useful technique for linking data to the propositions and asserted that pattern matching is a situation where several pieces of information from the same case may be related to some theoretical proposition. Thus, the data analysis was associated with the formation of performance measurement constructs aimed at identifying the applicability of the BSC within FM environments. This was done through the pattern matching process.

Findings of the research being reported

This research is best described as a study, which analyses FM performance measurement issues against the BSC business performance measurement concept. One of the outcomes of this study was a sharper and more insightful questioning of what is known about performance measurement in FM. Using Dubin's (1978) phrase: "This should add knowledge to the field by increasing the realms of the known and the knowable and by pointing out more accurately the realms of unknown".

In this context, this section sets out the different critical success factors and measurement tools relating to performance measurement, which exist in the FM organisation (there may be other performance measurement tools which have not been exposed through this research). The subsequent discussion describes these different types of performance measurement categories and the importance of making them visible. The identification of different critical success factors according to the BSC framework identified in a previous section, and related performance measurement tools which exist within FM organisations, present a new framework through which to measure FM performance aimed at increasing the effectiveness of the FM process thereby to increase the overall organisational efficiency. Further, this process provides a basis for the discussion around usefulness and applicability of performance measurement within FM through the exposure of each type of FM critical success factors and related measurement tools, by linking facilities performance within the overall organisational performance. Findings are presented in sections below by taking each perspective at one time.

Types of customer related FM critical success factors and associated measures

This section outlines three types of customer related critical success factors, uncovered primarily from the case study findings. These critical success factors are quality, timeliness and degree of partnership and corporation. It is not the existence of these types of success factors which is an important issue for facilities managers but the way in which they are being measured, and the development of a shared understanding of each type of critical success factor and related measurement tools.

Critical success factor	Associated measurement tools
Quality	Customer satisfaction surveys
Timeliness	Customer satisfaction surveys
Degree of partnership and corporation	Customer satisfaction surveys

Table 3: *Types of customer related measurements – Definitions*

Details relating to the pattern matching process in identifying the above critical success factors and associated measurements instruments are not presented in this paper, once again, due to space limitations. See Amaratunga (2001) for more related information.

FM processes, learning ad growth issues and financial capabilities

Similarly, tables shown below (Tables 4,5 and 6) summarise the critical success factors and associated performance measures derived through the case study analysis.

Critical success factor	Associated measurement tools
Operational service efficiency	Post-occupancy evaluation Service standards Benchmarking Maintenance management
Contract management	Service level agreements Procurement partnerships Performance based outsourcing Controls assurance standards
Risk management	Controls assurance standards Periodic risk audits Incident reporting systems Probability analysis
Supply chain management	Level of communication Supply chain partnerships
Workforce management and employee competence	Cost effective management of facilities workforce Attitude surveys Team work Operational capabilities Investors in people award
Work environment	Overall health and safety performance Employee surveys
Capital asset management	Asset accountability rate
Facilities management culture	Job satisfaction Economic progress

Table 4: Types of FM process related measurements – Definitions

Critical success factor	Associated measurement tools
Strategic facilities information and management	Extent of reliable FM systems in place Communication
Innovation	FM service development cycle time Share of cost from new services Innovation success rate Number of ideas and suggestions
Professionalism and staff development	Investors in people award Training and development Employee alignment Staff strategic awareness Employee turnover
Knowledge resource	Employee satisfaction Skills gaps
Research and development	Output performance measurement Project goals achievement ratings R&D spend

***Table 5**: Types of FM learning and growth related measurements – Definitions*

Critical success factor	Associated measurement tools
Value for money/cost efficiency	Establishment and maintenance of cost data Cost efficiency Reduction of service operating costs Cost of service re-location Cost of acquiring and maintaining best FM practices Cash releasing efficiency schemes
Asset utilisation strategies	Asset utilisation rates
Procurement and purchasing strategies	Cost control effectiveness
Financial resource management	Balance of income and expenditure Financial reporting
Profitability	Return on assets

***Table 6**: Types of FM learning and growth related measurements – Definitions*

This section has outlined several categories of performance measurement issues, uncovered primarily from the case study findings. The case study data provided evidence that it is always desirable to expose these performance bases, as it is the first step in achieving an understanding of the usefulness of performance measurement within FM organisations.

The customer, internal FM Processes, learning and growth, and financial issues reflect the FM organisation's overall functions and activities and its perspective on critical success factors. However, that view is not necessarily correct and a well-balanced set of measures does not guarantee a winning strategy (Kaplan and Norton, 1996). They can only translate a particular strategy into specific measurable objectives. Failure to convert improved operational performance into improved financial performance make facilities managers rethink the FM strategy or the FM implementation plan.

Discussion of findings

Common issues derived through this research in trying to apply the BSC concept to create a performance measurement framework for FM are summarised below:

Identification of performance measurement tools in FM

The main body of this paper is an explanatory study which has tried to investigate the applicability and implementation of BSC principles in FM environments. The analysis uses empirical evidence collected in eight case studies, coupled with additional information assembled via other data collection methods. Some of the propositions achieved in terms of contribution to performance measurement initiatives within FM are outlined below:

Proposition one - FM organisations represented the need for performance measurement applications

A major hypothesis set at the commencement of the study reported in this paper was that there would be a need to develop new performance measurement practices within FM. Hence, comprehensive analysis of existing literature and practice tried to identify that there is such a need in order to confirm, or deny such a proposition. The main findings of this research in this respect is listed below:

- It has been emphasised that, despite the considerable achievements of the last few years, the field of performance measurement in FM remains at a very early stage of development in which it has few secure methods of its own to underpin good practice experience (Hinks, 2002);
- A large potential market for application, the diversification of facilities professions and context for facilities professions, have been identified as potential opportunities for performance measurement deployment in FM (Gagendran, 2000);
- The need for new approaches to measure performance in FM has been identified by highlighting the problems with existing approaches to performance measurement in FM (Amaratunga, 2001);
- Performance measurement in FM is currently focused on operational level measures rather than measures representing the strategic FM issues;
- Performance measurement systems rooted in general management literature have not been fully utilised by the FM community;
- Most of the existing performance models in FM do not explain the mechanisms through which FM can contribute towards the success of the core organisation;
- Current performance models of FM lack pure empirical support;

- Descriptive guidelines on performance measurement in FM have failed to generate useful guidelines for facilities managers; and

As indicated above, there is no indication of how performance measurement activity is permeating within the FM organisation, leaving room for the identification of new ways of deploying performance measurement within FM organisations.

Proposition two - There was empirical evidence leading to the development of new performance measurement constructs in FM organisations by using BSC as the theoretical framework

A major research construct set at the beginning of this study was that there would be empirical evidence in FM organisations matching the core performance measurement principles described by BSC when it is used as the theoretical framework. This process of searching for validation helped to refine these principles and interpret them for application in FM environments. The following items represent the main findings of this research in this respect:

- Important theoretical replications were found for core performance measurement principles investigated, using BSC as the theoretical framework;
- General definitions of core performance measurement principles detailed through BSC can be generalised to FM, but required creative adaptation when it comes to implementation in practice;
- There is great room for improvement in FM by using the developed framework illustrated in this paper as the base line.

Proposition three – A general performance measurement framework for FM can be established

Critical analysis of existing literature in FM indicated that performance measurement in FM requires the development and identification of more effective mechanisms. New performance measurement techniques need to be identified in order to close the gaps in knowledge relating to performance measurement principles found within FM.

In this context, it is worth re-emphasising the importance of having a clear understanding of the underlying issues and organisational demands relating to performance measurement in FM (Varcoe, 1996). In this paper, the use of performance measurement concepts in the field of FM have been identified as relatively sparse and this has led to an over simplification of the role and the processes of performance measurement in FM organisations.

It is worth emphasising that it was understood that improvements in FM performance have to pass through a natural evolutionary process, starting from improvements in quality and time and then progressing towards lower cost and service efficiency. Therefore, whilst business survival may require focus on one or two competitive criteria of the performance measurement framework identified in the short-term, it seems that a logical and evolutionary sequence is the most likely way to achieve sustainable competitive advantage in the long-term.

Links between business performance and FM performance

The case for a strong link between FM and organisational performance was made by Duffy, as far back as 1988: "Costs are now made in new ways – not just how many pounds per square metre of construction, but real costs of occupancy related to how much per head of workforce – or even better, per rate and quality of information processed. FM at last makes it possible to bring up to board level the total picture of occupancy costs". Derived BSC model for FM supports this as critical success factors are derived based on the facilities organisational strategy, which clearly has links with the core organisational vision and strategies.

Good practice performance measurement

This paper emphasises how to bring together different kinds of measures in a single comprehensive view of the entire FM business. In this sense, the BSC framework development outlined in this paper bring together customer related FM measures, FM internal process related measures, FM innovation and future potential issues and FM financial base. It is important that this view describes what facilities managers actually want to put in focus. Experience has shown that developing this kind of measurement system and then using it in the ongoing exercise of management control is a good tool for strategic FM control as well.

Both financial and non-financial measures

The financial environment in which today's organisations do business puts new and different demands on management control and on the control systems which organisations use (Olve et al, 1999). In this context, the choice of non-financial measures illustrated in Tables 3,4,5 & 6, is determined by the focus of the FM organisation, the people who are using them and what they are being used to measure. Non-financial facilities performance indicators are most frequently determined by organisations themselves and although there are commonalities between organisations within the same sector, it is more likely to be a wider range even within one business sector as organisations display the view of their core competencies.

Strategy communication through measurement

Performance measurement and management framework development outlined in this paper helps FM organisations map out a clearly defined destination, as well as a plan to navigate by (Kaplan and Norton, 1996). The structure of the performance measurement system provides a framework to translate strategy into operational terms be identifying the related critical success factors and associated performance measures so that it can be effectively communicated, understood, and acted upon. The process: align strategy with the FM organisation and resources, leverage hidden assets and knowledge, link people and processes, and create strategic feedback systems that accelerate organisational wide performance. The result: making strategy work – rapidly, measurable, knowledgeably (Kaplan and Nortan, 1996).

Performance management and not simply performance measurement

As identified already, performance measurement is an area which has been discussed increasingly over the past few years, and the adages "you can't manage what you can't measure" and "what gets measured gets done" and "has never been so powerful a truth" (Peters, 1987) (cited in Stone, 1996) are an all too common elements of many management texts. Performance management on the other hand, is the use of performance measurement information to effect positive change in organisational culture, systems and processes, by helping to set agreed performance goals, allocating and prioritising resources, informing managers to either confirm or change current policy or programme directions to meet those goals, and the sharing of results of performance in pursuing those goals (PEA, 1998). The system outlined in this paper tries to develop links between the FM strategy and its operational processes and measurements, thus creating a performance management culture within the FM organisation.

Future suggestions

Issues discussed throughout this paper has attracted interest of both academics and practitioners. The need for further research in the area is supported by the recent developments in the FM knowledge base, that is to raise its awareness within the core organisational setting. The following recommendations for further research are primarily driven by emerging performance measurement strategies identified in this paper:

- There is a need to uncover more critical success factors and corresponding performance measures relating to learning and growth issues of FM performance as there seems to be opportunities for such new explorations beyond the cases used in this research;
- There is a necessity to justify the framework's application in different FM settings to verify its validity. Such an application will further increase the generalisability of the FM BSC framework;
- There is also a need to understand the relationships that exist between the different types of performance measurement constructs, for e.g., between customer related issues and internal FM processes. By doing so, it will be possible to eliminate the constructs which do not have strong relationships among each other from the BSC framework;
- Further, development of a facilities performance measurement assessment criteria is required for facilities managers to develop tools for communicating the performance measurement dimensions of FM. Methodologies to integrate FM performance constructs with the core organisation's performance measures are needed as also emphasised by Hinks (2002). This will help to understand the facilities contribution towards the core business performance;
- The development of further clarification of FM performance measures, where FM performance measurement leads in the future being based upon how useful FM is to the core business;

- Provide a cost benefit analysis of implementing performance measurement systems in FM organisations. This is one of the key issues to be addressed in future by FM researchers in the field as it would be of interest, both to organisations who have made the move to performance measurement and to those who are considering it, to know exactly how much value is added;
- Further, clarifying the FM organisational performance measurement process as to its dependence on the existing knowledge base of the FM organisation. That is, observing how the content of the FM knowledge base impacts the FM organisation's ability to learn;
- Examining FM organisational learning by observing the changes to the FM organisation's knowledge base. In particular, changes to the FM knowledge base of the core organisation and the impact of this on other knowledge bases, would be an interesting study;
- The findings of this research are most visible in large FM organisations. The vast majority of businesses in the UK are small businesses and in these organisations FM is often integrated with other functions and may not play a major role. In large organisations, such as the case studies identified in this paper the importance of FM performance measurement is reasonably obvious, but this may not be true for small or even medium sized organisations. Thus, this area needs further attention.

Hence, the clarification and development of the concepts relating to FM organisational performance measurement in this paper provides a basis upon which further research can be conducted, as suggested above.

Conclusion

This research study has focused on the evolving role of performance measurement within FM organisations.

The proposed FM BSC framework and the resulting classification constituted a contribution in the form of a new tool to expose performance measures in FM. The model may be viewed as being a collection of work on different elements of performance perspectives.

Further, as suggested in a previous section, the outcome of this research will lead to the exploration of performance measurement applications in FM further, especially in terms of identifying the facilities contribution in terms of achieving the objectives set at the core organisational level.

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A facility manager's role to provide quality service through reflecting user needs

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Abstract
The uniqueness of role of facility manager is also based on its integral and multidisciplinary work ability. Among the various expectations of a facility manager, one of the important issues is to produce a quality service defined by the customer (Cotts, 1999). This paper raises and discusses the following questions, 1) how quality can be defined in facility management and why it should be defined by the customer, 2) how facility managers can find out customer (user) needs, 3) what are the difficulties in finding out user needs and in delivering quality service, and 4) whether improving quality always means requiring higher cost. Based on the classic perspectives of quality management by Juran and Crosby, cost and quality issues in facility management are further discussed in terms of the impact on bottom line, and in terms of effectiveness and efficiency. Some plausible directions to meet the customer needs are suggested.

Keywords: facility management, service quality, customer expectations, user satisfaction and needs

Introduction

Facility management activities are more than the operations and maintenance of facilities. From creating a new space to fulfilling organizational business needs and individual needs, to maintaining the quality of space within the life span of a building, and to final disposal, the roles of a facility manager are very various. According to IFMA, facility management is the practice of coordinating the physical workplace with the people and work of the organization. Major responsibilities into several major functional areas are 1) long-range and annual facility planning; 2) facility financial forecasting; 3) real estate acquisition and/or disposal; 4) work specifications, installation and space management; 5) architectural and engineering planning and design; 6) new construction and/or renovation; 7) maintenance and operations management;8) telecommunications integration, security and general administrative services.

As most of the vital activities and responsibilities of facility management are associated with various customers and facility quality, customer satisfaction is an important issue in facility management field. Especially, in an organization where facilities service is a key part of the business such as hospitals, education facilities, hospitality facilities and public facilities, providing a facility to support customer needs is crucial for the success and effectiveness of the business. With the growth of service sector and its increasing role in the world economy (Javalgi and Moberg 1997; Ramcharran 1999), it is natural of more facility management activities to be involved in quality issues. In addition, as technology develops, human labor can be replaced by other technologies. Facilities and equipment may become a more important asset to provide high quality service. In this context, many of works of FM can be considered as practices that provide tangibles (physical environment) and intangible service.

Quality by Customer

The term quality can be considered as abstract, elusive and indistinct one. Crosby (1979) defines quality as "conformance to requirements," and the requirements must be clearly stated so that they cannot be misunderstood. Juran defined quality as "fitness to use," i.e., the users of a product or service should be able to count on its performance (March 1986; Costin, 1998). Quality issues cannot be considered without customer-oriented perspective. Parasuraman et al. (1985) mentioned that service quality involves a comparison of expectation with performance. "Service quality is a measure of how well the service level delivered matches customer expectations. Delivering quality service means conforming to customer expectations on a consistent basis (Lewis and Brooms, 1983)"

Friday (2001) emphasized the importance of customer defined quality in FM the profession. According to her, customer service becomes a goal that most facility management organizations strive to achieve. Building a solid FM organizational structure that will meet customer requirements, perceptions, and expectations necessities an institutional commitment to the concept of customer-defined quality.

To understand service quality fully, the three characteristics of service quality - intangibility, heterogeneity and inseparability- should be acknowledged (Parasuraman et al., 1985). First, most services are intangible (Lovelock 1981). However this aspect might be controversial in FM because most FM services are delivered through tangible physical aspects. Second, service performance often varies due to the behavior of service personnel (Carmen and Langeard, 1980). A well-developed job specification and training help to improve the consistency of services of facility management. Third, production and consumption of many services are inseparable. Usually interactions between the client and the contact person from the service provider take place (Lehtinen and Lehtinen, 1982). The service provider may have less managerial control over quality because the customer affects the process (Parasuraman et al., 1985). Flexible response and communication strategy need to be considered.

Quality criteria

Due to the characteristics above mentioned, service quality is considered as hard to evaluate. However, many researchers in marketing and other service industries have developed quality dimensions and criteria that are applicable to FM. According to Lehtinen and Lehtinen (1982), quality dimensions are "physical quality" which includes the physical aspects of the services, "corporate quality" which involves the company's image and "interactive quality" which derives from the interaction between contact personnel and customers. There are several criteria to measure service quality.

Parasuraman et al. (1985) developed determinants of service quality through intensive executive interviews and focus group of customers in four service areas (see table 1). From the 10 dimensions, Parasuraman et al. (1988) further developed the dimensions and proposed “Servqual,” a multiple-item scale for measuring consumer perception of service quality. Specifically they measure the differences between expectation and perception in 5 dimensions which are 1) tangibles: the appearance of the physical facilities, equipment, personnel and communication materials, 2) reliability: the ability to perform the promised service dependably and accurately, 3) responsiveness: the willingness to help customers and provide prompt service, 4) assurance: the competence of the system in its credibility in providing a courteous and secure service, and 5) empathy: the approachability, ease of access and effort taken to understand customers’ needs.

Reliability	Consistency of performance and dependability -keeping the records correctly -performing the service at the designated time
Responsiveness	The willingness or readiness of the employees to provide services. It involves timelines of service -calling the customer back quickly -giving prompt services
Competence	Possession of the required skills and knowledge to perform service -knowledge and skill of the contact personnel -knowledge and skill of operational support personnel -research capability of the organization
Access	Approachability and ease of contact -service is easily accessible -convenient hours of operation -convenient location of service facility
Courtesy	Politeness, respect, consideration and friendliness of contact personnel -consideration for the consumer’s property -clean and neat appearance
Communication	Keeping customers informed in language they can understand and listening to them -explaining how much the service will cost -assuring the consumer that a problem will be handled
Credibility	Trustworthiness, believability, honesty -company name and reputation -personal characteristics of the contact personnel
Security	Freedom from danger, risk or doubt -physical safety -financial security -confidentiality
Understanding	Making effort to understand the customer’s needs -learning the customer’s specific requirements -providing individual attention -recognizing the regular customer
Tangibles	Physical evidence of the service -Physical facilities -tools or equipment used to provide the service

Table 1: Determinants of service quality

Source: Parasuraman, A. Zeithaml, V.A. & Berry, I.L (1985). A conceptual model of service quality and its implication for future research. *Journal of Marketing*, vol 49, p 47

Servqual became one of the methodologies to measure service quality in various service areas such as health care facilities (McAtarsney 1999; O’connor et al. 2000; Duffy et al. 2001) and the hospitality industry (Heung et al. 2000). By using Servqual, Dalrymple et al. (1995) analyzed service quality in order to investigate which dimension customers see as the most highly values and what customer expects in each dimension from any service provider. They investigated the gap between the expectation and perception of customer in five dimensions. As a result, in the dimensions of tangibles and reliability, the perceptions of customer were lower than their expectation. Duffy et al. (2001) examined the service quality expectation of residents, family and administrators within a long-term-care context.

Being different from a customer satisfaction survey, Servqual can show the gap between the expectation and perception in 5 specific dimensions and provide more managerial direction. However, for the FM practices, the items of the scale need to be further developed and elaborated.

Barriers and Process

To find out customer's expectations and needs, a facility manager should be aware of who are the customers, including both potential and apparent customers and then should search and figure out appropriate way among multiple choices that might suit their organization and business.

However, because there are a variety of groups of customers with various expectations a facility manager is supposed to fulfill, there are some barriers to understanding customer needs and expectations.

First of all, a facility manager faces and deals with a wide range of customers. Customers can be categorized as internal and external sources. Internal users or customers can be from senior executives to department or division managers to individual employees. External customer can be external visitors or users out of the organization who visit and use facilities. Friday (2001) enumerated various customer groups including organizational units, building units, the FM organization, senior management, external clients, vendors, tenants and even facilities. In this paper, customer groups can be different from the various stakeholder groups of FM and can be defined as user group who mainly stay in or use facilities and/or equipment in a certain period of time.

It is hard to fulfill the different needs of various groups of users at the same time. Donnely et al. (1995) pointed out that the interest of different group of customers might be in conflict. It is not only because people seek different things but because with limited resources, distribution of the resources can cause conflict. For instance, tow departments complained lack of their workspace and asked to update technical systems. Facility manager should find out the degree of urgency of the requests and prioritize them and work with two departments. Ability in negotiating, compromising, prioritizing and communication are important to solve this kind of problem.

Second, the gaps between the groups exist and play a role in managerial and planning decisions. In environment behavior studies, the term, "gap" commonly refers to discontinuity between designers and those who will eventually live and work in their buildings (Zeisel, 1981). In service quality areas, this brings out different requirements and specifications according to eye holder's view. Quality tends to be judged in terms of the expectation of professional, managerial, or interested third parties rather than service recipients (Duffy et al., 2001). The gap between the service provider and consumer expectations has been significantly linked to consumer dissatisfaction (Klose & Finkle,1995). Increasing communication between the groups may seem to be an unremarkable but necessary suggestion (Bell et al., 2001). Using a proper language is also important to reduce the gaps.

Third, customers may often play a passive role in addressing their needs and expectations. Indeed, researchers have found that clients of professional services in general tend not to acknowledge their dissatisfaction until they are extremely dissatisfied (Duffy et al., 2001).

Fourth, customer satisfaction surveys often lack tangible ideas that are related to specific customer needs. In addition, customers may be not clearly aware of what they really want to do or receive prior to using a space or service. Planning a new facility requires a facility manger or a planning group to put intensive efforts to find out various customer needs including latent needs.

Finally, to find out customer needs and expectation, there is no universally accepted instrument or measurement. Dalrymple et al. (1995) surmised that the main weakness of customer satisfaction surveys is ignoring customer's expectation in favor of Servqual. However, there were issues about the validity of Servqual and how it can be most effectively operationalised (Kiernan, 1996). POE (post occupancy evaluation) is recognized as an integrated approach to measure performance of built environment in perspectives of occupants. However, Presier (1999) mentioned "to date, there is little or no standardization of measurement technology and methods used on POE ". Krueger (1994) proposed the problems under basic assumption of mail and telephone surveys that individuals really do know how they feel and individuals form opinions in isolation in addressing necessity of focus group method to get opinion of customers.

As physical conditions of facilities, organizational structure and culture vary even within the same kind of business, a facility manager or planner should carefully adopt a certain method and be aware of what can be acquired thorough the method adopted. In addition, although it is hard to have a generalized measurement, more cases, practices and more reliable tool to measure customer' needs, expectation and satisfaction toward FM service should be developed.

In order to understand and meet customer needs and expectations, a facility manager can use several kinds of methods such as customer satisfaction surveys, Servqual, interviews, focus group interview, observation, casual talks, and management and technical audits. It is difficult to argue that one is superior to any other. More often, facility managers can use multiple methods together according to the task and scope of a project. However, recognizing the significance of customers and their inputs will be a key to secure good quality and success. Becker (1990) emphasized the importance of customer or user participation. For a new and better office quality, Becker suggested that more efforts should go into the preliminary processes for planning and designing buildings with more user involvement. This should include systematic post-occupancy evaluations, employee's reviews and feedback about not only the physical designs but also the management policies and procedures. User participation becomes one way to reflect user's view in planning and managing facilities.

Cost of Quality

As quality improvement efforts often require an integrated approach within an organization, the cost of quality is addressed in terms of investment and its return in value. How far should a manager go in finding out customer needs, meeting requirements and improving the quality of service? Does improving quality always mean requiring higher cost? The cost of quality has been more often mentioned in manufacturing goods. The "1-10-100 rule" is a common term in the cost of defects in manufacturing. For the cost of quality, two leading quality 'gurus', Crosby and Juran have taken different approaches. Though their approaches mainly focus on the manufacturing industry, their fundamental perspectives provide better understanding of cost of quality in the provision of services.

Cost of quality can be divided in three categories. Prevention costs are the cost of all activities undertaken to prevent defects in design, development, purchasing, and labor in developing products or service. Appraisal costs are used for conducting inspection and evaluation. Failure cost are disposition, customer affairs and credibility, labor, etc. (Crosby,1979). In order to improve quality, prevention cost and appraisal cost are required however, as results, improved qualities reduce failure cost and customer complaints and result in business profit.

Juran explained that there is an optimal level in the balance between the failure costs and the cost of appraisal and prevention. To reach zero defects (100% quality), the cost of appraisal and prevention and other efforts are too high. If an organization spends too small amount of effort and a small cost of appraisal and prevention, the defects rate is too high and the loss is huge. Therefore optimal level is a point in which cost of quality is minimized. "Zero defects was not a practical goal, for to reach the level, prevention and appraisal costs would have to rise so substantially that total costs of quality would not be minimized (March, 1998)"

Crosby was an advocator of zero defects. Crosby states that the cost of quality is the cost of conformance and non-conformance while Juran advocates measuring internal failure, external failure, appraisal and prevention costs (Chang, 1998). In summary, if quality is improved, eventually profitability will increase. "If management established a higher standard of performance and communicated it thoroughly to all levels of the company, zero defects was possible (March, 1998)"

Setting optimal level is a goal of quality programs (March, 1988). Optimal range is related to setting the bottom line level. Bottom line tends to be set based on the past experience of a manager. With minimum cost, time, and human labor, securing a certain level of quality believed as acceptable by management may appear as efficient; however, its effectiveness may be questionable. Differences between the optimal level and bottom line should be recognized. Juran's approach might be more practical and prevalent in most of FM activities. For instance, in fulfilling and supporting psychological and behavioral aspects of customer needs. Decisions for repair, remodeling or renovation need be based on an optimal point to ensure the quality of operation or performance of the facility. However, for technical and primarily functional aspects, Crosby's approach can be more appealing. For instance, in a construction project, waterproofing at an early stage is vital for successful use and completeness of the facility. If it is defective, after people moved in, it requires huge cost to correct the errors. The "1-10-100 rule" can be applied to his situation.

Developing specifications, continuously seeking information and attitudes from the customers, and the audit of facilities helps facility mangers to be effective and efficient in the cost of quality. For instance, like Servqual, measurements that fit the organizations and the facilities need to be developed. FM service request procedures and reports to the customer about the results should be prepared and updated, Most of all, management inputs and control related to customer issues are vital to lead those efforts to successful outcomes.

Discussion

Facility managers may easily overlook customer inputs or put them aside due to daily management pressures. Quality aspects are hardly discussed without taking a long-term view. Especially in service business organization, facility managers should involve external as well as internal customers. A facility manager should provide not only intangible services but also physical environments that are user friendly and sustainable over time. During the life span of a building, a facility should be properly managed to support organizational business and user expectations.

Research results in service quality show that there are pros and cons in adopting any methodology to find out customer needs. If facility managers are aware of the barriers and difficulties in understanding customer expectations, it helps to select the appropriate method for any particular circumstance.

Even with the variation in physical aspects of work settings, the quality of facility management is quite different from other services. Servqual measures the gaps between expectations and perception in 5 dimensions. The five dimensions are generally applicable but not well covered in FM service areas. The gaps from different groups may reveal different expectation toward FM service quality and show the different group expectations. By developing these dimensions, the structure of gaps will provide better understanding of FM profession. For future research, a more elaborated service measurement that has different dimensions and determinants in FM activities needs to be developed so that facility managers can transfer and utilize them in their practices.

In addition, two perspectives by Juran and Crosby are useful to understand the cost of quality in FM. It provides a general approach that is useful in FM. However the lack of empirical research and case studies hampers the implementation of these approaches. Empirical research and cases in this area will help facility mangers to make better decisions.

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A customer-focussed risk and opportunity management system for facilities management

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Abstract
This paper presents a case study which documents the development and implementation of a Risk and Opportunity Management System for Multiplex Asset Management (MAM). This will be used for its projects and facilities around the world and is both practical and simple to use, yet incorporates the latest thinking in risk management research and practice. The aim of this paper is to discuss why the system was developed, how it was developed and how it adds value to the business objectives of MAM, its customers and its business partners.

Keywords: Facilities management, risk management, opportunity management, customer-focus, Multiplex Asset Management.

Introduction

Why do so many people get hurt on construction sites? Why do so many projects run over budget and exceed their programs? Why do seemingly healthy companies suddenly collapse? Every week, our journals and magazines are littered with literally hundreds of examples of corporate crises and project disasters, which inevitably provoke unanimous and almost ritualistic condemnation, after the event. While hindsight is a wonderful management tool, in almost every case, the companies involved do not have an effective risk management system in place. Recognising this, MAM have created a risk and opportunity management system which seeks to transfer the latest research in risk management into the facilities management sector. The purpose of this paper is to describe why it was developed, how it was developed and how it works.

Risk management

Risk management is the process of systematically identifying an organisation's risks and analysing them in terms of their likelihood and potential consequences in order to make informed decisions to control them effectively (Baker et al 1996, Bamber 1999). One of the most common misperceptions about risk management is that it is a managerial "wonder-drug" that can eliminate an organisation's risks. However, the elimination of risks is not to any business's advantage and, usually, every time a company moves forward it is because someone has taken a risk and tried something new. Managers who are averse to risks should not be in business and, contrary to common belief, risk management is not about avoiding risks but is about recognising them understanding them and controlling them effectively (Raftery 1994). The basic principle that underpins risk management is that the worse and most dangerous type of risk is one that has not been identified and responded to. Once a risk is identified it ceases to become a risk but instead becomes a management problem and therefore a potential opportunity.

The distinction between opportunities and risks is central to this paper and to MAM's system. There is substantial evidence to suggest that opportunities and problems need to be managed differently and that a distinction does need to be made in risk management systems (Loosemore 2000). Unfortunately, almost without exception, current risk management systems only pay "lip service" to the concept of opportunism, providing no guidance on how to deal with opportunities effectively. A typical example is the system advocated by ICE (1998) which distinguishes between risks and opportunities but then goes on to provide control mechanisms designed only to mitigate rather than optimise. In the construction industry this negative focus on problems rather than opportunities is perpetuated by the industry's traditional culture of confrontation, penalty and fear (Loosemore 2000). In this context, it is not surprising that the industry's performance is often publicised as being sub-optimal. If the construction industry is to improve its performance, it must recognise that opportunity management is as important as risk management and provide systems and mechanisms which recognise the difference.

About Multiplex Asset Management

Multiplex Asset Management (MAM) is a subsidiary of Multiplex Constructions Pty. Ltd., one of the largest construction companies in Australia and a major force in construction across South East Asia, Middle East and more recently the UK. Multiplex's culture revolves around its ability "to get the job done" and it has been responsible for the construction of some of the world's most famous landmarks. For example, it won the contract to build the Olympic Stadium for the Sydney 2000 Olympic Games and is currently contracted to build the new Wembley Soccer Stadium in the UK.

MAM was established in 1998 to offer developers, building owners and investors an integrated range of facilities and asset management services. MAM extends the services offered by the Multiplex Group to the entire building life-cycle from inception, through design and construction to the ongoing use and management of the built facility. MAM's business is based on the increasing recognition that the land, buildings and support infrastructure owned by an organisation is a vital support resource that makes an important contribution to its customers' core business objectives (FMA 1999, Nutt and McLennan 2000). The strategic importance of real-estate, as a business resource that needs effective management, has been reinforced by the realisation that after staff costs the next highest category of costs for many large corporations is facilities-related. The role of MAM is to ensure that an organisation's real estate assets support and contribute to core corporate goals and at a national level, to provide appropriate infrastructure support to all business and public endeavours across all industrial sectors.

MAM has grown rapidly since 1998 based on the provision of innovative and value-adding services that manage risks and opportunities profitably, thereby maximising the return on shareholders and clients' investments. Essentially, the core business of MAM is risk and opportunity management and the size of the projects they manage such as the Olympic Stadium, ensures that these risks are significant. Indeed, in many ways, the risks for MAM are larger, albeit, less densely spread, than those experienced during construction, since the costs of operating a building over a twenty-five year period can be as much as ten times higher than its initial capital cost (Citex 1999). Furthermore, MAM are often required to manage risks which have been created by people over whom they have little control (such as designers and sub-contractors) and at a time when the difficulties and costs of doing so are at their greatest. Research has shown that most risks are created in the design stages of a project and that the operational phase of a building is the most difficult and costly period in which to manage risks (Bea 1994, Gray et al 1994). This is the dilemma of risk management for facilities managers.

The need for a risk and opportunity management system.

MAM recognised that risk management should be an integral part of good management practice and that the benefits of effective risk and opportunity management can be enormous in terms of improved efficiency, better performance, increased competitiveness and higher profitability. Indeed, it was anticipated that reductions in insurance premiums alone, which are higher in construction than in any other industry in Australia, would over time, pay for the development of the system (NOHSC 1999). Furthermore, MAM recognised the global trend towards an more risky and legislative business environment that increasingly requires companies in the construction industry to manage their risks more effectively. The penalties for not doing are becoming ever more severe, particularly in the area of safety and the environment where charges of corporate manslaughter and major fines are becoming increasingly common (Wells 1996, Craig 1996, Teo 2001). The UK's Construction (Design and Management) Regulations 1994 and Australia's Occupational Health and Safety Regulation 2001, are good examples of the increasing trend towards risk-related legislation around the world.

Rather than waiting for these changes and reacting to them, MAM decided to be pro-active and develop a formal system that could provide a common framework for risk and opportunity management across the company with consistent terminology, tools and techniques. While most managers already practiced risk management informally, MAM recognised that risk and opportunity management would be even more effective when applied systematically and consistently across the company. The aim was to develop a new umbrella system that would cover to all management levels and business functions in MAM, encompassing existing safety and environmental management systems.

The objectives of the system

It was important to MAM that the system reflected, communicated and reinforced its business culture, which was based upon the three main principles of: *value-adding*, *openness* and *pro-activeness*. To this end, the guidelines had to be:

- **Realistic, easy to understand and easy to use** – minimising jargon and using plain English.
- **Customer-focussed** – adaptable to the individual needs and circumstances of each MAM customer and adding real value to their business objectives.

- **Innovative and forward thinking** – incorporating the latest thinking in risk and opportunity management and exceeding international standards (AS/NZS 4360:1999 *Risk Management*).
- **Opportunistic and pro-active** – focused on maximising opportunities as well as mitigating risks.
- **Consultative and inclusive** – recognising the needs of all stakeholders and encouraging of collective responsibility, cooperation and teamwork.

MAM did not want a system which “sat on the shelf” but one that would add real and significant value to their business and to their customers’ businesses. The system had to achieve the following key objectives:

- **Culture** - To make risk and opportunity management an integral part of MAM’s business culture.
- **Exceptional service** - To provide evidence of MAM’s dedication to innovative work practices and exceptional service performance through system documentation.
- **Continual improvement** - To continually improve MAM’s performance beyond expectations through vigilant and expedient response to all potential risks and opportunities.
- **Client satisfaction** - To ensure MAM’s clients’ core business needs are met and ideally exceeded, through the efficient procurement and management of their facilities.

The process of developing the system

Initial discussions with key stakeholders soon revealed the complexity of the decision to develop a new risk and opportunity management system. While the creation of the guidelines was to be a major undertaking, so was changing peoples’ existing expectations and behaviour. Research suggests that only then would the system become an integral part of MAM’s business culture, automatically determining the way that people operated, acted and behaved on a day-to-day basis (Schein 1990). Schein’s work suggests that no matter how well designed the system was, peoples’ acceptance of it would be critical to its success. Furthermore, while it is very easy to change peoples’ behaviour in the short-term, it is extremely difficult to keep it changed. This was the challenge MAM faced which was as equally important as the development of the system itself. In particular, MAM did not want to sterilise the decision making process and eliminate the “gut feeling” and intuition that had been at the heart of many good decisions made by Multiplex over the years. MAM were acutely aware of the dangers of “paralysis by analysis” and of the importance of being decisive and risking being wrong than agonising at length and being right too late.

In MAM’s enthusiasm to develop the system, the temptation was to rush in. Instead, the process was carefully planned over a one-year period. The first five months involved writing the system and the remaining seven months was used to implement them. To encourage people to “buy into” the system, MAM’s Directors championed it and were intimately involved in its development so that it realised their initial vision and MAM’s corporate goals. Senior management commitment is widely recognised as being vital to success of risk management systems (ICE 1998, Smith 1999). There was also extensive consultation with other MAM stakeholders, external and internal to MAM, at all stages of the system's development. As a result, the final document evolved in a dynamic way and went through numerous changes before it was ready for use and everyone was happy with it.

An extensive training program was also planned to bring people's' confidence and skill levels to a point where they would feel comfortable with the system. This training was essential to overcome the common fear of risk management and the perception that it is "rocket science" and just another management fad that will eventually go away. An effective support infrastructure was also created which involved forming a risk management team with specific responsibilities for implementing, managing, monitoring and updating the guidelines. The structure of this team is depicted in Figure 1 where the wider resource implications of developing a risk management system become clear.

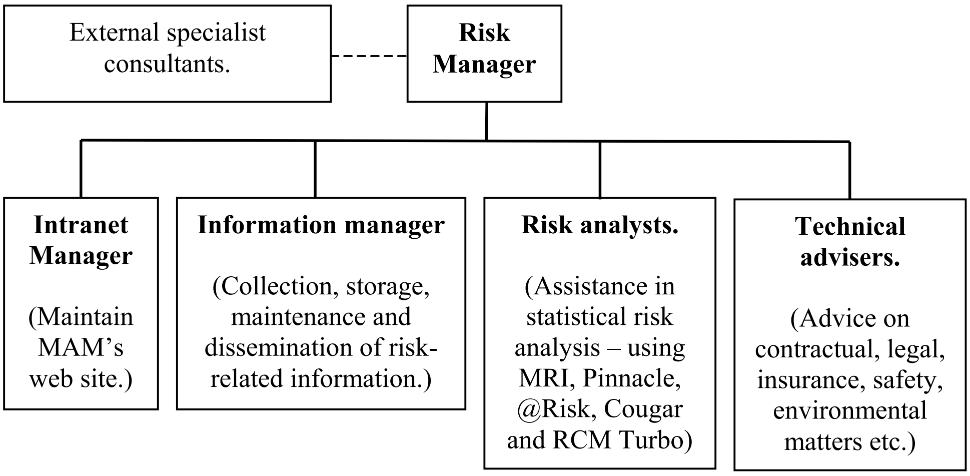

Figure 1: MAM's risk management team.

MAM also established a risk and opportunity management section on its existing intranet site which allowed those working on MAM facilities to share, visualise and communicate information about risks with clients, staff, sub-contractors, suppliers, consultants and authorities, anywhere in the world. On the intranet site, employees can find:

- An electronic copy of the guidelines.
- Standard forms which can be down-loaded for use on site.
- A dedicated facility-specific file where every person using the guidelines will be expected to record their risk and opportunity management decisions.
- A data-base which provides people with information to help you manage your risks effectively.
- A library of useful references.
- A risk and opportunity management noticeboard which is continually updated with useful tips, contacts and information.
- A discussion page that will enable managers to share their experiences.
- A suggestion box which allows managers to provide ideas for improvement.
- A help-line where people can consult an expert by e-mail, fax or telephone on a range of issues.

Finally, to encourage people to use the new guidelines, a monitoring and reward system was established with the intention of linking peoples' risk management performance to their to annual performance appraisals.

The system

The final system is presented in an un-intimidating 50 page document which specifies procedures to follow and risk management tools to use. It is written in plain English, with minimal jargon and provides numerous practical examples of how to use the tools specified. This is important for Australian users but particularly important for non-English speakers on Australian and overseas projects. Readers are taken through the document by a series of simple questions, which they would be likely to ask as they encounter the system or the concept of risk management for the first time. Most questions are presented in the first-person and examples include, "What types of decisions are covered by these guidelines?", "When do I start risk and opportunity management?", What is my first step?", What do I do when I have identified a risk? etc. Considerable thought also went into the design of the document, which is important from a psychological perspective. For instance, white space is maximised on each page to make it less daunting, colour and images are used to enliven the document and help readers navigate, simplicity of approach is maintained by restricting the number of steps to follow to no more than three in any one stage of the process, simple box diagrams are used to summarise processes and the margin on each page is used to summarise the main points to emerge.

One of the many unique things about this system is its flexibility that is facilitated by having four levels at which it can operate. This is illustrated in Table 1 and allows people to chose a level of complexity with which suits their particular circumstances and needs.

Complexity	Level	Description
Simple	1	A minimum standard to be employed in all decisions that involve any significant risks and/or opportunities to MAM's employees, customers and business partners.
↓	2	A standard to be employed in decisions about business activities of *medium* risk and opportunity.
	3	A standard to be employed in decisions about business activities of *high* risk and opportunity.
Complex	4	A standard to be employed in decisions about business activities of *exceptionally high* risk and opportunity.

Table 1 MAM's four level Risk and Opportunity Management System.

The appropriate level in any situation is determined by an individual's answers to a series of simple questions, which relate to the complexity of their business activity, the time they have available, the data that is available etc. Risk management does not have to be complex to be effective and its benefits are not confined to large and complex projects or facilities. The important thing is that people make an appropriate choice and justify it. Of course, everyone is expected to do everything that is *reasonably practicable* to manage their risks and MAM's long-term aim is to enable all their staff, through training, to be comfortable operating at all four levels if needs be.

Having established the appropriate level of operation, the guidelines take people logically, step-by-step, through the four stages of risk management;

1. **Risk and opportunity identification** involves identifying *what*, *how* and *when* things can go wrong or improve.
2. **Risk and opportunity analysis** involves analysing the level of risk by estimating the *likelihood* and *consequences* of any potential risks and opportunities.
3. **Risk and opportunity control** involves deciding upon and implementing appropriate management responses.
4. **Monitoring, reviewing and learning** involves ensuring controls achieve their intended result now and in the future and conducting project post-mortems to learn and communicate lessons for future projects.

This process is depicted in Figure 2 with key questions to ask in each stage.

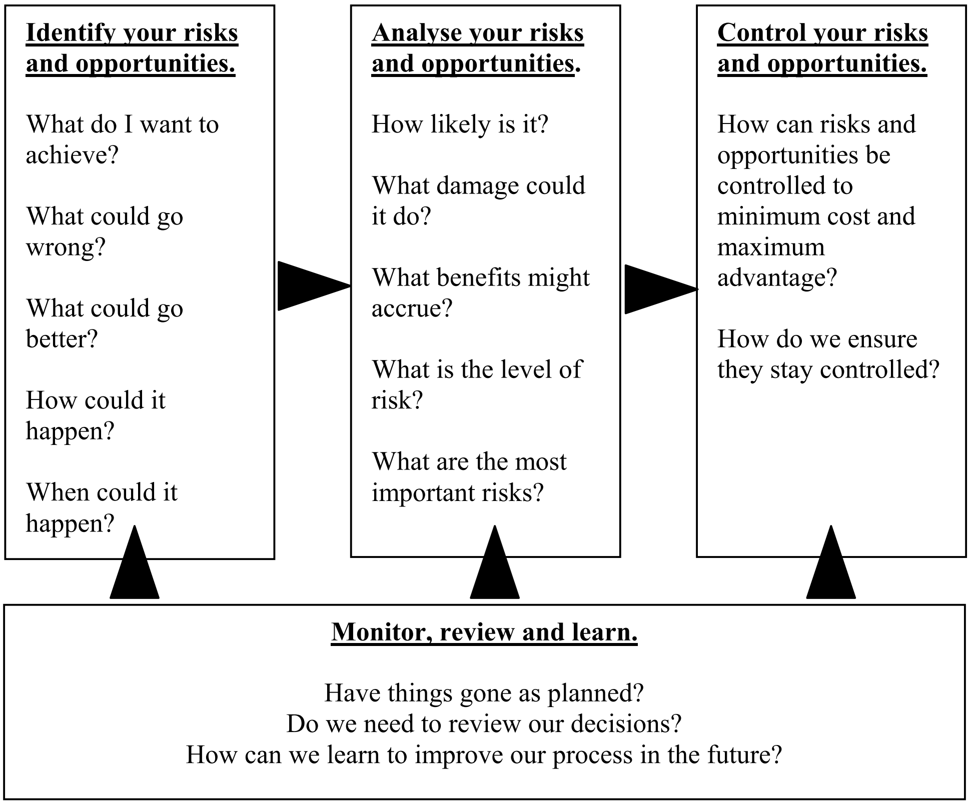

Figure 2 The risk management process.

As one works through the guidelines, the importance of the four-tier system becomes evident as readers follow different paths through the document depending on the level that is identified as appropriate to their needs. In particular, users are referred to a series of pre-defined risk management techniques that correspond to their chosen level of complexity. The guidelines provide people with simple steps to follow and examples of how each technique is used in practice.

The Appendices to the guidelines are important since it is here that standard forms are provided for people to complete as they move through each stage of the risk and opportunity management process. In contrast to many risk management systems, there are only eight simple forms to complete for the entire process but they are very important for record keeping and auditing purposes. The Appendices also contain a glossary of terms, a standard checklists of common risks and opportunities to MAM's business, guidelines for consultation, lists of management responsibilities for risk and opportunity management at all levels of MAM and sources of potential information to assist people in managing their risks etc.

The end result

While each individual making decisions on an MAM contract must follow these guidelines, the end result at a project level is a facility-specific Risk and Opportunity Management Plan (ROMP). The ROMP performs the following important functions:

- It acts as a record of decisions and consultations made at each stage of the risk and opportunity management process.
- It provides a valuable audit-trail and basis for status-reports throughout a contract's life-cycle.
- It provides important evidence for employees, customers, clients, business partners, insurers, financers, unions and pressure groups, of MAM's commitment to innovative work practices and exceptional service efficiency.
- It provides an important source of information to support capital expenditure authorisations from the Board. All business cases should highlight expected ranges of outcomes and describe how business units will manage the risks associated with these variations.
- It facilitates learning within MAM by providing a post-mortem data-base of what went well and what went badly on a contract and how risks and opportunities were dealt with. Managers of other facilities can use these lessons to improve their effectiveness.
- It provides important evidence to demonstrate that MAM managers did all that was "reasonably practicable" to eliminate and mitigate risks.

Conclusion

This paper has described MAM's new Risk and Opportunity Management System. However, we end this paper with a warning. While risk and opportunity management will play an important part in the continuous improvement of MAM's business, it is not a risk-free process. MAM recognises this and has put mechanisms in place to avoid them through the careful monitoring and control of the development and implementation process. The main risks of risk and opportunity management are listed below.

- **Invincibility** – Having put so much work into the system, there was a possibility that it could generate a "it can't happen to us" attitude, which ironically, could blind people to risks.

- **Fear** – People do not like dealing with problems and can cover them up. Problems grow if they are not dealt with immediately and everyone must accept responsibility for the risks they create through their work activities.

- **Over caution** – Increased knowledge about risks can be a major source of risk by causing an over-cautious approach to decisions.

- **Paralysis by analysis** – Risk and opportunity management can lead to hesitation in decision-making. Sometimes, decisions based on intuition are the more effective and some decisions need to be made fast to capture their full benefits or to minimise damage.

- **Negativity** – If managed poorly, risk and opportunity management can be a negative, recriminatory and gloomy affair. To be effective, risk and opportunity management should be exciting and opportunistic.

- **Resources** – Risk and opportunity management takes time and resources and there is a tendency to rush it or avoid it altogether. However, the potential benefits of risk and opportunity management far outweigh the costs.

- **Continuity** - There is a tendency to think that risk and opportunity management is a one-off process. Risk and opportunities continually arise demanding a continuous process that does not stop until a decision is successfully and fully implemented.

- **Culture** - Risk and opportunity management is often seen as another management fad and is treated with scepticism. To be effective, it must be an automatic way of thinking for everyone. Its success depends as much on people changing their behaviour as they do upon well-designed systems and procedures.

The implementation of the system is currently being monitored in terms of its effectiveness. This will be assessed in terms of how it has changed peoples' attitudes and working practices and how it has improved the management of MAM's facilities. Most importantly, the success will be measured against the impact on MAM's clients' business objectives rather than MAM's objectives. This is the most important attribute of a truly customer-focussed system.

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Multiple Criteria Decision Support On-Line System for Facilities Management

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Abstract. *Facility management is an information business. Technological innovation mainly through changes in the availability of information and communication technology inclusive calculators, analysers, software, neural networks, decision support and expert systems that have been provided by a variety of new services developed by the facility management sector. Most of all calculators, analysers, software, decision support and expert systems, neural networks seek to find out how to make the most economic facility management decisions and most of all these decisions are intended only for economic objectives. Facility management alternatives under evaluation have to be evaluated not only from the cost (design, construction, indirect expenses, operating and maintenance expenses, renovation costs, the interest paid on loan), but take into consideration qualitative (aesthetic value, flexibility, comfort (noise, air quality, thermal comfort, working conditions)), technical, technological, space and other characteristics as well. Therefore, applying multiple criteria analysis methods and decision support systems may increase the efficiency of facility management calculators, analysers, software, neural networks, decision support and expert systems. Based on an analysis of existing the information, expert and decision support systems and in order to determine the most efficient versions of facilities management Multiple Criteria Decision Support On-Line System for Facilities Management was developed by authors of paper. The related questions were analysed in this paper.*

Keywords: Facilities Management, Multiple Criteria Analysis, Decision Support On-line System.

1. FACILITY MANAGEMENT CALCULATORS, ANALYSERS, SOFTWARE, NEURAL NETWORKS, EXPERT AND DECISION SUPPORT SYSTEMS

The major players in facility management Web sites can find calculators, analysers, software, neural networks, expert and decision support systems. Calculators and analysers are most often used in the on-line regime. In most cases they are provided free of charge. To a lesser extent, software, neural networks, expert and decision support systems can also be used in the on-line regime. Other software, neural networks, expert and decision support systems can be downloaded from the Internet and used on one’s own personal computer.

A calculator is software application used for completing mathematical calculations. Calculators range from very cheap software, capable of performing the basic arithmetical operations, to those whose capabilities extend to sophisticated mathematical and statistical manipulation and those that may be programmed with a large numbers of steps. Facility management Web sites sometimes contain calculators: CRESA Space Calculator [2] (calculates office space needs), Comfort calculator [3] (analyses thermal comfort and estimates the optimal temperature), Lighting calculator [4] (identifies and analyses options for reducing lighting costs), Ventilation calculator [5] (examines the supply of outside air ventilation to a space), Moving calculator [6] (estimates how much your local or interstate move might cost), Home Improvement Calculators [7], etc.

Web sites might also contain various purpose analysers [8, 9, 10] that help customers to analyse various facility management situations. For example, Analyser-USA [9] provides Facilities Management Services for business computer systems.

Information about facility management software can be found on the following facility management Web sites: ARCHIBUS/FM [11], FM:Systems [12], SPAN [13], Drawbase [14], Aperture [15]. Above facility management software are offered various modules and tools: lease management, move management, strategic space planning, maintenance management, accounting chargeback, communication/cable management, personnel management.

An expert system [16, etc.] is a computer program or set of computer programs that contain a knowledge base and a set of rules that infers new facts from the knowledge and from the incoming data and are used to help solve problems in certain areas. Moreover, the system performs many secondary functions, as an expert does, such as asking relevant questions, explaining its reasons and the like. The degree of problem solving is based on the quality of the data and the rules. Expert systems today generally serve to relieve a 'human' professional of some of the difficult but clearly formulated tasks. For example, the purpose of Expert System for Intelligent Simulation of Housing Modernization Works (developed by A. Retik, V. Marston, and M. Alshavi) is to facilitate the evaluation of alternative strategies under uncertain conditions.

According V.Sauter (1997), over the years expert systems have evolved into an integrated component of many decision support systems that were provided to support decision-makers.

A decision support system is an information system that stores and processes information and data from various sources. By using different mathematical and logical models it provides the decision-maker with the necessary information for analysing, compiling and evaluating the possible decision alternatives, making decisions and effecting the output and storage of the obtained results. Therefore, the decision support system that can be based on the data accumulated from different sources should enable consumers to transform a huge amount of unprocessed data into information that is necessary for the analysis of a particular problem and for further decision-making.

The decision support system (DSS) should comprise of the following four major constituent parts. These parts are: a data (database and its management system), models (model base and its management system), a user interface and a message management system.

DSS provides a framework through which decision-makers can obtain the necessary assistance for decisions through an easy-to-use menu or command system. Generally, a DSS will provide help in formulating alternatives, accessing data, developing models and interpreting their results, selecting options or analysing the impacts of a selection.

The major players in facility management can use various purpose decision support systems [17, 18, 19]. For example, M.I.Okoroh (1996) created a decision support system for selecting subcontractors of refurbishment projects. This is done on the base of the system of criteria, their values and weights. In the analysis, values and weights of criteria is reduced into a single criterion that describes the various dimensions of the considered alternatives. A.Kaklauskas, G.Ambrasas and Z.Turskis (1999) developed Housing refurbishment multiple criteria decision support system. Based on the housing refurbishment database, the developed Housing refurbishment multiple criteria decision support system enables the user to analyse projects quantitatively (i.e. a system and subsystems of criteria, units of measure, values and significances) and conceptually (i.e. text, formula, schemes, graphs, diagrams and video tapes).

Neural network is a method of computing that tries to copy the way the human brain works. A group of processing elements receives data at the same time and links are made between the elements as repeated patterns are recognized (Oxford dictionary of computing, 1996). Many various-purpose neural networks can be found on the Internet. For example, solimar.net [1] uses Solimar Valuation Technology that is an intelligent, neural network valuation technology that powers collateral valuation products. It uses a continuously updated nationwide data store to gather specific data on the subject property and then estimates the value of properties in real time and is based on comparable sales data.

2. MULTIPLE CRITERIA ANALYSIS OF FACILITY MANAGEMENT ALTERNATIVES

Most of all calculators, analysers, software, neural networks, decision support and expert systems seek to find out how to make the most economic facility management decisions and most of all these decisions are intended only for economic objectives. Facility management alternatives under evaluation have to be evaluated not only from an economic position, but take into consideration qualitative, technical, technological and other characteristics as well. For example, an analysis of the service of a facility is usually performed by taking into account operational productivity, aesthetic value or public image, comfort (noise, colour, air quality, thermal comfort, working conditions), flexibility, and cost (design, construction, indirect expenses, operating and maintenance expenses, renovation costs, the interest paid on loan). Facility management alternative solutions allow for a more rational and realistic assessment of economic, technical, technological, space conditions and traditions and for greater satisfaction of different customer requirements. Therefore, by applying multiple criteria analysis methods and decision support systems the efficiency of facility management calculators, analysers, software, neural networks, decision support and expert systems may be increased.

Bart D. Bauer (2000) discussed six major facility phases which include the following: definition of need, planning and programming, design, construction, operate/maintenance and decision for use the next time. According to Bart D. Bauer (2000) each of these phases has five process groups called: initiating, planning, execution, controlling and closing. On that score, a facility management's life cycle has many alternative versions. Variants are based on the project's alternatives of the definition of need, planning and programming, design, construction, operate/maintenance and other processes. The above solutions and processes may be further considered in more detail. For example, there are several ways that companies can provide necessary cleaning services (Paul R. Smith, etc., 2000): in a traditional department, all personnel are company employees; in support of a traditional department, some companies are adding their services of a competent consultant; the company can use a management service to support its own production team; in a full-service program, a service company provides all the management and production personnel, tools, equipment and supplies; in combination programs, the company uses its employees to perform part of the cleaning responsibilities and the contracts with a service company for the remainder.

Thousands of facility management's life cycle alternative versions can be obtained in this way.

The determination of the utility degree and market value of the facility management alternatives under investigation and the establishment of the priority order for its implementation, does not present much difficulty if the criteria numerical values and weights have been obtained and the multiple criteria decision-making methods are used.

3. AN INCREASE OF SOFTWARE AND INTELLIGENT SOFTWARE EFFICIENCY BY THE APPLICATION OF A MULTIPLE CRITERIA DECISION SUPPORT ON-LINE SYSTEM FOR FACILITY MANAGEMENT

Based on the analysis of the existing information, expert and decision support systems and in order to determine most efficient versions of real estate and facilities management a Multiple Criteria Real Estate E-Commerce System was developed. The Multiple Criteria Decision Support On-Line System for Facilities Management (OLSFM) consisting of a database, database management system, model-base, model-base management system and user interface is a part of the Multiple Criteria Real Estate E-Commerce System and was developed by the authors. A short description of the OLSFM follows.

3.1. Database

Facility management involves a number of interested parties who pursue various goals and have different potentialities, educational levels and experiences. This leads to various approaches of the above parties to decision-making in this field. In order to do a full analysis of the available alternatives and to obtain an efficient compromise solution, it is often necessary to analyse economic, qualitative, legal, social, technical, technological, space and other type of information. This information should be provided in a user-oriented way.

The presentation of information needed for decision-making in the OLSFM may be in a conceptual form (i.e. digital/numerical, textual, graphical, diagrams, graphs and drawing, etc), photographic (see Fig. 1), sound, video and quantitative forms.

The presentation of quantitative information (see Fig. 2) involves criteria systems and subsystems, units of measurement, values and initial weights that fully define the provided variants. Conceptual information means a conceptual description of the alternative solutions, the criteria and ways of determining their values and the weights, etc.

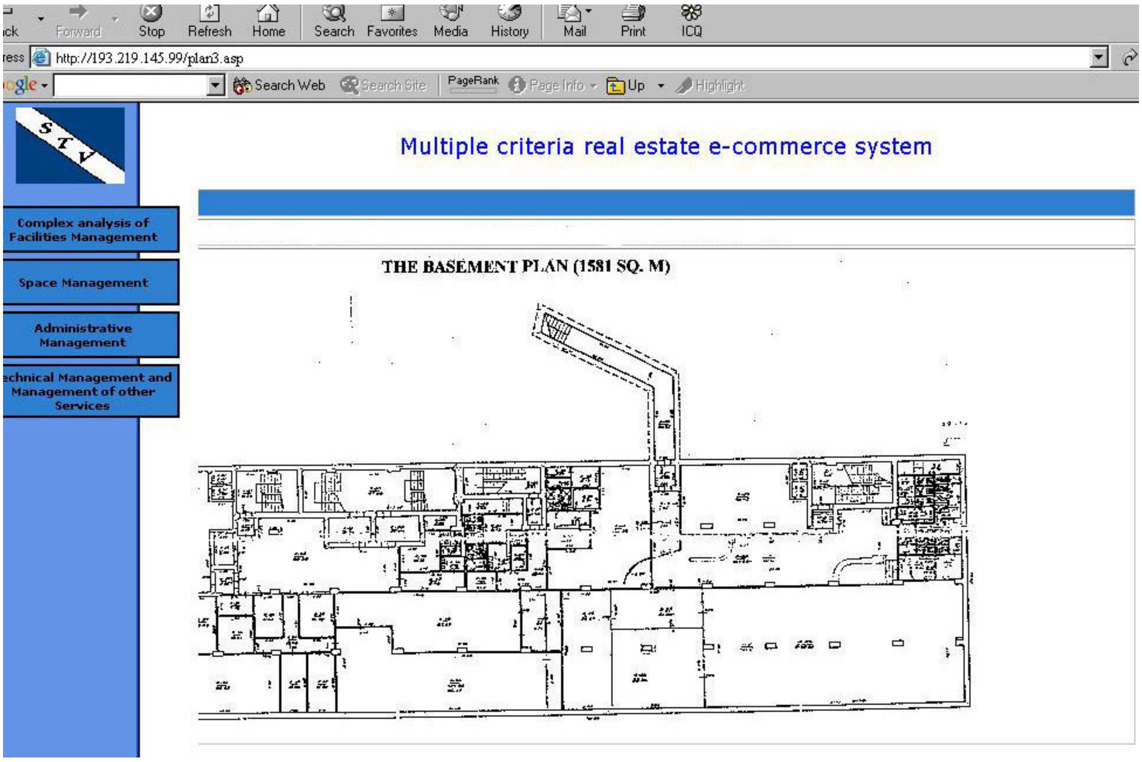
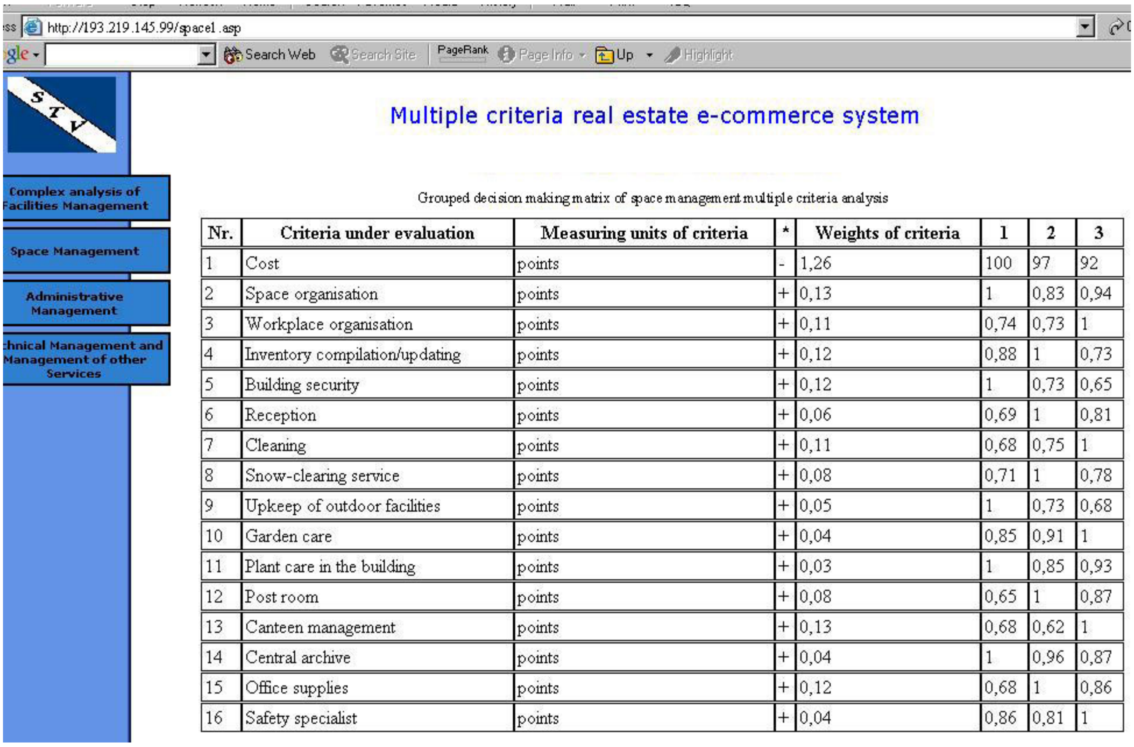


Fig. 1. The presentation of information needed for decision-making in the OLSFM may be in a photographic form



Grouped decision making matrix of space management multiple criteria analysis

Nr.	Criteria under evaluation	Measuring units of criteria	*	Weights of criteria	1	2	3
1	Cost	points	-	1,26	100	97	92
2	Space organisation	points	+	0,13	1	0,83	0,94
3	Workplace organisation	points	+	0,11	0,74	0,73	1
4	Inventory compilation/updating	points	+	0,12	0,88	1	0,73
5	Building security	points	+	0,12	1	0,73	0,65
6	Reception	points	+	0,06	0,69	1	0,81
7	Cleaning	points	+	0,11	0,68	0,75	1
8	Snow-clearing service	points	+	0,08	0,71	1	0,78
9	Upkeep of outdoor facilities	points	+	0,05	1	0,73	0,68
10	Garden care	points	+	0,04	0,85	0,91	1
11	Plant care in the building	points	+	0,03	1	0,85	0,93
12	Post room	points	+	0,08	0,65	1	0,87
13	Canteen management	points	+	0,13	0,68	0,62	1
14	Central archive	points	+	0,04	1	0,96	0,87
15	Office supplies	points	+	0,12	0,68	1	0,86
16	Safety specialist	points	+	0,04	0,86	0,81	1

Fig. 2. The presentation of quantitative information in the OLSFM (grouped decision making matrix of space management multiple criteria analysis)

In this way, the OLSFM enables the decision-maker to receive various conceptual and quantitative information on facility management from a database and a model-base allowing him/her to analyse the above factors and to form an efficient solution.

The analysis of database structures in decision support systems according to the type of problem solved reveals their various utilities. There are three basic types of database structures: hierarchical, network and relational. OLSFM has a relational database structure where the information is stored in the form of tables. These tables contain quantitative and conceptual information. Each table is given a name and is saved in the computer's external memory as a separate file. Logically linked parts of the table form a relational model.

The following tables form the OLSFM's database:

- Initial data tables. These contain information about the facilities (i.e. building and complexes).
- Tables assessing facility management solutions. These contain quantitative and conceptual information about alternative facility management solutions: space management, administrative management, technical management and management of other services, complex facilities management, market, competitors, suppliers, contractors, renovation of walls, windows, roof, etc.

To design the structure of a database and perform its completion, storage, editing, navigation, searching and browsing etc. a database management system was used in this research.

The user seeking for an efficient facility management solution should provide, in the tables assessing facility management solutions, the exact information about alternatives under consideration as to the client's financial situation. It should be noted that various users making a multiple criteria analysis of the same alternatives often get diverse results. This may be due to the diversity of the overall aims and financial positions of the users. Therefore, the initial data provided by various users for calculating the facility management project differ and consequently lead to various final results.

The character of the objective's choice for the most efficient variant is largely dependent on all available information. It should also be noted that the quantitative information is objective. The actual facility management services have real costs. The values of the qualitative criteria are usually rather subjective though the application of an expert's methods contributes to their objectivity.

The interested parties have their specific needs and financial situation. Therefore, every time when the party uses the OLSFM they may make corrections to the database according to their aims and their financial situation. For example, a certain client considers the sound insulation of the external walls to be more important than their appearance while another client is quite of the opposite opinion. The client striving to express his/her attitude towards these issues numerically may ascribe various weights values to them that eventually will affect the general estimation of a refurbishment project. Though this assessment may seem biased and even quite subjective, the solution finally made may exactly meet the client's requirements, aims and affordability.

The tables assessing facility management solutions (for example, see Fig. 2-4) are used as a basis for working out the matrices of decision-making. These matrices, along with the use of a model-base and models, make it possible to perform a multiple criteria analysis of alternative facility management projects, resulting in the selection of the most beneficial variants.

3.2. Model-base

The efficiency of a facility management variant is often determined by taking into account many factors. These factors include an account of the economic, aesthetic, technical, technological, management, space, comfort, legal, social and other factors. The model-base of a decision support system should include models that enable a decision-maker to do a comprehensive analysis of the available variants and to make a proper choice. The following models of a model-base aim at performing the functions of:

- A model for the establishment of the criteria weights,
- A model for multiple criteria analysis and for setting the priorities,
- A model for the determination of a project's utility degree,
- A model for the determination of a project's market value.

According to the user's needs, various models may be provided by a model management system. When a certain model (i.e. search for facility management alternatives) is used the results obtained become the initial data for some other models (i.e. a model for multiple criteria analysis and setting the priorities). The results of the latter, in turn, may be taken as the initial data for some other models (i.e. determination of utility degree of space management, administrative management, technical management and management of other services, complex facilities management, market, suppliers, contractors, renovation of walls, windows, roof, etc.).

The management system of the model base allows a person to modify the available models, eliminate those that are no longer needed and add some new models that are linked to the existing ones.

Since the analysis of facilities management is usually performed by taking into account economic, quality, technical, technological, management, legal, social, space and other factors, a model-base should include models which will enable a decision-maker to carry out a comprehensive analysis of the available variants and make a proper choice. The following multiple criteria analysis methods and models as developed by the authors (Kaklauskas, A., Zavadskas, E.K., Lepkova, N., etc., 1999, 2001) are used by the OLSFM in the analysis of the facility management alternatives:

1. A new method and model of complex determination of the weight of the criteria taking into account their quantitative and qualitative characteristics was developed. This method allows one to calculate and co-ordinate the weights of the quantitative and qualitative criteria according to the above characteristics.
2. A new method and model of multiple criteria complex proportional evaluation of projects enabling the user to obtain a reduced criterion determining the complex (overall) efficiency of the project was suggested. This generalized criterion is directly proportional to the relative effect of the values and weights of the considered criteria, on the efficiency of the project.
3. In order to find what price will make a valuated project competitive on the market a method and model for determining the utility degree and market value of projects based on the complex analysis of all their benefits and drawbacks was suggested. According to this method the project's utility degree and the market value of a project being estimated are directly proportional to the system of the criteria and adequately describe them, the values and weights of these criteria.
4. A new method and model of multiple criteria multi-variant design of a project's life cycle enabling the user to make computer-aided design of up to 100,000 alternative project versions was developed. Any project's life cycle variant obtained in this way is based on quantitative and conceptual information.

Application of Multiple Criteria Decision Support On-Line System for Facilities Management (OLSFM) allows one to determine the strengths and weaknesses of each phase and its constituent parts. Calculations were made to find out by what degree one version is better than another and the reasons disclosed why it is namely so. Landmarks are set for an increase in the efficiency of facility management versions. All this was done argumentatively, basing oneself on criteria under investigation and on their values and weights. This saved users' time considerably by allowing them to increase both the efficiency and quality of facility management analysis.

Below is a list of typical facility management problems that were solved by users:

- Analysis of space management, administrative management, technical management and management of other services alternatives.
- Analysis of complex facilities management alternatives.
- Analysis of interested parties (competitors, suppliers, contractors, etc.),
- Determination of efficient loans,
- Analysis and selection of rational refurbishment versions (e.g. roof, walls, windows, etc.),
- Multiple criteria analysis and determination of the market value of a real estate (e.g. residential houses, commercial, office, warehousing, manufacturing and agricultural buildings, etc.),
- Analysis and selection of a rational market,
- Determination of efficient investment versions, etc.

4. PRACTICAL EXAMPLE

Žirmūnai, a suburban supermarket (Žirmūnų Street 68a) is in Vilnius, Žirmūnai Precinct. The supermarket (see Fig. 1) was built in 1974. It is currently owned and run by the Real Estate Company "OBERHAUS". The supermarket's building has 2 storeys and a basement. The total floor space of the building is 5318 m^2. The physical depreciation is not considerable. The site has a large parking lot. At the moment the premises are rented out to various firms, such as "Ritos smuklė", "Čili picerija", Photo Company "Fuji" and other businesses. These companies take up around 3420 m^2. There still remains a free non-rented area of 1898 m^2.

Alternatives to facilities management are changing as are their prices and the quality of services offered as well. Many options of facilities management are now able to be considered by tenants. In this article we analyse two edge alternatives from the owner and tenant's point of view namely:

- Lease without facilities management services;
- Lease including all facilities management services.

It should be noted that in the multiple criteria analysis of facilities management alternatives the point of view of the owner and that of the tenant could be completely different.

These comparative options are described below.

When a lease without facilities management services is considered, it is deemed that the rent is paid only for the usage of the premises. The owner or manager does not render any facilities management services in this case.

When a lease including all facilities management services is considered, the manager (owner) takes care of the property's security, technical management, surroundings and the cleaning of the premises, etc.

The following criteria for determining the best facilities management alternative is based on advice and expert opinions both of which were selected for this example. They are as follows: rent price per month, management expenses, time spent by a tenant, rental profit per month, property protection, technical part management, supervision of surrounding areas, cleaning, contract management, building's utilisation control and advertisement.

These criteria are describes below.

Established on the basis of the estimated calculations, the rent price without services per 1m^2 was 21 LTL whereas the rent price with all services per 1m^2 was 25 LTL. One American dollar equals about four Litas (LTL).

The value of management expenses has been determined after summing up the protection, room cleaning, supervision of surrounding areas, insurance, building's utilisation control, building's technical management and advertisement expenses.

Time spent by the tenant evaluates the time spent by the tenant on the facilities management.

The value of rental profit per month has been determined by subtracting facilities management expenses from the income gained when renting out the premises. This criterion and its value have been used in the multiple criteria analysis, only in respect to the owner.

Property protection criterion evaluates only the quality of the protection against break-ins and thefts. This quality is measured by using a ten-point system.

The technical part management criterion helps to evaluate the quality of management control of the technical parts of the building. Technical management includes the operation, inspection, repairs and maintenance of the systems and mechanisms and these include gas, water supply, sewerage, heating, water heating and electricity. It further includes the building's and room protection, cables and network and other systems. This quality is measured by using a ten-point system.

The criterion of the supervision of surrounding areas evaluates the quality of maintenance of the surrounding areas. The supervision of surrounding areas includes window and roof cleaning, snow cleaning, plant growing and environmental protection. This quality is also measured by using a ten-point system.

The cleaning criterion evaluates the quality of the premise's cleaning and its garbage removal. This quality is measured by using a ten-point system.

The contract management criterion helps to evaluate the quality of management's contracts included in the facilities management. Contract management includes the conclusion of contracts and the signing of insurance policies. This quality is measured by using a ten-point system.

The building's utilisation control criterion evaluates the maintenance and optimisation of the budget, co-ordination of services, monitoring of the transactional obligations and transfer and acceptance of the building. It also includes management of the building and its parking lot, record keeping, preparation of messages and enhancement of the property's image. This quality is measured by using a ten-point system.

Advertisements include the arrangement and systematic approach and concordance of advertising signboards. This is useful not only to the tenant but also to the owner. This quality is measured by using a ten-point system.

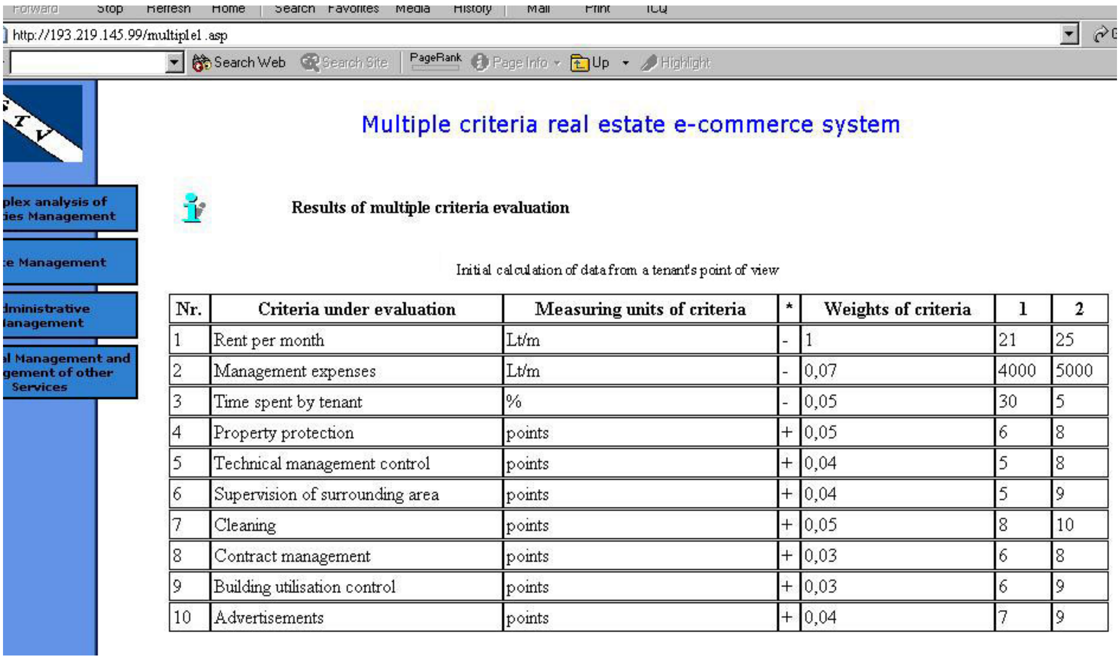
After questioning 20 facilities management field experts and processing the obtained results by expert methods, values of qualitative criteria were calculated. Included were aspects such as: property protection, technical management, supervision of surrounding areas, cleaning, contract management, building's utilization control and advertisement. According to both tenant's and owner's points of view, criteria values, except for the time spent by a tenant and the lease's profitability, all other aspects coincided.

This result is understandable because:

- Calculated values of quantitative criteria (i.e. rent price per month, cleaning expenses, time spent by tenant and lease profit) are objective;
- Values of qualitative criteria were calculated according to the opinion of independent facilities management field experts.

As can be seen, alternatives to facilities management have been analyzed both from the tenant's and the owner's points of view. Therefore, in order to establish the effectiveness of facilities' management alternatives under consideration in this study, two decision-making matrices were on-line formed namely:

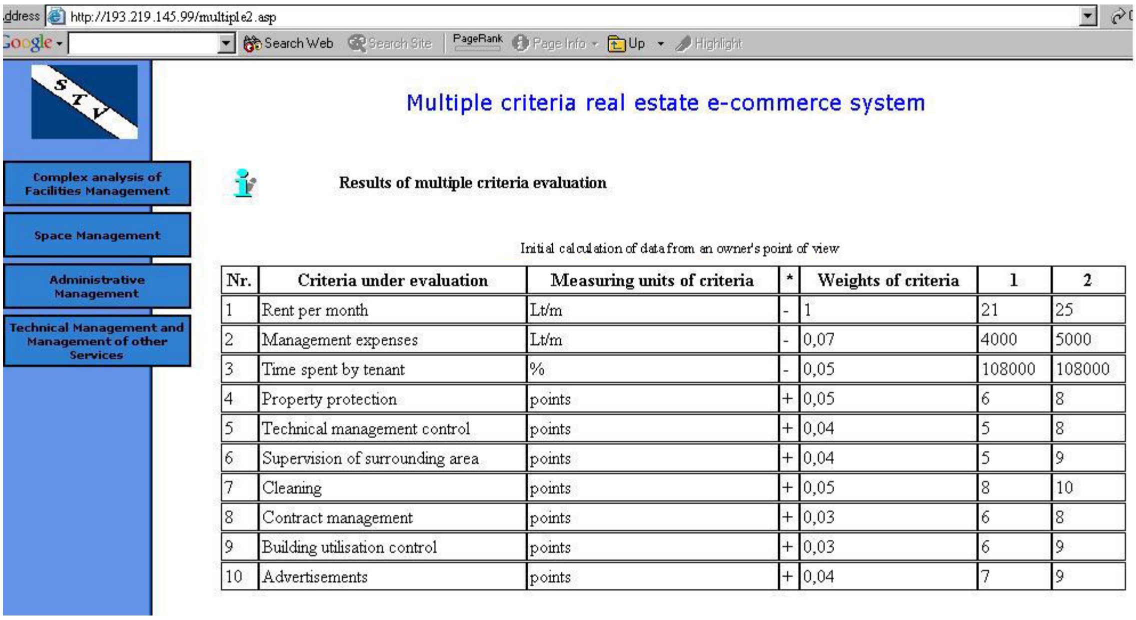
- Analysis of services rendered from a tenant's point of view (see Fig. 3);
- Analysis of services rendered from an owner's point of view (see Fig. 4).



Nr.	Criteria under evaluation	Measuring units of criteria	*	Weights of criteria	1	2
1	Rent per month	Lt/m	-	1	21	25
2	Management expenses	Lt/m	-	0,07	4000	5000
3	Time spent by tenant	%	-	0,05	30	5
4	Property protection	points	+	0,05	6	8
5	Technical management control	points	+	0,04	5	8
6	Supervision of surrounding area	points	+	0,04	5	9
7	Cleaning	points	+	0,05	8	10
8	Contract management	points	+	0,03	6	8
9	Building utilisation control	points	+	0,03	6	9
10	Advertisements	points	+	0,04	7	9

Fig. 3. Initial calculation of data from a tenant's point of view

When these two decision-making matrices (see Tables 3 and 4) are on-line formed, multiple criteria analysis of facilities' management alternatives can be performed. Above on-line analysis is then completed by using the project's multiple criteria complex proportionate valuation method that has been proposed by the authors (1999).



Initial calculation of data from an owner's point of view

Nr.	Criteria under evaluation	Measuring units of criteria	*	Weights of criteria	1	2
1	Rent per month	Lt/m	-	1	21	25
2	Management expenses	Lt/m	-	0,07	4000	5000
3	Time spent by tenant	%	-	0,05	108000	108000
4	Property protection	points	+	0,05	6	8
5	Technical management control	points	+	0,04	5	8
6	Supervision of surrounding area	points	+	0,04	5	9
7	Cleaning	points	+	0,05	8	10
8	Contract management	points	+	0,03	6	8
9	Building utilisation control	points	+	0,03	6	9
10	Advertisements	points	+	0,04	7	9

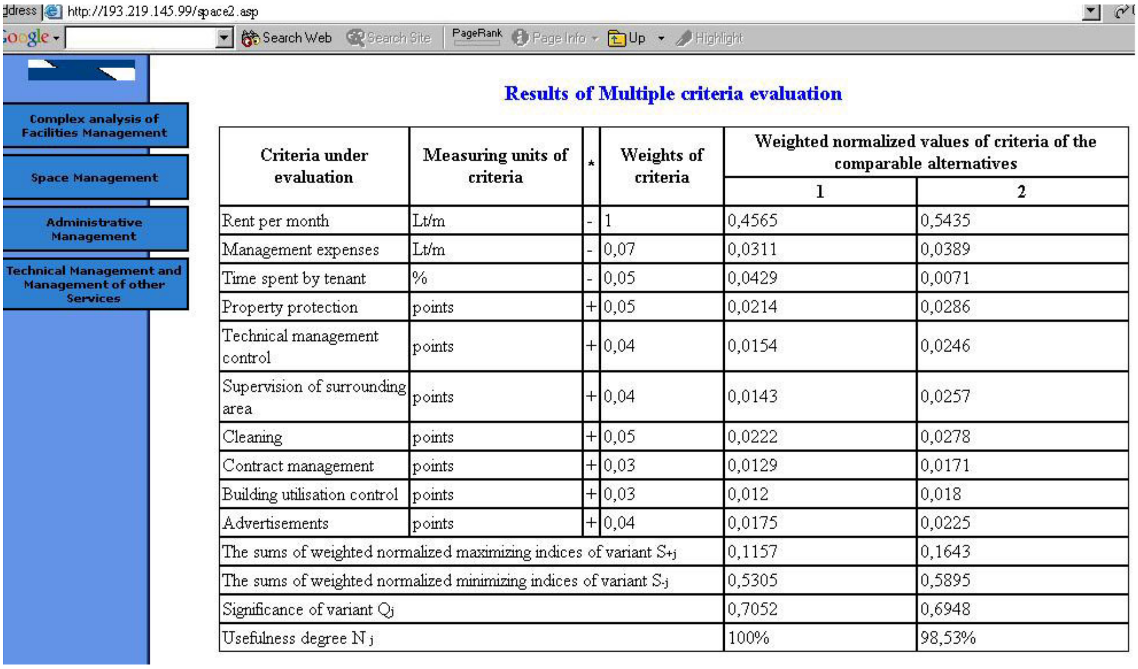
Fig. 4. Initial calculation of data from an owner's point of view

It can also be seen from the data presented in the tables that each alternative has both positive and negative features. Property protection, technical part management, supervision of surrounding areas, cleaning, contract management, building's utilization control and advertisement have been estimated by using the ten- point system.

For example, one can see from the data presented in the Figures 3 and 4 that the quality of the alternative suggested with all facilities management services (e.g. property protection, technical management, supervision of surrounding areas, cleaning, contract management, building utilization control and advertisement) is better than the alternative of lease without facilities management services. However, the rent of one square metre per month of the alternative suggested with all facilities management services is higher by 4 Litas than the alternative of lease without facilities management services (see Figures 3 and 4).

The higher the level of importance and the more relevant this index is for experts, the tenant and the owner, the higher the influence on the final estimated result. For example, it was determined that the weight of cleaning is estimated to be 0.05 point and weight of advertising is 0.04 point, i.e. the first index is more relevant than the second one by 20%.

Results of the multiple criteria analysis from a tenant's point of view are presented in Table 5. These results show that 'Lease without services' (usefulness degree N_1=100%) is better for a tenant and 'Lease including all services' (usefulness degree N_2=98,53%) is of less use by 1,47%.

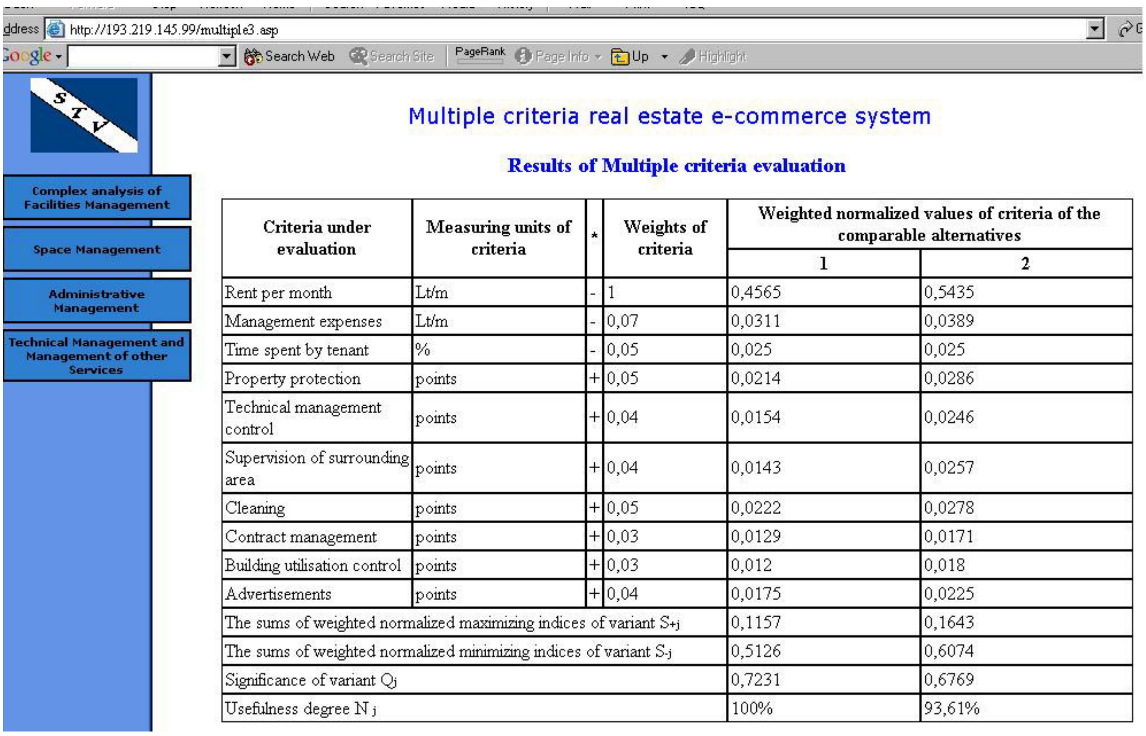


Results of Multiple criteria evaluation

Criteria under evaluation	Measuring units of criteria	*	Weights of criteria	Weighted normalized values of criteria of the comparable alternatives	
				1	2
Rent per month	Lt/m	-	1	0,4565	0,5435
Management expenses	Lt/m	-	0,07	0,0311	0,0389
Time spent by tenant	%	-	0,05	0,0429	0,0071
Property protection	points	+	0,05	0,0214	0,0286
Technical management control	points	+	0,04	0,0154	0,0246
Supervision of surrounding area	points	+	0,04	0,0143	0,0257
Cleaning	points	+	0,05	0,0222	0,0278
Contract management	points	+	0,03	0,0129	0,0171
Building utilisation control	points	+	0,03	0,012	0,018
Advertisements	points	+	0,04	0,0175	0,0225
The sums of weighted normalized maximizing indices of variant S_{+j}				0,1157	0,1643
The sums of weighted normalized minimizing indices of variant S_{-j}				0,5305	0,5895
Significance of variant Q_j				0,7052	0,6948
Usefulness degree N_j				100%	98,53%

Fig. 5. Multiple criteria alternatives analysis from a tenant's point of view

Results of the multiple criteria analysis' calculations from an owner's point of view are presented in Table 6. These results show that 'Lease without services' (usefulness degree N_1=100%) is better for an owner and 'Lease including all services' (usefulness degree N_2=93,61%) is of less useful by 6,39%.



Multiple criteria real estate e-commerce system

Results of Multiple criteria evaluation

Criteria under evaluation	Measuring units of criteria	*	Weights of criteria	Weighted normalized values of criteria of the comparable alternatives	
				1	2
Rent per month	Lt/m	-	1	0,4565	0,5435
Management expenses	Lt/m	-	0,07	0,0311	0,0389
Time spent by tenant	%	-	0,05	0,025	0,025
Property protection	points	+	0,05	0,0214	0,0286
Technical management control	points	+	0,04	0,0154	0,0246
Supervision of surrounding area	points	+	0,04	0,0143	0,0257
Cleaning	points	+	0,05	0,0222	0,0278
Contract management	points	+	0,03	0,0129	0,0171
Building utilisation control	points	+	0,03	0,012	0,018
Advertisements	points	+	0,04	0,0175	0,0225
The sums of weighted normalized maximizing indices of variant S_{+j}				0,1157	0,1643
The sums of weighted normalized minimizing indices of variant S_{-j}				0,5126	0,6074
Significance of variant Q_j				0,7231	0,6769
Usefulness degree N_j				100%	93,61%

Fig. 6. Multiple criteria alternatives analysis from an owner's point of view

The level of usefulness of the comparative alternatives expresses the level of the ability to reach tenant and owner's goals. In the case of the example presented here, the total efficiency of the comparative alternative of lease without services is better than that of a lease that included all services.

5. CONCLUSIONS

The analysis of information, the expert and decision support systems used in real estate and facility management that were developed by researchers from various countries assisted the authors to create of their own Multiple Criteria Decision Support On-Line System for Facilities Management (OLSFM). OLSFM differ from others in the use of new multiple criteria analysis methods as were developed by the authors. The database of a facility management was developed providing a comprehensive assessment of alternative versions from the economic, technical, technological, infrastructure, qualitative, technological, legislative and other perspectives. Based on the above complex databases, the developed Multiple Criteria Decision Support On-Line System for Facilities Management enables the user to analyse alternatives quantitatively (i.e. a system and subsystems of criteria, units of measure, values and weights) and conceptually (i.e. the text, formula, schemes, graphs, diagrams and videotapes). The efficiency of calculators, analysers, software, neural networks, expert and decision support systems may be increased by applying OLSFM.

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Future Business Models & the Impact of Technology Property & Facilities Perspectives

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There are three ways to ruin yourself: gambling, women and technology.Gambling is the fastest, women are the most pleasurable and technology is the most certain
Georges Pompidou

Models of Organisation

Organisations are driven by many different pressures, both internal and external. They often develop organically, without any long-term strategic intent, and can take on a self-sustaining life of their own. However the irresistible drive towards generating stake-holder value and concepts of value based management are driving organisations to question their existing and future structures.

The concepts of core and non-core business activities have been well rehearsed elsewhere. There are no standard answers; often competitors in the same industry can be successful with widely differing business structures. The key to success is ensuring the organisations focus is on delivering value for customers, whether internal or external. Organisational thinking has evolved significantly since Charles Handy’s original clover leaf model where the “job for life” perception was replaced with groups of workers who had differing longevity in terms of their career opportunities. The difference at the time was the recognition that the employment contract was a two way thing; value being added both for the employer in terms of shareholder value, and for the employee in terms of development of transferable skills. Also, the contribution of service providers and others in the value chain was recognised.

Advances in technology have challenged the parameters that result in effective and efficient organisations. The combination of evolving business drivers, changing customer demands and the evolution of enabling technology is producing a business revolution. Electronic connections are changing the way in which companies deal with partners, and internal and external customers. Information access, services and speed are becoming key differentiators.

Technology trends & ASPs

Technology-driven paradigms have been hyped before, so what’s different? We are all familiar with the rate of development in the computing field. PC’s for the home are faster, have more storage space and are much cheaper than business-based servers were only five years ago. Communications costs (even in the UK) continue to fall, and availability of cost effective high bandwidth is increasing meaning information can be shared more quickly, and business applications can be delivered in different ways.

The Application Service Provider (ASP) model is driving phenomenal growth in the delivery of application services. ASP's provide delivery of application software via a network (primarily the Internet) through an outsourcing contract, usually predicated on usage based or transaction pricing, on a per user, per month fee. Early ASP's began by providing e-mail and groupware products, but now vendors are providing even large- scale enterprise packages via the ASP model. Importantly, the ASP model will assist small-to-medium sized enterprises and aggressive growth companies of all sizes to obtain packaged applications at affordable prices, while the enterprises themselves concentrate on growing their respective businesses. The lack of customised solutions is not as big a problem for these enterprises because they do not have the established infrastructure of large organisations and are therefore better able to adapt their business processes and practices to accommodate the requirements of the package.

The ASP value proposition

The benefits of an ASP solution include :

- No up-front capital costs; lower on-going total cost of ownership
- Full life cycle application services
- Simplified pricing
- Faster implementation time
- Cost effective access to industry-leading applications
- Solutions are readily scalable
- Technology risk is taken by the ASP

The ASP model also provides some enterprises with industry-specific domain expertise and templates, enabling the ready provision of end-to-end service offerings covering the implementation, customisation and on-going operation and support of applications. For example, Coflex Ltd is working with an industry-leading provider of helpdesk software, delivering effective helpdesk technology to our clients.

ASP – potential problems to consider

The issues around use of ASP solutions are not dissimilar to those associated with management of in-house solutions, although there are some key differences.

- Access to, and ownership of, the data. The data belongs to the customer of the service, but this must be defined clearly in the contract. No part of the supply chain should be able to use or access the data being managed on behalf of the customer without their specific consent.
- Security of access. This is complementary issue and customers should be concerned with all aspects of security in respect of their data, in the same manner as they would be with an in-house provision. Customers need to be confident of the provisions made within the ASP organisation such as password management and firewalls, as well as issues like data backups, hardware and power failures.
- Security of the connection between the ASP and the customer. Since data flows between the ASP and the user each time the user accesses the application, security of the connection is clearly an issue to be addressed through encryption, a virtual private network or some proprietary solution.

- Pricing. While the prospect is a scalable solution, customers should ensure that they fully understand the current and future pricing models to be employed by the ASP. For example, customers should be wary of significant step changes in price driven by user numbers. Increases in user numbers may drive the cost of an ASP over a pricing threshold and result in an unexpected increase in costs.
- How is the application served. Is the customer's data on a dedicated machine, or is it shared with other organisations' data. Both approaches are common, and customers need to be confident that their data retains its integrity in the specific environment.
- Problem management. The ASP should have rigorous processes and procedures to manage problems with hardware and software. Their approach must also deal with disasters, and customers need to be confident that restoration of their data will be within the necessary timescale to support their business operations.
- The exit plan. Customers should not enter into a contract without having clearly defined the process for changing the solution provider. This is particularly important for mission critical applications and needs careful consideration, both from contractual and technical perspectives.
- Accessing the application. Some ASPs are accessed via web browsers, others require applications to be loaded on the customers hardware. Users need to be aware of the technical requirements and ensure that they understand any likely costs to be incurred if extensive hardware upgrades are required. The speed of delivery is also dependent on the customer's bandwidth to the internet. Users perceptions of the application and its ease of use will be very dependent on its speed of response and reliability of the connection. (Applications need to be tested via the worst connections, rather than just those in Head Office!)

The ASP model: not exactly outsourcing

Alternative models are emerging for providing outsourced application services. Although there is much hype around the ASP model, it has some similarities with service bureaux, it is just a new form of application outsourcing with the attendant infrastructure services required to deliver the application service in a robust manner. However the ASP model differs from traditional outsourcing business models in several important ways.

- Delivery is over the Internet and is browser based
- Operations are shared – server based processing and hosting
- Full life cycle application services compared with outsourcing only
- Billing and pricing are simplified
- Rapid implementation
- Complexity is hidden from the end user.

The ASP solution is at the intersection of three paradigm shifts that are shaping today's business:

- Outsourcing
- Packaged application business strategies
- The Internet.

The implications

Back office activities, including the management of facilities and property are, by their very nature non-core activities for most businesses. The primary requirement is that these activities are delivered in a timely and cost effective manner. They can be defined by outputs that are aligned with the core business drivers. The key elements for managers are the management and measurement of delivery, timely and accurate information on outputs become paramount. A number of trends are facilitated by the expansion of the ASP model of information management:

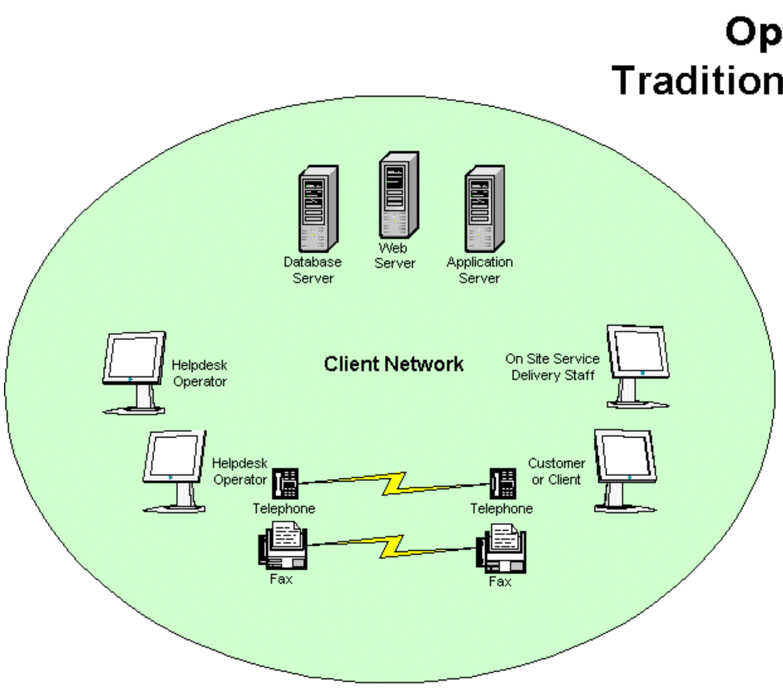
- Competitive differentiators will derive from market agility, organisational flexibility, speed and time to market and closeness to customers. Information solutions will focus on collaboration and interaction across entire supply chains. Open ASP solutions will facilitate such commerce and support effective communications with all elements of the supply chain.
- In future, Facilities and Back Office service managers will become more managers of information than tasks. There is generally little real competitive advantage in the manner in which these services are provided, the key elements are cost and appropriate service quality.
- ASP solutions will allow a separation of the service provider from the implicit knowledge of the organisation. The key knowledge and information that can impact on service delivery in service provision is now embedded in smart applications rather than residing with the service provider, whether the later is internal or external. Changes in service provider can be divorced from the management of information, making changes easier.
- More back office activities will be delivered through the use of ASP's for example HR support. HR policy and strategy will be determined in a conventional manner. Much of the information required to implement policy and strategy will be embedded in smart applications delivered over the Internet.
- Organisations will change to reflect smarter ways of managing non-core information. Non-core departments will shrink to become highly skilled informed buyers and managers of services. These will include HR, finance, IT and property and facilities. Headcount in these areas will decline, as will their workplace requirements.
- Space for servers and support teams is effectively outsourced via the ASP model, although existing small server rooms will still be required to provide infrastructure and communications functionality.

The above thesis may seem like more jam tomorrow. We've seen the hype around e-commerce wax and wane, before establishing a basis for viable business propositions. Even large enterprises have had their fingers burned in investing in e-enabled applications only to find that their supply chain isn't ready or able to support their aspirations.

Real FM ASPs

What's the prognosis for solutions that are relevant to the Facilities and Property world? There are some developed and delivered solutions that are working for businesses today. One example: an ASP helpdesk that is readily deployed and scalable to include management of remote working, and on-line information to the facilities or property manager and users alike.

Helpdesk technology is well developed and critical to the effective delivery of support services. Sadly, it does not attract the interest of the IT department since it's remote from the core business. Our ASP solution has been developed in partnership with a leading helpdesk software provider. It is accessed via a conventional web browser, and presents a full-blown helpdesk application on the users desk, without the problems of software distribution and equipment upgrades. Access can be provided to users so that they can track the progress of their jobs, again without interfering with the operation of core business software. The solution is secure and delivered in a totally transparent manner so that it appears to be running on the users desktop, while in reality the application sits on a remote, fully managed server. Use of the application is on a time/user basis, so that real costs in use can be identified and budgeted. Additional modules can be added to the core functionality simply by requesting the additional functionality. It's almost literally plug and play technology.

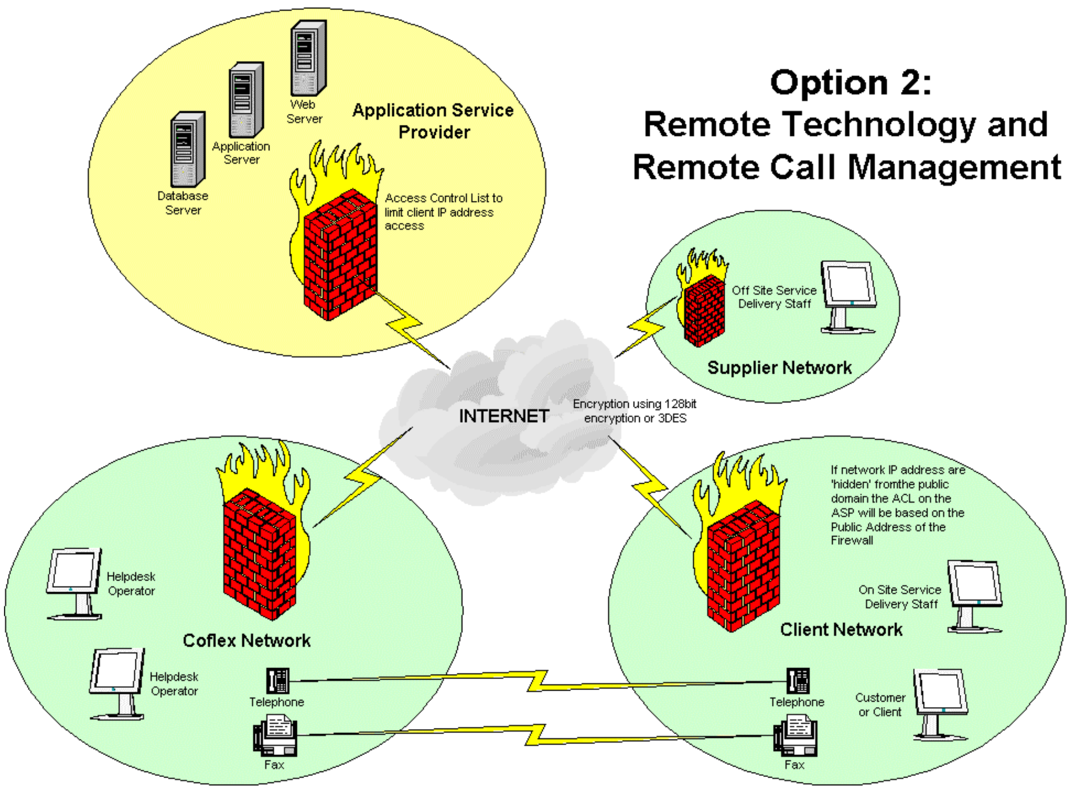


The traditional approach is internally focused, based on the assumption that all information relevant to the organisation has to be managed internally. It's worth challenging this assumption and considering the possibilities afforded by a different approach, enabled by proven technology that delivers significant benefits and allows an organisation to focus on its core business.

The ASP approach affords a different solution where the importance of the information is recognised, rather than its delivery mechanism. This model is readily deployable, scalable and responsive to the needs of the organisation. The technology issues are transparent to the user and the solution allows separation of the roles of information management and service provider.

These types of solutions have much to commend them. It is likely that they will transform the back office activities of many organisations enabling different approaches and more flexibility in information sharing within and between organisations.

Internet-enabled approach to managing information



These sorts of solutions can be envisaged for any number of back office activities where the key requirement for the organisation is effective and efficient delivery of the service. Smarter applications embed substantial knowledge of operations, and help drive different behaviours, allowing information to be made available to managers and users alike.

The ASP method of delivery makes powerful business applications available to a much wider range of organisations on a variable cost basis, taking away the up-front investment and technology risk for the user. Applications that previously were only available to large corporations are now within reach of SMEs. They are already changing the way businesses operate, supporting a greater focus on core business activities and facilitating organisational and operational change.

Developing Estonian National FM Standard: Process, Problems and Outcomes

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Abstract: *There are different strategies used to identify and regulate FM activities in different countries. Thus, the definition for FM may slightly differ, there is the fundamental requirement that the managed facilities should be safe and acceptable for the user.*

Availability of a national FM standard is the key factor when determining the understanding about the obligations of the owners, users and the different service providers. Every single property and facility has unique requirements to be followed, correspondingly different FM policies may be implemented when keeping in mind an 'acceptable standard' of the facilities. Standards are also required for the FM service providing companies to plan the workload for the professionals.

By 2001, Tallinn Technical University (TTU) in co-operation with the Estonian Association for Property Management and Maintenance developed the national standard for FM activities. The standard is built up as the hierarchic list of activities targeted to gain the general goals described in the standard. The aim of this standard developing project was to simplify and rationalise the understanding of all the activities required when running different properties and keeping them in proper repair and suitable for the user. This standard defines the relevant terms and the major obligations for the related parties to develop the common understanding about FM, but also defines the major performance criteria for the quality.

Keywords: national standard, FM activities, Estonia, maintenance, property management, LCC

1. FM and the national context

English has become the predominant language when identifying different professional terms internationally. Therefore, in international business and research community the professionals of different nationalities use English terminology. However, in parallel step-by-step these English terms also become the part of national terminology. There may be an equivalent national term available there, but anyhow the one in English is quite often added to explain the national one. When communicating daily, professionals, practitioners, or common people try to avoid international terminology, they never ever try to pick up the nuances of English terminology. Only the academic papers handle the terminology issues with extremely great care highlighting the details of interpretation.

Similar is the situation with the term 'facilities management' (FM). The author of the current paper entirely accepts the differences and similarities highlighted by the English-speaking professionals for 'Facilities Management', 'Asset management', 'Property management'. (e.g. 1, 2, 3, 16, 18) However, it is not always reasonable to transfer these very refined differences of English terminology into national languages, especially when the property market is relatively small there. Availability of several closely inter-related and clearly defined professional terms in English is greatly the result of clear division of labour on large property markets. These markets can employ professionals with quite narrow qualifications, being definitely skilled and motivated, and these markets provide enough possibilities to use these skills regularly.

On small (national) markets (e.g. Estonia) similar professional expertise for FM anyhow exists, but there are not so clearly defined boundaries between different professional activities there. The Estonian umbrella-term for all the similar professional activities is ‘immovable (property) management’ (IM) that traditionally covers all the professional activities in keeping up the existing properties and built-environment. (12) IM does not include the activities for new construction, neither the transfer of title for ownership (e.g. selling). The societal transition of the last decade (during the 90s) has strongly supported introducing the professional term for IM.

During the Soviet period ‘immovable property’ or ‘real estate’ were missing from our professional glossary. Different organisations or individuals could use buildings for their everyday business, but the buildings were the public property. Nevertheless, the company that was using a building had the full obligation of keeping the building in proper repair.

The whole philosophy of the transition policy in the ECE countries was mainly based on the transfer of the ownership title of the formerly public properties to legal or physical bodies. In this case privatisation of land and buildings (with all the assets located there) became the major (and the most valuable) object for privatisation. Correspondingly, ‘immovable’ (but also ‘real estate’) became the principal umbrella term describing all the activities related to land (plot) and buildings. Estonian property law identifies immovable as the site together with the permanent buildings and the plants (trees) there, but also together with the obligations and encumbrances related to this property.

Not surprisingly, all the companies and organisations whose core activities required using of different buildings became the owners of immovable property through privatisation. In parallel to this, most of these companies created the ‘departments for immovable’. These functional departments were established to provide all the necessary support services for core business (responsibilities related to property, professional services and facilities).

There is another aspect to be considered concerning IM. The former publicly owned housing stock was managed by local-authority owned housing management companies. Especially in England, ‘housing’ and ‘housing management’ (HM) have very specific meaning to identify the particular field for professional activities. But, on small markets problems related to ‘housing stock’ are handled similarly as to any other units of built environment. Most of the buildings have similar built in services, structures and utilities, they are designed and built using similar technology. These properties require also similarly organised management and maintenance services. Relatively frequently, buildings are transferred from dwelling units to offices (or vice versa) to meet the demand-supply equilibrium.

In Estonia, there are no local authorities dependant specialised housing management or maintenance companies any more. By today these organisations are either fully abolished or transferred into private ownership management and/or maintenance companies for all types of immovable. Moreover, the professionals for IM of these companies are currently competing on the market for contracts and requiring fully comparable technical and economical information about property management.

The basic outcome is that on small markets there is no need to introduce any special and totally different principles for analysing the performance of managing and maintaining the facilities depending on the purpose of use. Facilities (structures, premises, services) have only different users with different needs and requirements. Increasingly, for a national property market there is no need to define in detail the international terms for FM, AM, PM, HM, as the national umbrella-term for IM covers most of these activities. The major professional competence on the market is targeted to provide a quality-level service to the users of built environment. (12)

Finally, for large property-owning companies it is essential to adopt a systematic approach to the overall management of their properties. In Estonia, only a few of these property owners (enterprises, companies, or organisations) are organising the necessary FM or IM services for their own. The majority of these property-owners have understood that a professionally contracted-out IM service may be more efficient for the owner, especially when there are office blocks with multifunctional premises that are let out for different users. Due to that (not surprisingly) when the companies for IM advertise about their services on their www-pages, one can see very different examples of experience. These companies are managing offices, condominiums, detached houses, but also very specific buildings (embassies, shops, hotels, and industrial estates). Only professionally skilled managers who are employed by the IM companies try to be qualified for working on much narrower sectors – there is the quite clear process of specialisation amongst the professionals there.

Not depending on the size and complexity of the property market, managing and maintaining the properties and the facilities is becoming an important service sector requiring clear principles to be followed. In Estonia, IM has become the umbrella term, that includes a wide range of professional activities related to the issues of using the property in the most efficient way.

2. From the very bottom up to the national standard

Western authors highlight the fact, that in spite of the complexity and importance of the property management and maintenance sector, the public profile and perception about this career is low. (3, 17) In our (Estonian) case, the background is more than this. Based on the former Soviet description of jobs these for the construction sector were clearly described starting from a non-qualified operative up to the professionally skilled executives of the engineering staff. Building maintenance related jobs were missing from this list.

Though, there were the specialised companies for housing maintenance, their role was not to carry out any planned or preventive maintenance, rather to react only on emergency cases in the multi-flat dwellings. Correspondingly, all the industrial enterprises that were using buildings had to employ permanently construction workers to refurbish the premises. In fact, management and maintenance of facilities was equalled to smaller *ad hoc* repair and refurbishment activities.

In the situation like this, the newly created or restructured companies for property management and maintenance inherited the extremely low imago and inefficient performance from the former periods. There has been also not very clear understanding about the IM activities, neither about suitable forms for contracts, and about the benchmarks to be gained. Problems started to occur not only in housing, but also in business sector. The reasons for these conflicts have been developed from total misunderstanding of the role and the duties of IM companies. The owners of the properties were confused, as the responsibilities for the chain **owner-manager-user** were also not clearly defined.

Due to the unsolved problems, by the end of 90s the situation on the national property market became greatly emerging. Correspondingly, the major interested parties have initiated the project to identify the IM activities (procedures and levels of quality) for the national market. (11)

The involved partners for this project were:

- Estonian Association for Property Management and Maintenance – being the ‘classical’ professional body for the companies and professionals (individuals) acting in the IM sector.
- Tallinn Technical University – being the methodological principal for the whole project, TTU is the only provider of national academic education and training for built environment related topics.
- Estonian Ministry of Economic Affairs – is the body responsible for all the transition policy, and for the construction, housing and property sectors in particular.
- Finnish Ministry of Environment – is running long-term co-operation projects to support the actions for regenerating the built environment in Estonia.
- Housing Department of Tallinn City Government – being the largest local authority in Estonia they face the major problems when running the existing municipal properties; they have to mediate the classical conflicts between the owners, tenants and service-providers.
- Estonian Association for Co-operative Housing – NGO that is co-ordinating the activities for different types of condominiums.

In fact, the project for identifying the IM was launched already in 1999 when the first contract of mutual interests was signed between the two partners – TTU and the Professional Association. This contract highlighted the common understanding about the emerging problems in the property management sector. Insufficient performance provided by the management companies required precise identification of the targets. (12) Also new principles for professional and vocational training were required. Due to extremely high ratio of home-ownership (93%), the principles to manage the properties should be understandable for the majority of the citizens as well – in-house management is still quite popular amongst the small property owners.

The co-operation of the parties that were involved in the project resulted when the Estonian National Standard for IM was adopted. According to the EVS 807:2001

(Eesti Vabariigi Standard – Standard of Estonian Republic) the main aims of the for IM activities are the following ones:

- providing assistance for the parties on the property market when aiming to extend the life-time of the properties, but also the major structural elements and utilities there;
- creating pre-conditions for reducing of the number of break-downs in engineering services, and to reduce the number of emergencies in the buildings;
- assisting when designing the personnel policy for the staff of the maintenance companies;
- improving the efficiency level of the methods and technology for maintenance works in these companies;
- providing assistance for the interested parties when selecting the most efficient methods for maintenance, and when advising the owners;
- reducing the level of different risks related to the property, and improving the safety on the workplaces, but generally in the built environment there;
- preserving and improving the esthetical value of single buildings with heritage value;
- managing and controlling these activities that are targeted to carry out the planned maintenance and analysing the gained results assisting to introduce the principles for benchmarking in this sector;
- assisting when initiating and carrying out any development projects that are targeted to maintain and improve the property the way it will meet the increasing criteria for energy saving and sustainable development, but also the criteria for functionality;
- managing the existing built environment the most suitable for the owners and users way and in parallel to this meeting the legally stated statutory requirements.

Acceptance of the Standard (EVS 807:2001) at the end of 2001 became an important yardstick for the R&D project, but also for its major partners. When developing the project there have been the three major inter-related stages there:

- identification of IM for the national context, and describing the major principles for built environment maintenance management, with the relevant professional training needs and principles for documentation;
- defining the national standards for professional activities (similarly to UK National Vocational Qualifications) in the field for IM and launching the system of professional certification for individual practitioners, but also authorisation for the companies that are providing services in the field; (12)
- compiling the standard for IM activities; this stage has been supported by relevant handbooks and with a set of forms for documentation when tendering, contracting or running any of the IM-activities. (9, 10)

By today (summer 2002), all the very different entrepreneurs (by size and specialisation) are provided with the basic tools to implement the standard. The standard has passed the all-national consensus discussions and public presentations where the interested bodies had the chance to present their point of views as to the topic. When running this R&D project, also international professional literature on FM was examined to discover the best practice and international transferability aspects there. (4, 5, 6, 7, 8, 14, 16) Information from these reviews was used to formulate the step-by-step development of the project, but also the major problems to discuss. At the same time, the proposed system is hopefully flexible enough allowing certain amendments to be done in the future and to be adapted for the requirements in EU. (13)

For a small market like Estonia, the system of standards and handbooks as described above has ensured that in a relatively short time these documents have become the basics for the 'fair norms' in the sector.

3 The structure of the Standard for IM

The current paper is aimed to present only the major results and findings as to the structure of the IM activities in the national standard. Though there will be no step-by-step description of the stages of the project, it is still useful to call back to some of the major issues discussed when proceeding with the project.

In fact, the first problem the partners of the project were facing was the lifetime concept for the properties. Running the properties one has to describe different activities and obligations not only verbally. All these activities have the exact moment of time when they are expected to be fulfilled, and there are inevitable costs there. Management of properties consists of a large number of inter-linked and time-consuming sub-processes requiring scheduling and the relevant costs to be forecasted.

The experience of neighbouring countries as to property management and LCC was studied. (4, 5, 6, 7, 8, 14) Constantly two basic questions about the situation on the Estonian property market have been asked:

- Is the system of documentation, which is currently used to depict the property development process suitable also for efficient functioning of IM?
- How the existing cost-planning system in construction can be expanded also for LCC purposes?

The principles for cost classification that is used in Estonia are based on the relevant German DIN (German Industrial Norms) structure. The DIN classification principle was found suitable for the IM standard as well, but there was the necessity to define and classify all the IM activities, but also to describe the principles of shaping the relevant costs.

Anyhow, the activities based approach became the basic concept. Therefore, the standard was built up as the list of the property owner's obligations (either legal or contractual ones) including the list of detailed descriptions for the corresponding activities. This list of activities was classified and the hierarchy was refined. Figure 1 depicts the hierarchy of activities that are to be carried out at any moment of the lifecycle of the property.

The described above approach for classification has a number of strengths when the practical implementation is going to be in question.

- The majority of these activities listed, though being identified as the owner's obligations or responsibilities, are mainly contracted out to relevant professionals and operatives. Correspondingly, descriptions of these activities are suitable as specifications for reasonable contracting.
- On the third level of the hierarchy, all these activities can describe both, the statutory obligations for the owner and the client's/user's requirements. At the same time, these descriptions can include also the technical requirements for the activities and the criteria that the contractor has to follow.
- All the obligations and the relevant activities are always inevitably related to expenditures. At the same time, any activity is always related to a precise moment of time to be carried out. The more clearly the activities are described and scheduled, the more clearly the relevant expenditures can be related to these activities and later on used for LCC analyses. Following these principles, the activity-based structure will allow carrying out comparable analyses about the efficiency of the IM activities.
- This hierarchical description of activities will allow to develop the most suitable training schemes for different professionals. Specifications of activities will create the possibility for forecasting the labour-consumption and the necessary skills required, but also to prepare relevant documentation forms and procedures the parties will require when acting on the market.

Based on the principles described above and strengths listed, but also following certain traditions on the market, and the existing division of labour, it was reasonable to arrange all the IM related activities into the following seven major groups.

GROUP CODE	THE MAJOR GROUPS
100	ADMINISTRATION OF THE PROPERTY
200	TECHNICAL MAINTENANCE OF THE STRUCTURES AND FACILITIES
300	CLEANING AND WASTE DISPOSAL
400	REPAIR AND RECONSTRUCTION ON THE PROPERTY
500	OWNER'S LEGAL AND CONTRACTUAL OBLIGATIONS
600	CONSUMPTION OF UTILITIES
700	OPERATIONAL SERVICES TO SUPPORT CORE BUSINESS

Table 1. Major groups of classification for the IM activities.

In table 1, there are only the generic definitions for the major groups of activities. These acronyms cannot be used directly when describing the exact contractual obligations for the parties, but this classification level has become the major one for IM budgets today. For a single property (or a facility, or rental premises) a property owner, or a service providing IM-company has to describe all the obligations and activities together with the relevant costs on more detailed level. (Figure 1)

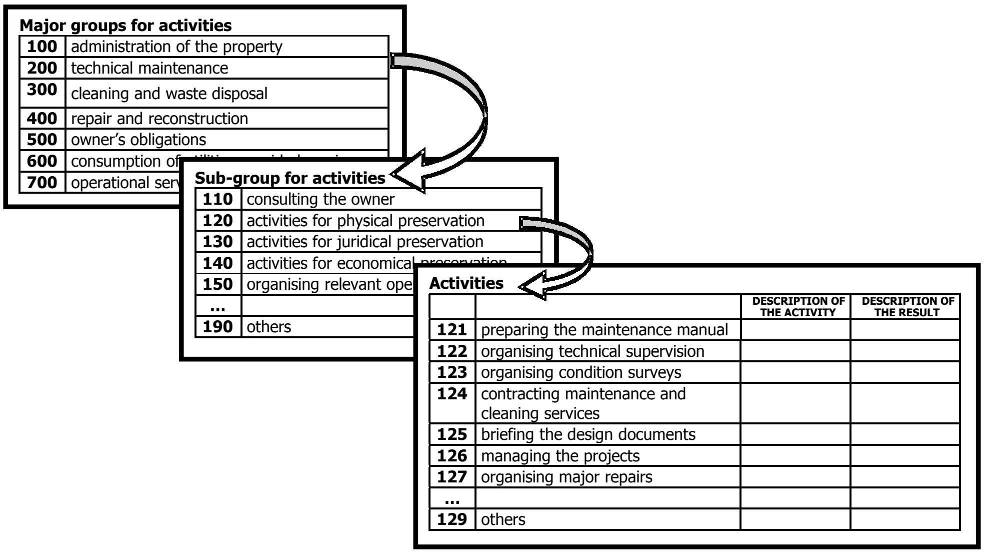

Figure 1. The classification system for Estonian standard for immovable property management

4 The principles to classify the IM related activities

The Estonian National Standard for IM activities was prepared and published in Estonian language. The current paper is not targeted to give the precise translation of all the definitions, rather to explain the major methodological aspects considered when preparing the standard and structuring the activities.

Firstly, the project team tackled with the problems of terminology and with the interpretation of the terms. In Estonian, for a long period the terms for immovable 'management' and 'maintenance' have greatly been used as synonyms. At the same time in different papers and books there is also slight confusion when describing the FM related activities. Sometimes the FM activities do include physical maintenance works done; sometimes even the costs for heating the buildings are included.

The classical meaning of the term 'management' describes administrative functions. Correspondingly, to get the best of the data collected it is important to keep the administrative activities separated from the maintenance works. Also the resource consumption costs related to the premises users should be analysed separately from all the works and activities.

Traditional understanding about 'management' is related to a number of 'management' functions such as planning, organising, co-ordinating and controlling. All these functions are targeted to achieve a goal that has to be presented in the form of a solution, a report, or a formal document. This generic approach to 'management' became the primary one for describing also the activities for IM. IM is the field for professionally carried out administrative activities targeted to preserve the property in the condition that will allow using it for the functional purposes. (12)

Together with the title to ownership, the property owner receives also the obligation to manage the property. The primary aim of the owner is to preserve the immovable property, keeping in mind not only the fiscal value, rather than the functional value. In the standard, the activities for preserving the property are classified into three major fields: (12)

- physical preserving – organising the property (mainly the building, its structures and the utilities) to be maintained in the condition meeting the specifications by the designer and not becoming hazardous for the users and for the third parties;
- legal preserving – administering the obligations and the related to this activities the way that the owner will not be burdened with additional penalties due to either not following the obligations, nor due to non-professional realisation of these obligations;
- economical preserving – organising and planning the set of activities the way that the ownership will remain affordable for the owner, following the requirements and limits stated in the budget.

Following from this definition of IM, two additional aspects should be considered. Firstly, as there are the managerial (or administrative) activities in question, all these require certain information for professional decisions to be done. For this the owners, but also the qualified managers will always require the set of documents describing the property. Accordingly, the system of IM-related documentation forms had to be proposed in the handbooks for practical implementation of the standard.

Secondly, based on the principles of cost calculations the definition of management allowed us to shape out also a quite clear division of labour for different professionals. Managerial activities are always related to the consumption of time, but also costs for consumables and for communication (computing, phone, etc.). Thus, IM activities were separated from all the maintenance works and about 40 different administrative activities have been described in the standard. All these activities are supported with relevant forms for documentation, procedures for preparing, and guidelines for training.

The next step for structuring the activities was to define clearly the very different maintenance activities and to classify them the most suitable way keeping in mind the existing, but also the possible division of labour in this field. Especially here, dense co-operation with different professional associations was necessary. Current analyses show the following clear trends there:

- though the former housing management companies provided only services for emergency repair, but currently wide range of planned, preventive and conditional maintenance works are carried out by specialised companies where the majority of contracts are signed on price-quality tenders; maintenance manuals are introduced and followed on different types of properties;
- there are several construction sub-contractors specialised on works for certain structures, or for installing single structural elements, or utilities; these companies are interested in extending the contract-period for the maintenance period; this has effected the preconditions for LCC analyses as well, and the classification used in the standard for maintenance activities has to follow these trends in construction management as well;

- in parallel to maintenance of the existing structures, elements and systems of the built environment, different cleaning works have become quite significant and profitable business that is using modern technologies and equipment; companies for cleaning have developed mainly into three distinguished sectors – services for outdoor areas, for façades of the buildings, for premises inside the buildings.

Following these trends described, it was reasonable to identify two quite different fields for maintenance activities: (10)

- technical maintenance – the planned, preventive, conditional or emergency works undertaken in order to keep or restore every technical facility (buildings and its parts and elements) to an required or agreed standard;
- cleaning – specific maintenance work targeted to preservation of territories, areas, surfaces and/or rooms from dirt and waste; in addition to preservation of surfaces these works are targeted to create hygienically acceptable and safe conditions for the users.

Following these basic descriptions, the two following classification groups were established – for technical maintenance (200) and cleaning together with garbage collection (300). In parallel to these, the activities to improve the facilities (reconstruction, re-installing, refurbishing, etc.) were described by the group (400).

Property ownership is always related to a number of obligations for the owner. Some of these obligations are very specific ones and do not require any activities, rather than payment to be done, like fees, burdens, taxes, etc. For proper LCC analyses all these charges are to be analysed and studied separately from all the other costs in-use. These charges describe the ‘price for the ownership’ as mostly they are not related to the performance of maintenance level. Correspondingly, different charges are classified in the group (500) describing the legal or contractual obligations of the owner/owners.

The group (600) is related to services that are mainly based on the consumption of different resources by the users – energy, water, but also for using the different communication lines. Different properties have miscellaneous systems for utilities, all the related costs are depending either on the consumers’ habits, or on the performance of maintenance works done, but also on the prices for these services.

The last group (700) includes the so called operational services that are most often listed when describing the major functions for FM. For example:

- organising security and parking services,
- services for offices (photo copying, booking the meeting rooms, etc);
- catering,
- in-house services (design, planning the rooms and workplaces, removal);
- helpdesk, etc.

The proposed system of classification used in the standard is not the finally fixed one. There can be further modifications or additions done to tailor this scheme for any single immovable property. Current experience of using the standard – though relatively short one – gives the evidence that the companies are willing to follow the proposed concept.

5 Some conclusions and findings

The paper gives an overview about the results of the R&D project carried out in Estonia to improve the state of art when managing the properties on the national market. The first two chapters of the paper describe the background for the related problems, later on the paper addresses the major stages of developing the national standard together with the major results gained.

The work for compiling the national standard has been the joint effort by different organisations – property (facilities or immovable) management has been on the crossroad of their interests. The standard, relevant handbooks and guidelines have created the necessary preconditions to improve the reputation of the sector.

In parallel, there are several other interrelated sub-problems addressed. Firstly, the debates about standard drew public attention to the fact that the elementary IM activities require relevant professionalism not only from the managers and operatives providing the service, but also from the owners or their representatives. Currently, there is no(-)body representing clearly the interests of the property owners on the national market.

Due to that, secondly, lot of attention was given to improve the existing system of professional education and training, but also there has been the growth of IM consultancy services proposed on the market. The private sector owners have understood the necessity to invest into IM services, but the public structures and local authorities are still relatively disadvantaged here due to lack of relevant funds.

Thirdly, no standard can improve the situation on the market if no reliable information will be available about the property and about the services provided. The major problems about this are:

- what are the primary data required for efficient IM? and
- how this ‘raw’ information about any single property can be made beneficial for all the parties involved?

Information about the property and IM activities there belong to the owner of the property, but the professional IM companies collect, handle and analyse this information. The problem is – how the analysed information can be made useful for the whole IM society on the market without harming the interests and rights of the owners.

Finally, though the standard was targeted for national (Estonian) market, there have been the interested bodies from the other Baltic states and Finland showing up their interest when implementing the proposed scheme in practice. This gives certain evidence about the necessity to continue the methodological work started and done by now.

Acknowledgements

The author gratefully acknowledges the sponsorship and support by the parties involved in the consortium of the project, but especially the representatives of the companies of the Estonian Association for Property Management and Maintenance.

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Public Sector Property Strategies within Australia

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Abstract
The changing economic drivers at the end of the 1990's led business and governments to focus on their property procurement strategies. Many governments globally adopted a market driven approach, subjecting non-core service delivery to competitive tendering and contracting with many services outsourced to the private sector. Australia readily adopted the new market approach and each State has to varying degrees implemented new strategies. The Commonwealth Government set about a major property review implementing a user pays market system followed by a comprehensive outsourcing of commercial property. This paper examines the property evaluation process and critically reviews the disposal processes adopted. It shows where lack of forward strategic planning led to a significant loss of value to the public purse. The paper concludes with a recommendation that public sector authorities establish a clear strategic approach rather than adopt a chop and change one led by management fashion.

Key Words: Government, Australia, Property, Facilities Procurement

Introduction

As facilities managers we are all aware of the rapid changes within our industry and the growth of our profession over the past couple of decades. The focus by business, brought about largely by economic forces on its operational assets, has seen a dramatic shift in the way that these assets are owned and operated. A similar and oft more dramatic revolution has occurred in the provision of operational facilities within the public sector. These changes in public sector property resourcing strategies have occurred across much of the developed world. In Australia, in typical Aussie style, management has whole-heartedly embraced the global trend and moulded and adapted it to our particular circumstances. This paper seeks to identify the global trends in property resourcing and discuss the application of these within the Australian public sector where some fervent application of the new property paradigm has resulted in considerable public criticism.

The Australian public sector has adopted a number of facilities provision strategies which have resulted in critical review by audit commissions and reported financial losses. The review of these facilities procurement processes will allow us to see where improvements can be made in the development of future property strategies. The outcomes of these recent public sector processes serve to show that the provision of facilities must be cost efficient and effective in support of Government service program. The development by the public sector of a long term strategic facilities plan linked to the overall direction of government, in place of ad hoc series of reactive investment and divestment decisions, is essential in maintaining public expenditure at optimum levels for efficient service administration.

Background

The global recession of 1979 is largely seen as the catalyst for the significant structural changes which occurred throughout the eighties and nineties. This heralded a period of privatisation, the relinquishment of control and financial responsibility for industries held by the State. In the USA, airlines and telephone companies were handed back to the private sector. In the public sector US agencies were exposed to market forces and expected to function as though they were private corporations in competition. Osborne, D. and Geabler, T. (1992) In the UK the newly elected Thatcher government quickly adopted the privatisation philosophy, disposing of many publicly owned assets including major public utilities. In 1979 state owned industries were losing $3billion per annum, however, sales of these assets between 1979 and 1990 raised $34billion to reduce net national debt by 12.5%. Moore John (1992) 87. At the same time the public sector was considerably reduced and much of the property assets of the state sold. The extent of this privatisation is illustrated by the dramatic fall in the contribution made by the British public enterprise to the Gross Domestic Product which from 1979 to 1987 fell from 11.5% to 7.5%. Vogelsang Ingo (1990:95)

In Australia microeconomic reform largely commenced under the Labour governments of Hawke and Keating 1983-1995. The previous Fraser government had abandoned the goal of full employment and based its economic policy on fighting inflation and, as such, had laid the basis for microeconomic reform. Elected in 1983, Hawke began the reform process with the floating of the dollar and a stated commitment to tight controls on government spending. At the same time government refocus on its core service delivery, together with a need to release funds to retire debt, led to the privatisation of a number of Government Trading Enterprises, including inter alia the Commonwealth Bank and Qantas. The graph at Figure 1 shows the rising level of Federal privatisations via both trade sales and public floats through the period 1991 to 1998.

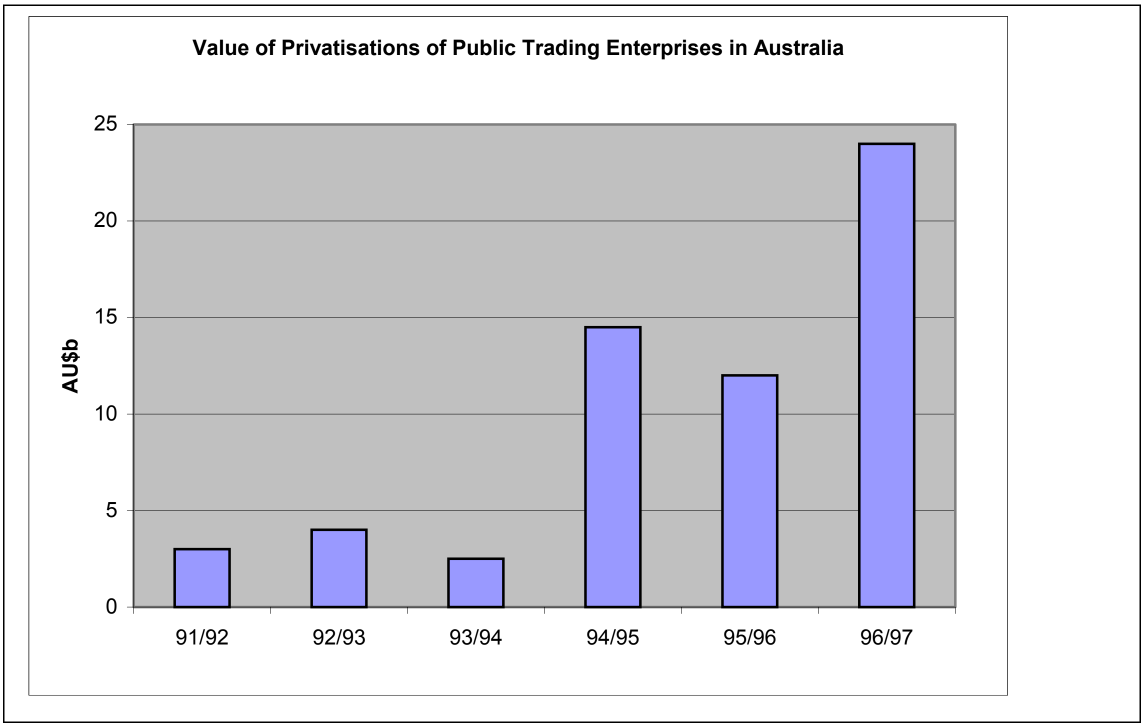

Figure 1 Value of Privatisation's of Public Trading Enterprises

Source; Reserve Bank of Australia 1997

This level of government privatisation is one of the largest among OECD countries as illustrated in Figure 2, with Australia second only to the UK in value terms and second to New Zealand as a percentage of GDP.

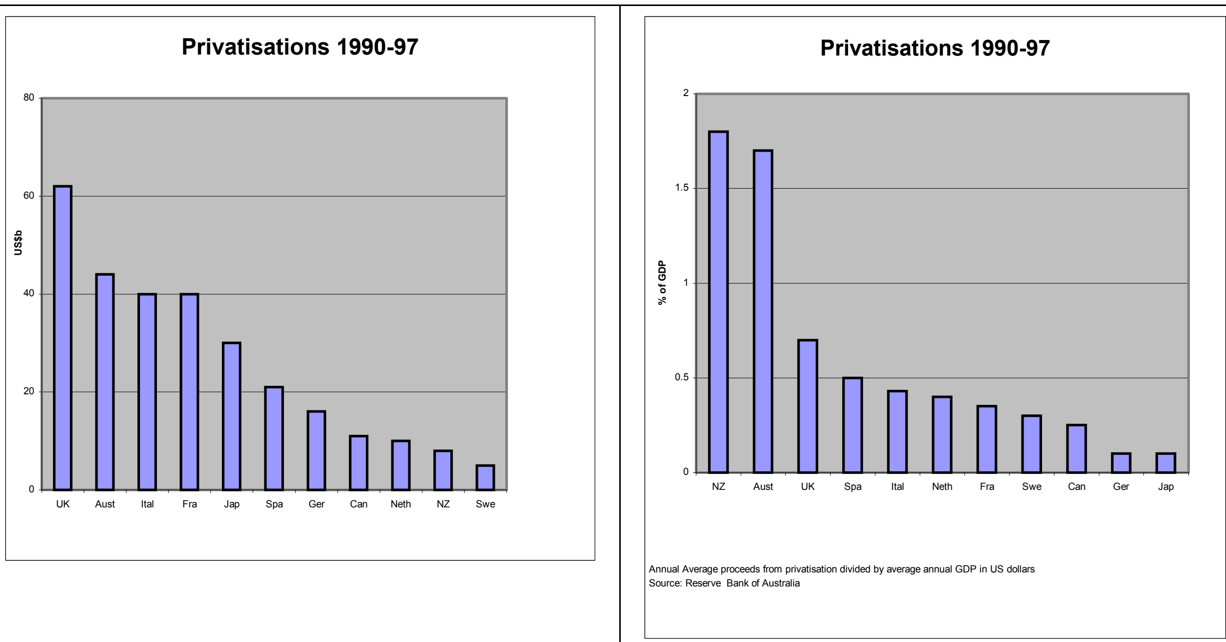

Figure 2 International Privatisations 1990-1997.

Source; Reserve Bank of Australia 1997

In 1989 Hawke announced ‘The Machinery of Government Reform’ Directions in Government (1993:3). The intention of the new agenda was to reform those sections of government with commercial potential in order to position them for privatisation. During the early 1990s policies of competitive tendering and contracting-out were introduced and led to a further contraction of government. In 1992 the then Prime Minister said, ‘the engine which drives efficiency is free and open competition’. Keating, P.J. (1992), thus indicating the government's clear aim to increase competition within government service provision.

In 1993 an independent inquiry published a watershed report the ‘Hilmer Report’, on National Competition Policy. Hilmer F et al (1993). The report had wide-ranging implications for government enterprises and departments with a series of recommendations designed to open up competition at all levels. The inquiry was a comprehensive investigation into all levels of enterprise in Australia, including all elements of competition policy. From a government perspective much of the report focuses on the role of government trading enterprises and the privatisation of what could be considered government held monopolies. However, under the heading of ‘Fostering Competitive Neutrality’ between government and private businesses, the report made a number of recommendations that are more generally applicable to government departments where they are seeking to tender works or compete against the private sector in securing contracts from other departments. This milestone report was the wakeup call to public sector managers to begin a process of divestment and contracting out of a wide range of non core services.

The Australian Government's principal review and advisory body on microeconomic policy and regulation, The Industry Commission, published a report 'Competitive Tendering and Contracting (CTC) by Public Sector Agencies' Industry Commission (1996), which built on the Hilmer Report in specifically addressing the procurement practices of public sector agencies. The report made a series of key recommendations, based on submissions received from industry and research undertaken, as to the most appropriate practices in procurement across a wide range of services. Figure 3 below, by way of example, shows the relative proportions of services being contracted out by three of the six States. It is significant that in two cases property related facilities management services, cleaning and maintenance, both represent a considerable proportion of contracted services.

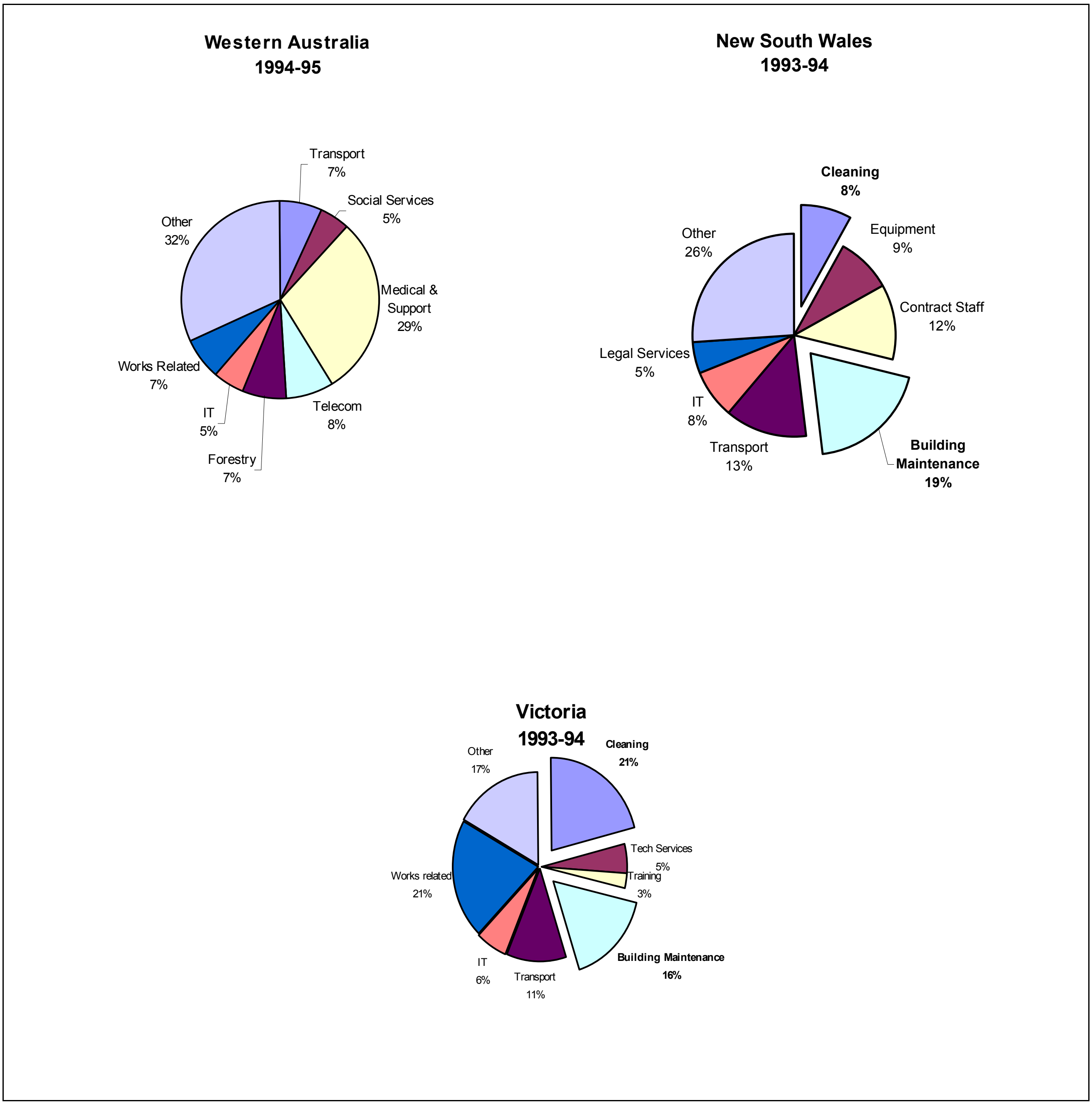

Figure 3 State Governments: Top contracted services by value (as a proportion of total contract expenditure). Source; Industry Commission (1996)

The key findings of the Industry Commission report were subsequently incorporated into government policy and compulsory competitive tendering, (CCT), was mandated across State and local government services which had previously been provided by in-house service departments. The former Liberal government in Victoria vigorously embraced CCT requiring that, by 1997, a minimum of 50% of each local councils total expenses be procured through CCT. Steane and Walker (2000). The pace with which CCT implementation has occurred varied considerably such that, at the beginning of the new millennium some considerable disparity now exists between State and Federal governments despite strong Federal level coercion to implement change. Political differences between States has meant that those which resisted the wholesale application of market provision during the 1990s are now able to learn from the experience of others and chart a course to best practice procurement through the coming years, incorporating CCT principles where appropriate .

Facilities Procurement in Government

The extent to which facilities procurement practices have changed varies considerably from State to State. This range of differing practices is brought about by a number of political and economic factors which provide us with an array of strategies to examine and learn from.

The largest and perhaps most instructive property portfolio belonged to the Federal Government. The Commonwealth or Federal Government had a property holding which, while centred in Canberra, also comprised a great many properties in each of the States and Territories. This estate had been changing in nature over the past few decades as attitudes to property ownership shifted. In 1976 the government directly owned and managed 51% of the office space it occupied, by 1996 this had fallen to 34%. The most dramatic change occurred, however, post 1996 when the level of owner occupied office space fell to virtually zero.

The management of the office estate since the late eighties provides a case study in the rapid change in attitude to property holdings while, at the same time, presenting some considerable areas of concern in the manner in which such objectives are achieved. In the late eighties the office estate underwent its first paradigm shift. The recognition globally that property should no longer be considered a free good led the government to fundamentally alter the methods used to manage its estate. The then Department of Administrative Services (DAS), through its division Australian Property Group (APG), embarked on a system of internal rental charges to occupier departments based on an internal lease type document or MOU. This public sector commercialisation was defined by the Australian National Audit Office. ANAO, (1992) as:

‘The adoption of various business practices akin to those of the private sector. Commercialisation involves a switch in reliance by a department of state on directly provided appropriation based funds, in favour of funds received from clients in payment for products and services'

This changed APG’s role, which was previously as a regulator of office space approving departmental requests against set space standards, to one of landlord.

Occupier departments no longer had to meet the occupancy standards but, alternatively, had to manage an accommodation budget. Thus departments which were efficient in their use of office accommodation were able to apply surplus budget funds to improve other elements of service provision. This was particularly so after 1994 when departmental property operating expenses were no longer separated from general operating cost. Department of Finance (1993). It thus became possible for a department to make the decision whether to spend funds on office accommodation, staff recruitment or delivery of services. In this way each department was effectively given responsibility for the management of its property affairs and was able to determine the most appropriate course of action within its budget constraints.

This system saw a marked improvement in the performance of the estate with a much higher level of tenant awareness as to the costs of accommodation provision. The recognition of property as a valuable asset was to a large extent responsible for the significant reduction in the size of the owner estate by 1996. An audit of the management practices in 1996 revealed that return from the portfolio was close to that of the broader market and significantly better in some areas. ANAO 29,1996

The second major policy shift occurred in 1996 when, within the context of the 1996/97 budget process, the government announced the formation of the Domestic Property Task Force. This task force sought input from the private sector as to the best method of managing the estate and future ownership of property and led to the formation of a private sector advisory committee, the Commonwealth Property Committee (CPC). This group oversaw the division of the office estate into three regions and the sale of the management of those properties to the private sector.

The privatisation of property management was shortly followed by the CPC's establishment of the Commonwealth Property Principles in July 1996. These principles were developed by the CPC in conjunction with the Department of Finance, and state that:

'The Commonwealth should own property where the long-term yield rate exceeds the social opportunity cost of capital or where it is otherwise in the public interest to do so' ANAO (2001)

The hurdle rate applied to test the ownership criteria is in the range of 14% to 15% real rate. It is quite obvious that the vast majority of real property assets will not pass this high hurdle rate and as a consequence, a rolling programme of asset disposals commenced. The use of a social opportunity cost of capital and the adoption of the 15% hurdle received much criticism at the time that it was launched and subsequently in a National Audit Office review of the process. The basis upon which the hurdle rate was fixed is an interesting lesson in property financing. The Department of Finance in 1998 explained the process to the Senate as follows:

'Given that the cost of capital to the Commonwealth is around 12–14 per cent the hurdle rate of 15 per cent used in the financial analysis of the Government's domestic property holdings was arguably too low. The evidence suggests that hurdle rates in the private sector are commonly 15 per cent after tax and that some companies involved in property development use hurdle rates in excess of 25 per cent. At the

time the decisions were taken on domestic property, the hurdle rate adopted by Commonwealth GBEs began at around 15–20 per cent. The Commonwealth Property Committee therefore erred on the side of caution using a hurdle rate of 15 per cent. The consequences of this decision would therefore have been that properties that would not meet a higher hurdle rate would have been retained. The Government would, however, be able to dispose of such properties at a later date'. DOF Submission to Senate Finance and Public Administration References Committee February 1998

To defend the CPP hurdle rate of 15% against criticism, DOF subsequently employed consultants on three separate occasions to advise them of an appropriate measure to apply to the own/sell decision. The first two consultants adopted similar rationales to arrive at a hurdle rate. They utilised the Capital Asset Pricing Model (CAPM) to estimate the expected return from real property in Commonwealth occupation. The first used a risk free rate of 6% and a beta for property estimated as between 0.4 and 0.6, where a most likely estimate of return is 10%. The second consultant, reporting in 1999, was a little more conservative with an expected return between 9 and 11%, recommending the adoption of the higher rate as a maximum. The third consulting firm, hired in December 2000, adopted a slightly different approach by applying the total market risk beta of 1 to the risk free rate and then adding a further 2-3% allowance to reflect the risk associated with property, thus arriving at a figure of 15%. The first two consultants adopted similar approaches to determine the appropriate hurdle rate, while the third consultant used a global market risk and added an additional margin to reflect property risk. This latter approach uses unconventional methodology but was adopted by the Department of Finance and supports the CPP hurdle rate figure of 15% used in the earlier property disposals. ANAO (2001)

It follows that, based on the adopted hurdle rate of 15%, the majority of properties evaluated against the property principles were earmarked for disposal. A handful were retained and of these only one property was retained on public interest grounds due to the sensitivity of its location within Canberra. Indeed, some properties that exceeded the hurdle rate were somehow also included in the disposals program. The effect of applying the CPP was the identification of 59 major properties for disposal with a market value of AU$1.05b. This major proportion of the commercial estate was packaged to achieve optimum income and disposed of over a period of three years, between late 1996 and 2000. It was the largest property disposal program undertaken within Australia and accounted for a significant proportion of the total market sales during the period. What is perhaps more significant is that the disposal program accounted for a 20% or $140 million write down in values.

The change in attitude to property ownership which occurred in 1996 has received some criticism, most notably in an Australian National Audit office Report which found a number of flaws in the approaches used to determine which properties should be retained at the time. The 15% hurdle rate was coupled with a devaluation of the properties by an average 20% as a result, in part, of tenancy changes. This meant that few properties exceeded the hurdle. The earlier leaseback arrangement for tenants resulted in many departments vacating some or all of their accommodation prior to sale, thus reducing the rental stream and devaluing the property. The flow of government tenants from the owned estate reduced the occupancy level by government and reduced the value of the government's rental covenant within the properties. The number of properties offered for sale, due to their not meeting the desired rate of return, was further boosted by applying the hurdle rate to the previous market valuation, not the revised market value at which the properties were to be sold. This further overstated the return needed to retain an asset. Had the current value or sale price been used with the rental stream to apply the hurdle rate, then the number of properties to be sold would have been dramatically reduced. ANAO (1996)

The argument still continues about the most appropriate hurdle rate, 11% or 15% with the Department of Finance defending its decision. Aside from this debate, there remain many other questions about the disposal process which can be instructive to future procurement decisions. The disposal program was undertaken between the end of 1996 and 2000, a time in which the Australian property market was somewhat depressed with large vacancy factors, low rentals and consequently low capital values across most markets. The result of offering a very substantial portfolio of properties into this market was a less than optimal sale price. Indeed the ANAO (2001) audit reveals a 20% discount to the property valuation. Further investigation of this discounting shows that, of the 47 properties disposed of for which pre-disposals program valuations are available, only 7 achieved sale prices at or above their 1994 valuations. The portfolio sold at approaching a 20% discount to valuation with 22 of the 41 properties studied returning less than 60% of valuation. The lowest figure achieved being just 25% of valuation. Even the best sale of a high grade, eight year old office tower in Sydney achieved just \$3,130/m^2 NLA compared to current 'A' Grade figures of \$6,800/m^2 in the Sydney market and an original construction cost to the tax payer of \$4,300/m^2 Colliers Jardine (2001) Thus, despite some very successful sales which achieved good figures, the total sales proceeds were some \$140,000,000 short of valuation.

A number of explanations can be given for the relatively low sales proceeds compared to pre-sales valuations. It is true that, at this time, the market was very depressed with low rentals, significant lease incentives and high vacancy rates, all of which would depress the value of these properties. It is also true that, in the context of the Australian property market at the time, the placement of such a large portfolio over a short period affected the prices investors were willing to pay. There are, however, a number of issues related not to the general market at the time but to the management process leading up to the divestment program which served to reduce the value of the assets. The purchasers of these assets were generally only interested in buying a rental stream secured by a government covenant, however the leaseback arrangements prior to sale reduced the rental levels and subsequent sale price.

Many of the properties sold by the Federal government had significant vacancies at a time when the market had an oversupply of office accommodation thus reducing the cash flow and security of a government covenant to pay rent. The vacancy rate was high as a result of two factors. The first, a reluctance through the early nineties to fill vacant owned accommodation with non-government tenants where no current demand existed within the government. The leasing of temporarily surplus accommodation was seen as competing with the private sector and also as a security risk. The second, the policy change to allow departments to negotiate rental deals gave them freedom of choice to move unchecked from owned office towers into privately owned accommodation. It was earlier noted in this paper that the percentage of owned accommodation dropped from 51% in 1976 to just 34% in 1994, but these figures hide the fact that the owned estate increased in size in this period by 8%. Thus the leased estate underwent a phenomenal increase at a time when government was seeking to reduce the numbers of public servants. The result of the increased reliance on leased accommodation was a greater level of vacancy in owned offices which, in turn, led to reduced levels of government lease back deals on sale. The high vacancy rate and low passing rents associated with the estate go a long way to explain the poor asset sales achieved, particularly in what was a depressed market.

There are a number of lessons we can all learn from the Commonwealth Government experience and the methodologies employed in identifying an appropriate and efficient provision of facilities solutions for the delivery of organisational goals. The Commonwealth Government had what was one of the largest property portfolios in Australia and, until the late 1980's, had managed the estate by providing regulatory standards. The dawning of property reform enabled government to rethink its strategy and to trial a number of approaches to property service delivery. Some of the early initiatives of freeing departments to make their own property choices within a user pays framework showed promise of reducing costs and increasing efficiency, albeit at a modest rate of change. The latter phase, which effectively resulted in a move out of direct ownership of real property, also served a number of objectives often associated with the process of outsourcing, namely a reduction in cost of service provision, a release of capital tied up in the provision of property and the removal of an administrative burden in the form of a large bureaucracy of public servants managing the property process.

There is little doubt that the process adopted by the Commonwealth relieved government of the burden of property development and the provision of commercial property management services, relying instead on the market to provide these services at a competitive rate. The question that this approach does not answer, and is only partially addressed in the audit report of the disposal process, is does this give the service department and ultimately the tax payer the best outcome both financially and in operational efficiency terms?

Conclusion

The lessons we can all learn from this disposal process is that property is a long term proposition and that rapid policy change, if not integrated into a whole of life asset plan cognisant of market conditions, can have a marked affect on the value of assets. The experiment by government in new procurement strategies incorporating unrestrained use of market forces and a preference for short horizon reductions in transaction costs against a consideration of medium term broader issues, does not produce the best outcome for society. Steane and Walker (2000)

The lack of a coordinated Facilities Plan which integrates the governments long term service and policy agenda with the facilities under management and the wider market within which they operate will not provide optimum efficiency. The practice of chop and change in procurement policy can lead to instability in the returns from the properties and a consequential increase in the apparent risk to investors. As we have seen in the case of the Commonwealth Government's approach, an initial strategy of competitive market equivalent provision of commercial office accommodation would have led, over time, to an equilibrium of owned to leased facilities which were market competitive and aligned with long-term service objectives. The decision to change to a wholly outsourced provision of property services could have provided a long term strategic position freeing up capital to retire debt. However, the implementation of both strategies within a relatively short period of time served to reduce the overall effectiveness of the outcome. The loss of value to the government of some 20% of what might have been realised from a more appropriate implementation of either scheme independently demonstrates the lack of a high level strategic facilities plan and a poor and inappropriate outcome for the public. The public sector should not be afraid to use its obvious market power in either owner-occupier or leasehold property procurements, but should use its position to add value to the overall service delivery objective via a business integrated strategic facilities plan. Government and similarly private sector organisations should adopt a clear long-term facilities resource plan which benefits the public or shareholders at large not the short term management fashions of the day. After all as it is well known, being slaves to fashion invariably results in an expensive lifestyle.

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Pro-active airport building management adaptation and renewal

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Abstract
This paper summarises the current position with airport design and suggests that efficient use of facilities cannot depend upon shareholder return alone but must be based on national interest and efficiency demonstrated through external benchmarking. The paper suggests that facilities managers must be aware of the expectations of the airlines and passengers and the indicators used in the assessment of performance. The paper outlines the reasons that influence an airport's decision to upgrade or replace its terminal facilities.

Keywords : Airport, Design, Facilities, Management, Performance**.**

Building Concepts

Although many different configurations exist for airport passenger terminal buildings virtually all can be placed into a few primary categories based on their geometrical characteristics. Two major passenger terminal building concepts have emerged in today's new, major and high volume airports. These may be defined as follows:

a. centralised passenger processing terminal building with finger piers as at the proposed second Bangkok international airport or Schiphol Airport in Amsterdam.

b. centralised passenger processing building connected by people mover system to satellite buildings airside as at the new Kuala Lumpur International Airport or Denver in the US.

Although different types of passenger terminals exist, this paper concentrates upon the finger pier type such as that at Changi Airport in Singapore.

Expansion of terminal facilities is required to meet seemingly ever-increasing numbers of passengers in the aviation industry. This has meant that more air-bridges and finger piers have been required. This can be achieved through either new construction or alterations to existing structures. As a result extensions of existing finger piers are quite common. Walking distances and overall travel time must also increase as distances between check-in and departure gates also increase. Over time the standard of service offered to passengers will be affected. Subject to there being no land constraints there is potential to ever increase the distance that must be walked or over which baggage must be transported. This raises the question as to whether a maximum viable size exists for passenger terminal buildings.

Terminal Size Determination.

This paper concentrates on nine factors which are seen as essential to the determination of the size of airport terminal buildings.

Walking Distance - This factor has a direct bearing on optimum size and takes into account both user psychology and the human scale. The maximum walking distance recommended by the International Air Transport Association (IATA) is 300 metres unaided. Beyond this a moving walkway or other people mover system is recommended. Other localised bodies have their own recommendations. In the UK BAA have a policy of no greater than 250 metres unaided with an overall journey of 650 metres being permitted where a maximum of 30% is unaided. Singapore's Land Transport Authority suggests a maximum walk to a bus stop of 300 metres.

Level of Service For Passengers - It is important to determine the level service that can be sustained at any specific capacity level. It may for example be easy to sustain a high level of passenger service at 1000 passengers per hour but only a low service at 1500 passengers per hour. This is a strategic decision which should be made in advance of design and operation. It may be that different levels of passenger service are acceptable at different times. Hence in general a higher level of service will translate into a lower capacity for a terminal building of given size.

Performance Standards - Most airport owners or aviation authorities set themselves targets for the purposes of measuring performance. In the general area of facilities management the benchmarking of various organisations against others continues to be a matter of much discussion. In airport management the two most important measurements of performance success tend to be the time it takes passengers to clear the airport upon arrival and the time it takes for baggage to be delivered.

Traffic Peaking Characteristics - it was mentioned earlier that a trade-off may be necessary in terms of service to enable capacity to equal demand for passenger throughput. Efficient use of facilities is dependent upon avoiding the tendency for passenger throughput to peak. A constant throughput of passenger numbers allows efficient use of all facilities with no reserve capacity being required. A tendency towards regular peaks means that for much of the time the facilities are being left idle whilst still representing a cost.

Transfer Volume - This factor will affect the need for capacity in certain areas. A higher transfer volume will mean a greater need for airside facilities such as circulation space and transfer counters but a proportional lesser need for landside facilities such as check-ins and baggage claims. Minimum connection times become of greater importance with growing transfer volume.

Hubbing - Efficient hubbing is best performed from within one terminal and certainly one airport. In the UK Bristish Airways have experienced considerable problems from being unable to hub at Heathrow in is entirety (Pitt,2001). The need to move passengers between terminals does not allow for efficient transfer times

Uncertainty of Demand - many factors affect the future demand for air travel both on a global and local scale. These factors include economic crisis, volatile transfer traffic, the continued relevance of hubbing in the light of longer range aircraft and the significance of airline alliances. These factors and others mean that it may be prudent for an airport developer not to overbuild (Wai & Teck, 2000). Consideration may be given to constructing flexible buildings in a modular form which can be modified in the light of unforeseen factors.

Sophisticated and Costly Airport Systems - some systems become so complex that the maintenance and redundancy back-up costs become prohibitive. Much like the size constraints mentioned earlier , technology too can be a restraining factor in the size to which airports can grow.

Wayfinding - the larger the airport the greater the need for effective and clear wayfinding.

Defining Optimum Capacity

It can be seen that optimum capacity is a subjective concept. The cosmopolitan origins of passengers on long haul air journeys are less likely to be prepared to tolerate crowded unpleasant public areas. In simple terms what the average flier will not tolerate will simply not do. This is of course far too simple a definition as the tolerance level of the holidaymaker is famously more (even though they may not know it) than the business traveller.

According to Blow (1991) the maximum capacity of a terminal with finger piers designed for hubing is around 30 million passengers per annum with 50 gates. Wai and Teck (2000) point to the six fingered pier terminal as being the optimal design in terms of efficient aircraft and passenger movements. They conclude that the optimal capacity for a six finger pier terminal is around 25 million passengers per annum. This capacity figure can only increase if trade-offs are made in performance related issues.

Airport Performance

Much has been learnt about the design and construction of new airports as the massive expansion in air travel continues. Modern airports such as Changi in Singapore provide a better and more efficient experience for travellers than some of the more cramped facilities that are found elsewhere in the world. The location of the airport is often a major factor in its efficiency. The contradiction between the need to invest in airports and the form of ownership was identified by Pitt (2001). The need for some airports to answer to shareholders and not governments has led to the peculiar situation where privatisation has been a company success but a national failure. Airport design advancement has been fast and achieved largely in the last twenty years meaning that many airports across the world and particularly in the UK require replacement and/or relocation. In order to demonstrate the efficiency of airports both the airport owners and the airlines use performance measurements. These measurements are only meaningful if they are benchmarked against other similar facilities. It is for example virtually useless to compare London Gatwick with London Heathrow and conclude that their performances are similar as they are both to some extent outdated facilities in the same ownership. What is needed is benchmarking external and internal to the country and to the company.

An Airport's Multi-Customer Base

Airports may be defined as multi-customer based facilities in two distinctly different dimensions. Firstly, Airlines themselves are interested in monitoring the performance of airports to ensure that overall operations are efficient and cost effective but also that the passenger receives a good service from the airport airline and any combination of the two (for example : the provision and manning of check-in desks). Airlines are acutely aware that when a passenger flies regularly the choice might be airport first and airline second. Maintaining a presence at a popular airport might be seen as essential by a network carrier such as British Airways. This ability for passengers to decide to fly from different airports represents the second dimension of an airport's customer base. It may be a decision to route through Amsterdam instead of Heathrow or to fly from Heathrow instead of Gatwick. In any event maintaining competing airports in different ownership is essential for competition to operate effectively. The extent to which an airport is ready and able to respond to the results of any benchmarking exercise is strongly dependent upon the form of ownership (Pitt, 2001).

As the requirements of the airport's customers are essential to its continued viability airports must be familiar with the latent grading that is adopted through research undertaken by airlines and the ratings placed upon airport performance by organisations such as the ICAO and IATA.

Airlines

The performance measurements used by an airline are often tools to bring shortcomings to the attention of airport staff. Very often the problem will be one over which the airline has no control. If airports want to avoid the exposure of weaknesses within their built facilities or management thereof they must be aware of what is being studied by the airlines and deal with these matters before they affect the competitiveness of the business. One of the main problems presented to airports is the difficulty in responding to the differing needs of the different types of airlines that are emerging (Pitt & Brown, 2001). Tables 1 and 2 below shows the customer service effectiveness measures that have been put in place by Aer Lingus the Irish national carrier and the resource utilisation measures used. These measurements are different to those undertaken by some other carriers but serve to illustrate the fact that airlines study airports and the interrelated, mutual and collaborative services that are provided.

Dimensions	Why?	How - Aer Lingus
Design	• relate problems to marketing with reference to conflicts between desirability and feasibility	• correlate customer feedback - make it relevant and ensure it is fed back to source in this case check-in as well as marketing
Performance	• are the frontline agents delivering as the organisation thinks they should be?	• use customer relations information to monitor performance. Use an outside agency . • staff appraisals - a function that is so people orientated that it is essential. The staff need to know what is expected and if they are performing
Reliability	• if we are capable of delivering what % of the time is there a short fall?	• establish metrics - e.g. throughput of passengers per day, amount of passengers dealt with per staff member, complaints per 1000 pax, % of check-in errors that caused delays.
Cost Reliability	• staff should be aware of providing value for money i.e. delivering the specification.	• it is important that the cost passengers are paying overall is noted. Likewise it is important that staff know the importance of yield.
Delay	• are queuing times too long or could we have them longer.	• measure queuing times in minutes not amount of people.
Duration	• how long is exchange - could it be shortened and/or re-engineered?	• study the actual exchange. It may be possible to speed it up if more attention was paid to transaction timing particularly during training
Timing reliabilty	• what percentage of time is a recognised standard delivered?	• establish standards and review if these are not being met e.g. no queue plus transaction time to be longer than 5 mins. Feedback from customers regarding specification will show what is acceptable.

Table 1 : Customer service - effectiveness measures

Dimensions	Why	How - Aer Lingus
Machinery/IT Equipment	• it is necessary to see if there is downtime for the IT equipment. This could impact on capacity.	• monitoring by staff to see the rate of systems failure
Labour	• emphasis is put on "softer" elements. However it is necessary to maximise available labour. It may be possible to provide the same level of service with less staff.	• it is the main expense because it is fundamental to the specification. However closer attention has to be paid to productivity • as an organisation the balance has got get closer to 50/50 in customer satisfaction versus resource utilisation.

Table 2 : Resource utilisation - efficiency measures

Passengers

As much as airlines can move from airport to airport so passengers can choose a departure point. In the case of levels of service IATA has developed a framework which permits the comparison of airports and sub systems through the use of common terminology. Table 3 below shows the category definitions from A to F.

A Excellent level of service; condition of free flow; no delays; excellent level of comfort.

B High level of service; condition of stable flow; acceptable delays; high level of comfort.

C Good level of service; condition of stable flow; acceptable delays; good level of comfort.

D Adequate level of service; condition of unstable flow; acceptable delays for short periods of time; adequate level of comfort.

E Inadequate level of service; condition of unstable flow; unacceptable delays; inadequate level of service.

F Unacceptable level of service; condition of cross-flows; system breakdowns and unacceptable delays; unacceptable level of comfort.

NB : Level of service C is recommended as the minimum design objective as it denotes good service at a reasonable cost. Level of service A is seen as having no upper limit.

Table 3 : Level of Service Framework (Source AACC/IATA,1990,5)

Many airports, such as the new Hong Kong International Airport are designed to meet level C standard as it denotes good service. The fact that the aim of one of the world's newest airports was to achieve only level C suggests that a compromise was reached between expenditure and service.

The level of attainment on this scale is an indication of the likely overall experience that passengers will gain at any airport. The decision to achieve a certain level of service is a strategic one.

Construction of New Facilities

Airports can influence their positioning on any benchmarked scale by cutting passenger numbers but the reality is that this is not usually possible in the airport business. Making decisions on new facilities must come as the norm or the industry benchmark is significantly above that at the subject airport.

Decisions to upgrade or replace airport facilities will depend upon the following factors :

1. Benchmarking outcomes
2. Form of ownership (Pitt,2001)
3. The extent to which the airport is publicly perceived as being outdated.
4. Changing customer needs (Pitt & Brown, 2001).
5. Environmental issues
6. Political pressure both internal and external
7. Economic climate in country of origin
8. Any other industry changes

Conclusion

The time has been reached on the world stage where many of the world's major airports are outdated. Modern construction techniques and design concepts have pushed the capacity and performance levels of new airport terminal buildings to new heights (Pitt, Wai & Teck, 2001). The barriers to the renewal and upgrading of airports are many. Some of these such as forms of ownership are government created, others are simply due to the growth of the air transportation industry itself.

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Issues in Conservation Maintenance Management

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Abstract
For most organisations its built assets are a resource that can allow the primary goals of the organisation to be achieved. Therefore effective strategic maintenance management of a property portfolio should be informed by and support the corporate goals of the organisation. However, for what we might term 'heritage organisations', the goal ***is*** *the protection and enhancement of the buildings themselves, not least because the fabric itself embodies and represents 'cultural significance'. All of the leading international conservation charters, as well as UK national guidance, emphasises the primary importance of maintenance in protecting the built cultural heritage. This paper considers some of the broader contextual issues in relation to maintenance management of the built cultural heritage and reports on some of the issues emerging from a current research project which has a particular focus on the key role that condition surveys play.*

"Maintenance is the single most important conservation process. Whether the place is architectural, mechanical or botanical, prevention is better than cure." (Semple Kerr 1995)

Background

This paper examines some key maintenance management issues for the built cultural heritage and in particular it focusses on the role and purpose of condition surveys within this sector. This paper draws on published work carried out by the authors in recent years (Dann, Worthing and Bond 1999, Worthing and Dann 2000 and Dann 2001) and reports on some of the emerging themes of a current project. The current project is supported by a grant from the RICS Education Trust.

One of the previous projects involved interviews with a small selection of maintenance managers of historic buildings and a questionnaire sent to over 60 maintenance managers. Some of the organisations involved were focused specifically on caring for historic buildings (heritage organisations); others were organisations with a significant proportion of historic buildings within their portfolio.

The project asked how and why the interviewees carried out certain tasks (and within what context). The purpose was to:

- Identify significant differences between the approaches adopted to maintenance management (of "historic buildings") between heritage and non-heritage organisations
- Identify issues in the maintenance management of historic buildings.
- Work towards developing a research agenda.

The research highlighted a number of issues. Of particular concern was the high percentage of non heritage organisations who made no reference to conservation principles and concerns in either their general approach to the management of historic buildings in their care, nor in their specific approach to maintenance and repair based issues. This was not the case for the heritage organisations. However within the latter group there were some issues which raised concern regarding the coherence of maintenance management policy and practice. The project reinforced our belief that condition surveys are a key task for effective maintenance management for the built cultural heritage. The current RICS sponsored project built on this work and paid particular attention to the role of condition surveys.

Aims and objectives of the paper

The aim of the paper is to examine some of the maintenance management issues for the built cultural heritage and in particular it focusses on the role and purpose of condition surveys within this sector.

The objectives are to

- Consider how condition surveys are undertaken by organisations that manage the built cultural heritage.
- Consider the role of conservation plans, in particular the concepts of significance and vulnerability and how these might influence the design, commissioning, implementation and output of condition surveys.

- Consider how improvements might be made in the effectiveness and efficiency of condition surveys for the built cultural heritage within a framework, which recognises the aims of conservation.

Conservation Issues: the current context

There has been a strong emphasis in recent years on the need for the built cultural heritage, whether individual buildings, sites or areas, to be managed more effectively. Power of Place (English Heritage, 2001), the recent report by the Historic Environment Review Steering Group, emphasises, amongst other things, the need to develop processes for managing change. The report also highlights the importance of methodological approaches which identify cultural significance and its vulnerability, such as conservation plans, as a fundamental pre-requisite in appropriate management processes for the built cultural heritage. This is reinforced by the DCMS report “The Historic Environment: A Force for Our Future” (DCMS, 2002). More detailed guidance on the maintenance management processes implied by the term Conservation Plan is given in the recent English Heritage document “Informed Conservation” (Clark, 2001). The production of management agreements (particularly for twentieth century listed buildings) as well as the growth in the use of conservation plans can be seen as a response, therefore, to the concerns about how change can be managed without devaluing significance. (i.e. addressing the issue of how cultural heritage can evolve whilst ensuring that values are protected and where possible enhanced).

It can be suggested that conservation plans and their methodological approach have had a significant impact on the “heritage sector” in the last few years. In large part the growth of the idea, and its implementation for some buildings and sites, can be seen to have emerged from the concerns about managing change that were referred to earlier. In practice however a key stimulus for the growth in conservation plans in the UK can also be attributed to the requirement of Heritage Lottery Fund who usually require one before allocating funds to a (complex) project. An HLF document articulates an approach to developing conservation plans (1998)

Much of the thinking behind conservation plans can be clearly seen to have emerged from the ideas embodied in the Burra Charter (ICOMOS 1987), one of the first international charters to try to articulate a coherent management framework for historic places.

Conservation plans have at their heart the idea that you have to start by exploring and then articulating what is significant and why, and then identifying immediate and potential threats to that significance by asking how and why it (the artifact, building or site is vulnerable). From this should flow management plans, which can develop and implement tactics and appropriate action. Any management plan derived from a conservation plan must include maintenance management and it follows that the maintenance plan must be carried out within the context of the identification of the (relative) significance of the fabric and its constituent parts. The key idea behind conservation plans - that in order to manage the built cultural heritage you need to be clear about exactly what is of value and what elements are integral to that value - is a simple and obvious concept which has not been explicitly applied in the past. It can be argued that the concept has not been applied because built cultural heritage has been seen as something which should be preserved and therefore a concept which implies that change might occur, never mind that it should be managed, was anathema to some. Also it can be seen that a system (i.e. the present listing system) which does not have an element which seeks to explain, and therefore to justify, why something is of value (thereby opening such interpretations for debate and challenge) is quite a powerful control system.

The role of maintenance

All of the key national and international documents which provide guidelines for the protection of the built cultural heritage emphasis the pivotal role of maintenance. For example the Burra Charter (ICOMOS, 1987), which defines conservation as being ". All of the processes of looking after a place so as to retain its cultural significance" also states that "A principle of conservation is that the cultural significance of a place is embodied in it *fabric*, its setting and its contents..". The charter goes on to state that maintenance… "is fundamental to conservation and should be undertaken where fabric is of cultural significance and its maintenance is necessary to retain that cultural significance."

Other international charters, for example the Venice Charter, the New Zealand Charter, the Canadian Code of Ethics and the Guidelines for the Management of World Cultural Heritage Sites, make similar points.

Advice from English Heritage (Brereton, 1991), the government agency responsible for historic building policy and advice suggests that

"The best means of ensuring the continued preservation of a building is to carry out regular maintenance. Such work is part of the day to day responsibility of all owners and occupiers.."

Planning Policy Guidance 15 Planning and the Historic Environment, makes the case for systematic maintenance even more strongly
"Regular maintenance and repair are the key to the preservation of historic buildings. Modest expenditure on repairs keeps a building weather tight, and routine maintenance (especially roof repairs and regular clearance of gutters and down pipes) can prevent much more expensive work becoming necessary at a later date…*regular inspection is invaluable*".

Despite the apparent importance of systematic maintenance emphasised by such documents, there has been no audit of the quantity and quality of maintenance for historic buildings, particularly for the over whelming majority of historic buildings which are owned by private individuals. Indeed the previously mentioned exhortation regarding the importance of regular maintenance being key, goes on to state;

"There is no specific duty on owners to keep their buildings in a good state of repair (though it will normally be in their interests to do so), but local authorities have powers to take action where a historic building has deteriorated to the extent that its preservation may be at risk.." (PPG 15)

The important role of maintenance is emphasized by the recently published British Standard (BS 7913:1998) ‘The Principles of the Conservation of Historic Buildings’ which states “Systematic care based on good maintenance and housekeeping is both *cost effective and fundamental* to good conservation”. Most recently the English Heritage managed review of policies for the historic environment, *Power of Place*, (English Heritage, 2001) stated that ‘..Regular systematic condition surveys and maintenance are essential if the money spent on major repairs is not to be wasted’. It suggests that the statutory conservation authorities should make a greater emphasis on regular inspections and maintenance for historic buildings and that this should be based on a new ‘duty of care’. In particular it suggests there should be regular and periodic review of maintenance for publicly owned historic buildings.

Philosophical issues for conservation maintenance

The important point about historic buildings, which should affect the approach adopted toward maintenance management, is that the fabric is important in itself - not just because of the function it performs. That is, unlike other buildings, the fabric has cultural significance - the building itself is an artifact. Therefore it is important to emphasise that the terms maintenance and repair should not be as interchangeable as they might be for other building types. This is because repair, whilst it may prolong the life of the element and the building, and therefore be necessary for the long-term protection of significance, will also involve damage to the fabric. As Brereton (1991) states “The unnecessary replacement of historic fabric, no matter how carefully the work is carried out, will have an adverse effect on the appearance of a building or monument, will seriously diminish its authenticity, and will significantly reduce its value as a source of historical information”. The Burra Charter (ICOMOS 1987) goes on to suggest that where ‘cultural significance’ is identified maintenance should be the first priority and it defines maintenance as

‘.. the continuous protective care of the fabric and setting of a place’ and as an activity that is to be distinguished from repair because ‘ Repair involves restoration or reconstruction.’

Maintenance is important in protecting cultural significance because, if properly implemented, it will, in the sense defined by Feilden (1994), be the least destructive of all the ‘interventions’ which inevitably occur in the process of conserving the built cultural heritage. The idea of approaching work from a minimum intervention perspective – as Burra would have it “as much as necessary, as little as possible” is articulated by Feilden (1994) as a hierarchy of intervention which puts in order of least harm to the fabric:

- the prevention of deterioration…
- protective measures…
- consolidation…
- and then repair

NB there is then reference to ‘other activities‘ such as restoration, reconstruction.

A number of principles have emerged in regard to maintenance and repair of historic buildings and these include:

- The need for research;
- Authenticity;
- The need for accurate records.
- Minimal intervention;
- Like for like approach to repairs;
- Honesty in repairs;
- Reversibility of repairs;
- Repair above restoration;
- Fitting the new to the old (and not the other way round);

Within these above widely accepted principles there are many potential contradictions and conflicts. For example, two key documents, 'The Repair of Historic Buildings' published by English Heritage (1991) and the 'The Purpose of the Society for the Protection of Ancient Buildings' (SPAB) (1987) may appear similar in approach but there is tension around the issue of restoration. SPABs overriding principle is "Repair not Restoration" whilst the English Heritage document allows for restoration (by additions or removals) where such work is not speculative and where no loss of historic fabric occurs.

The resolution of conflicts and tensions inevitably requires a case by case approach and one which should ideally start from the identification of cultural significance.

'..the sensitive repair and maintenance of an historic building and its landscape is not just a matter of specifying traditional materials and techniques. It requires an appreciation of why the site is significant, how this significance is embodied in the fabric and what impact potential repairs might have on It..' (Clark, 2001)

Condition Surveys

The term 'Condition survey' can be seen to imply that the activity is simply a record of the building's condition at a particular time i.e. a snapshot. Wordsworth (2001) refers to 'methods of measuring the compliance of buildings with their required performance standard'

However Wordsworth goes on to define 7 types of condition survey, from broad-brush stroke approaches to surveys which identify specific failure. Within this range he includes surveys to develop planned and cyclical approaches to maintenance.

Within specific sectors condition surveys have become critical activities which are seen as an essential tool for appropriate management. For example recent guidance (Day 1998) on the use of stock condition surveys for registered social landlords (RSL) points out that there is increasing pressure for RSLs to demonstrate that they are managing the maintenance and repair of their stock to 'best effect'. The 'Best Value' regime for the management of other local authority building stock in England and Wales will have an increasing effect on the practice of stock condition surveys.

A driver for effective condition surveys within the RSL sector has been the withdrawal of public funding for 'major repairs' which means RSLs are required more than ever to budget for future maintenance and repair. A recent good practice guide (Day, 1998) for RSLs states;

'with maintenance planning process becoming more important it is generally considered that the starting point must be a survey of the current condition of the organisation's stock and an assessment of the need for future repair and maintenance'

Condition surveys are used for more complex purposes than just the simple recording of condition assessment; they are often used to collect information related to assessments relating to the wider strategic aims of the corporate body. For example standardised condition survey information, gathered in respect to local authority school buildings, requires an examination of the buildings in terms of their 'suitability' and 'sufficiency' in relation to delivery of the national curriculum and other educational standards.

Condition surveys can be seen as an important potential management tool for planning work, budgetary control and monitoring of management performance. For example Marshall (1996) identifies a number of potential purposes (within the RSL sector):

Establishing disrepair or condition
Forecasting future repair needs;
Planning repair and renewal programmes
Assessing potential improvements
Stock valuation
Setting priorities;
Quantifying stock by type or by funding mechanism;
Establishing attributes – materials, space facilities etc.;
Producing an energy audit;
Provide evidence for loan or funding applications.

Marshall also concludes that given their wide potential, organisations undertaking condition surveys must have clarity in regard to their purpose and that clear objectives and appropriate data collection and storage are essential.

Research (Marshall, 1996, Chapman and Beck 1998) on condition surveys highlights a variety of problems with condition surveys.

- The lack of clarity of purpose and intentions for commissioning surveys. For example this frequently results in too much information being gathered which actually inhibits the development of workable maintenance programmes;
- Consultants producing inappropriately detailed and structured information. because they had no really understood the nature of the client's business;
- Problems with the compilation of data onto a database and its subsequent manipulation. In particular this resulted in the difficulties of linking information from the original condition survey with information on work subsequently undertaken, thus ensuring that the survey remains an accurate record of condition.

Condition Surveys for Historic Buildings –issues emerging from the current research

Emerging issues from our current research with five “heritage organisations “ include the following points:

The primary purpose of condition surveys for historic buildings should be about mitigating vulnerability and avoiding any unnecessary loss of fabric. Information from condition surveys can be used on an individual building/owner basis. However used collectively the information from individual condition surveys on historic buildings has the potential to provide broad and strategic monitoring of the effects of planning policy on the historic environment. As such it could satisfy the call for ‘regular monitoring of the state of the historic environment’ which was part of the ‘Power of Place’ (English Heritage, 2001) recommendations. The authors have experience of a scheme in the Lombardy region of Italy which is exploring such approaches. Here the regional authority use information collected from individual condition surveys of historic buildings to develop a ‘risk map’ of the vulnerability of the region’s built cultural heritage.

Within the organisations that took part in the project, Conservation Plans have not so far had the impact on the management of maintenance that we had anticipated. The evidence is that, currently, the planning of work tends to be driven by a maintenance management ethos rather than one lead from a significance and vulnerability perspective.

Clearly condition surveys are intended to produce condition information, which can then be used for planning and to provoke some ‘action’ i.e. an intervention in the buildings fabric. The important point for those managing the built cultural heritage is that the ‘action’ that may be most appropriate for minimal intervention, is the monitoring of condition and an identification of the need to carry out re-inspection, not necessarily intervention in the fabric. Consideration of significance and vulnerability, which is at the heart of conservation plan methodology, may emphasise the need for less physical intervention and more inspection and monitoring. This approach has been suggested for the social housing sector because it allows for the adoption of a ‘just-in-time’ approach – an approach which, we would suggest, could best fit with the conservation principle of minimum intervention.

We were interested to find out the reasons why particular frequency of inspection was used. The majority of the organisations undertook condition surveys on a 5 year basis. The Church’s Quinquennial survey is seen by some as a model for historic building inspections. This frequency seems to be assumed by the interviewees as being the most appropriate. None of the interviewees felt the need to justify the selection of this frequency; it had just ‘become the norm’. The vagueness about why 5-yearly cycle of inspection is appropriate for historic buildings is encapsulated in BS7913 ‘. twice in a decade rhythm is a *natural one* to adopt; it has precedent, and is recommended on that basis’. Of course this does raise the question of how accurately one can predict the rate of deterioration in order to implement ‘just-in-time’/minimum intervention in that fabric. A consultant interviewed for the project observed:

'..it's terribly difficult, I mean, you can look at a piece of decayed stone and say "that's terrible and very decayed and needs repair within 5 years" and you can go back and look at it in 5 years and see that it is in almost the same condition. It does not mean that the following day it is going to be in the same condition'

The conservation issue in regard to the frequency of inspection is that if the intention is to implement a maintenance regime which is focused on the principle of minimal intervention, this can only reasonably be supported by systematic and frequent inspections.

Condition surveys were intended by the organisations to be used for multiple purposes but, such purposes were not always reflected in the, albeit limited, briefing and tender documentation which we viewed. This reinforces the need to be absolutely clear about the purpose and required uses (and potential future uses) of the information to be collected. It requires those commissioning surveys to consider issues related to long-term information storage and flexibility of retrieval. There is also the need to consider how subsequently collected information on the condition can best be collected stored and utilised.

In a context where there is a lack of long term maintenance planning one of the major advantages of the procurement of a condition survey is lost. There is no point obtaining condition survey information if it can not be assimilated and moved forward into a prioritised maintenance programme. For some of the organisations the staff resource implication of translating condition survey information into a prioritised repair programme was an issue. It was clear that there is substantial work required in developing subsequent management processes and actions following the completion of the condition survey. For example, the data storage system should be one that is likely to be the same as, or at least compatible with, systems used on a daily basis for on-going maintenance management.

For any maintenance management organisation there is a distinct advantage to compiling records of building works undertaken on a property by property basis to assist future management understanding, analysis and planning. However for the built cultural heritage it is a particularly important task. This is because, as well as being useful for management, repairs and other physical intervention are part of the historical development of the building. The research suggests that the keeping of records was not given sufficient priority by the organisations involved.

All of the organisations categorised their maintenance processes in different ways. Though they used the same or similar terms, for example 'cyclical', 'medium term' 'major maintenance' the type of work categorised under these descriptions varied enormously between organisations. The time scale for all these descriptions also varied enormously. For example 'cyclical' maintenance in one of the organisations referred to repetitive works required within a 12-month period, for another this period was 60 months. This rather surprising proliferation of definitions warrants further study since some interviewees suggested that structural and cultural change within their organisation was partly driven by such terminological differences.

A primary driver for individual organisation's definitions seemed to be related to financial planning and budgetary arrangements. The importance that is attached to maintenance as an activity within the organisation can perhaps be judged by the relative certainty of budgets in the short and medium term. For one of those questioned maintenance budgets were fairly well established and had a degree of protection for the next five years. For another organisation the ring fencing only applied to maintenance for the next 12 months for annualised activities such as grass cutting, hinge oiling etc. Any other maintenance activity was bid for in competition with 'development proposals'. For another interviewee the maintenance budgeting is 'given priority over any development scheme'. However it was suggested in another organisation that there was no consideration for revenue funding for maintenance as part of the implementation of capital projects.

REFLECTIONS

Management organisations caring for heritage assets need to invest consciously in research to establish an understanding of the cultural significance of the assets and their fabric. This information can then be used to shape policy and maintenance management strategy. The development of conservation plans are clearly an area that should satisfy this requirement as long as the organisations effectively integrate them with the development of management plans including, of course, those dealing with maintenance. The potential danger for the fabric of the buildings in the division between and relative status of those concerned with the 'doing ' of intervention and those undertaking consideration of cultural significance

A key purpose of condition surveys should be related to the "minimal intervention" notion of identification for re-inspection as a first step before programming in works for repair and replacement.

"Take proper care of your monuments, and you will not need to restore them …….Count its stones as you would jewels of a crown; set watches about it as if at the gates of a besieged city……."

John Ruskin
From :The Lamp of Memory
Chp.6 of The Seven Lamps of Architecture

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FACILITY MANAGEMENT AS A SUPPORT TOOL FOR HERITAGE PROPERTY PRESERVATION

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Abstract
This paper follows on and expands upon a presentation made at the CIB W70 Symposium in Brisbane in 2000 indicating how facility management might be used as a support tool for historic preservation. A conceptual model was presented which amalgamated aspects of facility management with preservation needs. The objective was to show that facility management could provide services to support the curator and enhance the visitor experience thus improving the future viability of heritage property.

In the interim the model has been presented to preservation and facility management practitioners and academics to assess its workability. Through a series of Delphi style questionnaires the model has been reviewed in the United States and the United Kingdom. It has been further reviewed via a case study of one of the United States largest open air museums. At Colonial Williamsburg, Virginia a wide range of professionals responsible for the preservation and business management were interviewed. These included curators, conservators, interpreters and personnel involved in facilities maintenance and visitor management. (The Brisbane presentation recorded a case study at Sulgrave Manor in Northamptonshire, England.)

As a result of scrutiny, through the Delphi process and the case studies, the model has been revised. This paper introduces the revised model and reflects upon areas in which the facility manager might operate and whether facility management needs might be met by the curator, or a member of support staff if training could be made available.

Key words: Facility Management; preservation; heritage property.

Introduction

A paper presented at the W70 Brisbane 2000 Symposium outlined the development of a Facility Management (FM) Model to support preservation of historic buildings. It was developed from the FM concepts relating to the procedures for provision of support activities for the users of 'modern' premises who are undertaking business oriented activity. The model presented in Brisbane is shown in Figure 1. It indicated what were seen to be the essential basic elements of a good management model to serve the specialist group of properties involved. The paper and presentation noted that the elements were supported by a range of sub-elements and items which could be moulded to the specific needs of a property.

Interpretation was discussed as a special need for historic property and was included as a sub-element of Support Activity.

Explanation was given that the theoretical model was shortly to be refined and validated by a number of exercises to be carried out in both the US and the UK. The current paper briefly describes this process and outlines major outcomes.

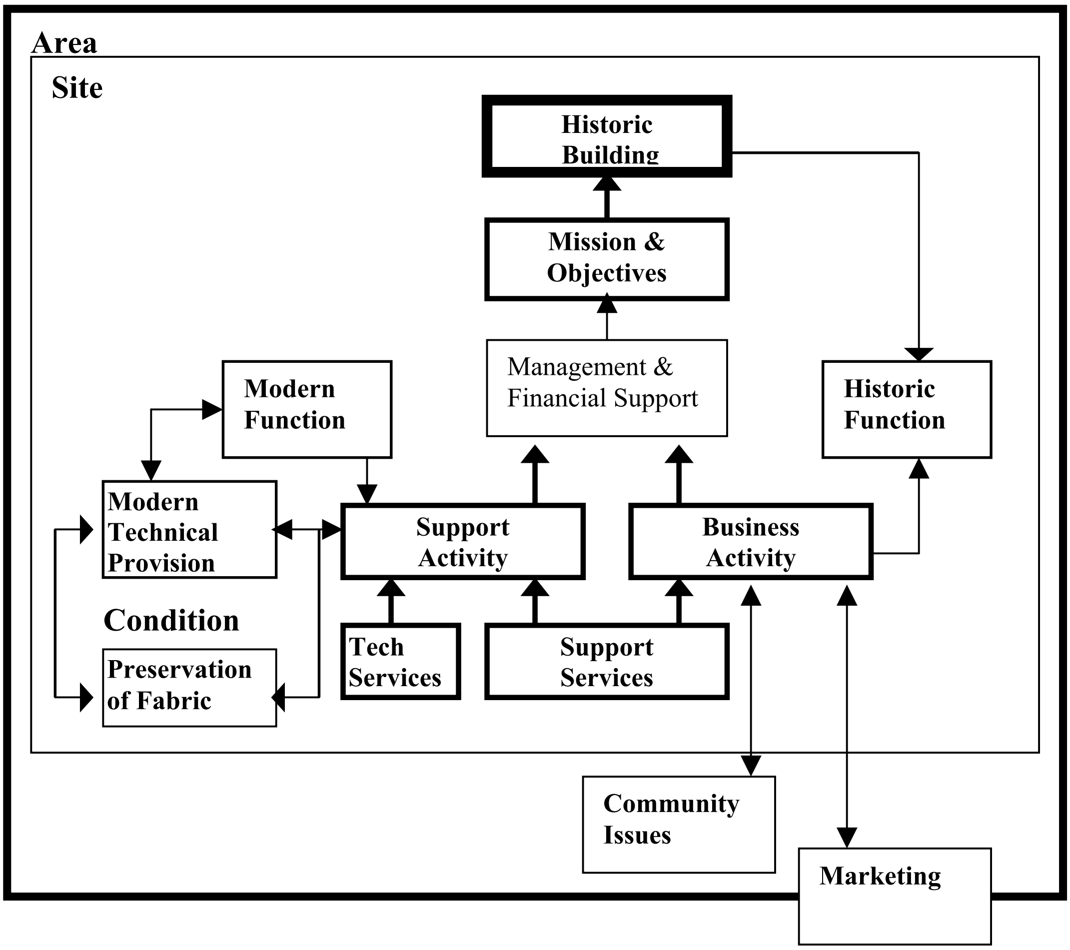

Figure 1: A FM Model presented in Brisbane.

Methodology

The model in Figure 1 was reviewed against two major non-government organizations---ICOMOS and the English Heritage Lottery Fund (EHLF). An in-depth case study was carried out at a site in the UK to allow the writer to personally review the model against a successfully run historic building. A Delphi Group was established with members in the US and the UK to gain expert advice from preservationists and facility managers. A second in-depth case study, at a site in the US, considered specific activities where FM skills might need improved knowledge/appreciation in order to be supportive of the Curator of an historic property. (These were initially seen to be Interpretation, Visitor Management, and Marketing.) The results were subsequently integrated to provide the Final FM Model. (See Figure 6.)

ICOMOS & English Lottery Fund

Review of ICOMOS Charters resulted in reinforcement of the view that Visitor Management and Interpretation were areas of importance in the upkeep of historic property. The Lottery Fund refers to developing 'new audiences' for heritage and the improvement of the 'quality and effectiveness of educational provision based on the heritage, including interpretation, services, or programmes of activity' [i]. Information and Communication Technology (ICT) to improve public access to, and understanding of, the heritage, and to promote its preservation is also promoted [ii]. ICT is considered by the writer of this paper as part of Interpretation.

The FM Model was revised to include Visitor Management as shown in Figure 2. Since, however, Interpretation was already included as a sub-element (and is not conventionally seen as an area for FM input) the decision was made not to upgrade it to an element without review by the Delphi Group.

UK Case Study: Sulgrave Manor

The objective of this case study was to test the FM Model against an organization reflecting good FM procedures. This case study also gave the opportunity to make a personal review of the conceptual model and the appropriateness of the elements and sub-elements before submitting it to ‘public’ scrutiny by preservation and FM professionals through the Delphi process.

Sulgrave Manor, Northamptonshire is the ancestral home of the Washington family. It is an historic building where management is deemed to have improved in recent years. By initiation of educational services to assist local schools with the teaching of history, and by improved marketing, the resident curator tripled the number of visitors to around 24,000 over the period 1988-1994. A visitor centre, completed in 1999 and predominantly funded by the EHLF, was observed to lead to improvements in both space utilization, support services, and visitor experience. Space management and support services were seen as areas where the Facility Manager is able to contribute.

The review was based upon a reconfiguration of the FM Model into a tabulated format. Review of records, together with observation, and interview with the Resident Curator were approaches used to check whether the elements of the FM Model might exist in a well managed historic property. The observations at Sulgrave Manor confirmed the contents of the conceptual model

FM Survey Instrument

The tabulated format of the FM Model was subsequently developed into a tactical/strategic management tool (the FM Survey Instrument) by employing the Elements/Sub-elements as Key Performance Indicators and applying Management-by-Variance principles, developed by Hinks and McNay [iii], to establish a grading system. The sense of a) ‘awareness’ or understanding of the elements that exist in an organization, and b) the extent to which the element has been developed and therefore has ‘availability’ to support it, are aspects that are measured in order to assess management strengths and weaknesses. Figure 3 outlines the format.

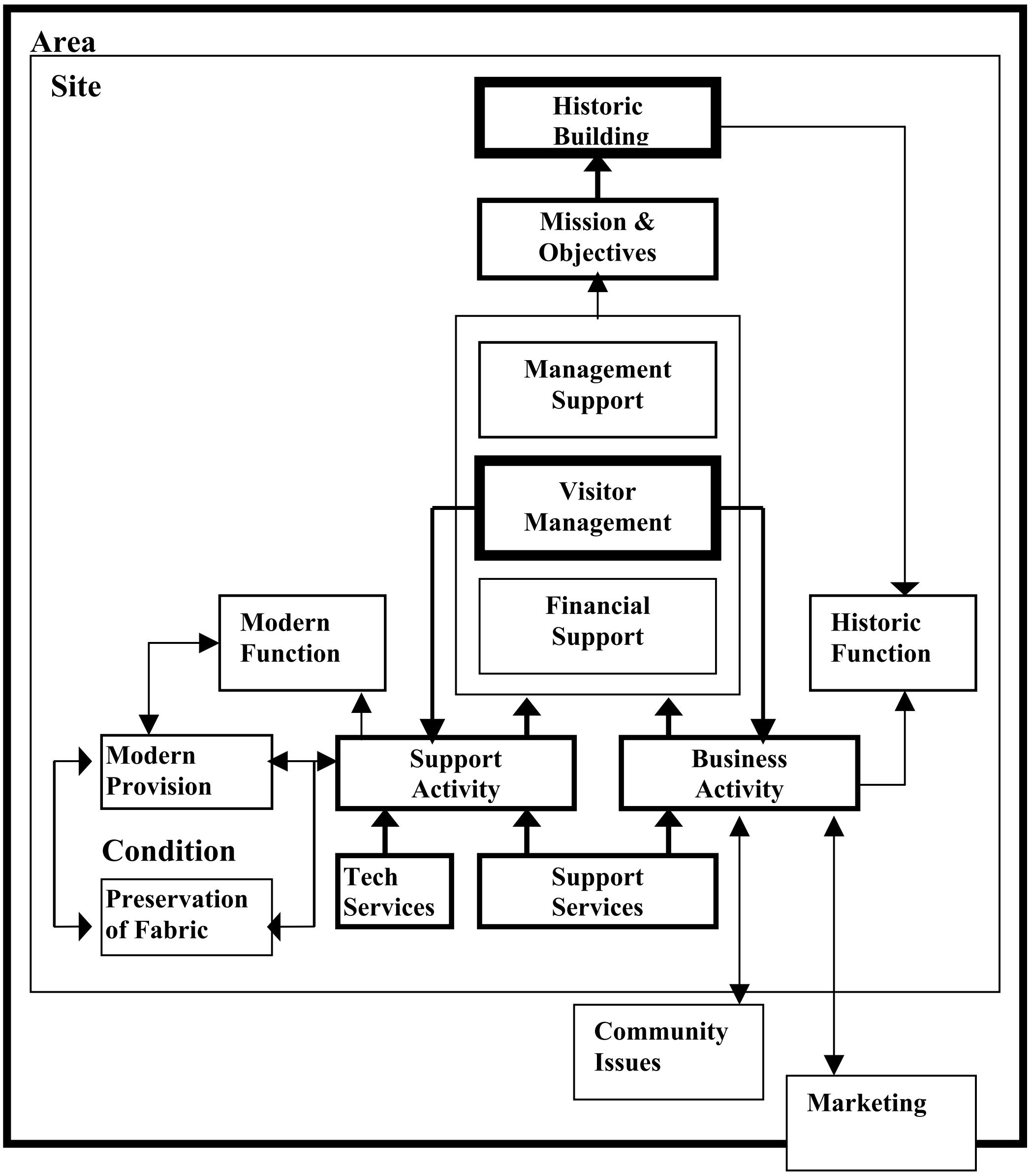

Figure 2: FM Model Reflecting Visitor Management

Delphi Group

The Delphi technique is a form of focus group wherein communication is undertaken with experts in the sphere of research but from a distance. The Delphi process attempts to 'identify consensus and agreeable solutions' and is 'used primarily with people who are experts' [iv]. Practitioners and academics in the fields of Preservation and FM fitted the mould for this research.

	ELEMENT/ SUB-ELEMENT	Awareness Availability
1	HISTORIC BUILDING	
2	Mission & Objectives	
3	Function	
3a	Historic	
3b	Modern	
4	Business Activity	
4a	Building(s)	
4b	Site	
4c	Area	
5	Support Activity	
5a	Support Services	
5a.1	Income orientated	
5a.2	Non-income orientated	
5b	Technical Services	
6	Condition	
6a	Modern Provision	
6b	Preservation of Historic Fabric	
7	Visitor Management	
8	Community Issues	
9	Marketing	
10	Management Support	
10a	Management structure	
10b	Financial	

Figure 3: FM Survey Instrument

A 3 phased Delphi process was employed to assist the research in two ways.

1) To provide expert comment upon the FM Model to assist in its refinement. This included deliberation upon whether or not to upgrade Interpretation to an Element. Support was given.
2) To make recommendations upon the choice of subject for the in-depth research planned for the second in-depth Case Study. The Group were asked to choose 1) Interpretation, 2) Visitor Management, or 3) Marketing by voting. The result was that 1) & 2) ranked closely together in popularity while marketing was considered less in need of research. (In the event 1) & 2) were investigated jointly as will be explained later.)

US Case Study: Colonial Williamsburg

The objective of this case study was to gain greater understanding of two elements, Interpretation and Visitor Management, against the mission, objectives, and organizational structure of Colonial Williamsburg Open Air Museum, Virginia where the core business is education. It also gave the opportunity to present the FM Model to a group of practitioners responsible for a leading heritage site.

For the period 1699 to 1780 Williamsburg was the capital of Virginia. George Washington was a burgess and attended the Capitol. Thomas Jefferson studied law in Williamsburg. Peyton Randolph, whose house still exists was Speaker of the House of Burgesses and President of the First and Second Continental Congresses in Philadelphia. Williamsburg in the 18C was a city of political and economic importance [v]. In 1780 state government relocated to Richmond fearing naval attack. From this time the city ceased to develop, as say Boston, but retained many of its earlier structures making it possible for John Rockefeller to sponsor restoration. Commencing 1926, the archaeological and architectural research that led to restoration became a model for work of a similar nature in many parts of the world.

The historic area consists of about 600 buildings. Many of these are original buildings. The mission of the Foundation is 'To create, restore, recreate, and interpret 18C Williamsburg to teach the history of early America' [vi]. The museum has, for many years received about 1 million visitors per year and needs an income from a group of this magnitude to continue its work of research, preservation and education. (In 1934 there were 31,000 paying visitors. In 1999 there were 960,000 visitors and the budget US$ 192 M. Employee numbers rose from 250 to 3,600 [vii].)

The Colonial Williamsburg Foundation is sophisticated and well integrated. It is, however, possible to isolate activities which support the parallel activities of Interpretation and Visitor Management.

The Foundation is structured in 11 Divisions. Of these, 2 Divisions relate to the activity of Interpretation (Research and Collections) and 1 Division to Presentation (Historic Area Presentations). In 2001 a new division, Production, Publication, and Learning Ventures, was established to develop a website to support management and work closely with interpretive groups to present Colonial Williamsburg electronically. This includes development of virtual access for some historic buildings in the event that wear and tear becomes too great. The other divisions providing support activities are those normally found in a modern organization. For instance the Operations Division is responsible for engineering services, facilities maintenance, landscape and custodial services. The Hospitality Division manages Colonial Williamsburg's holiday accommodation, food, and beverages. Visitor Management is more widely dispersed but notably falling under 1) the Hospitality Division, and 2) Historic Area Presentations Division.

Based upon interaction with the Delphi Group the approach to the investigation was to establish how Interpretation and Visitor Management was undertaken at Williamsburg.

In the case of Interpretation it was to review whether it was in fact a two part process. 1) Interpretation by Curators (which is an interpretive analysis or intellectual exercise) and then 2) Presentation (or practical exercise) either by them in traditional form (displays with some form of signage) or through Costumed 'Interpreters'. The target was to establish where FM might become involved, for instance in providing lighting, signage, cabinets etc on the one hand or changing and rest room accommodation for the 'Interpreters' on the other.

In the case of Visitor Management the guidelines of the English Tourist Board were one consideration. The UK Government Planning Policy Guide (PPG) 21 Conservation and Tourism advocates reference to its publication Tourism and the Environment: Maintaining the Balance. [viii]. The report amongst other things promotes, careful review to avoid 1) overcrowding, 2) traffic congestion, 3) wear and tear, 4) inappropriate development, and 5) conflicts with the local community.

Integration of Interpretation and Visitor Management

The case study took place in the summer of 2001. Meetings were arranged with practitioners carrying out interpretation and visitor management and a range of staff involved in FM as now structured in Williamsburg. The Manager, Museum Professional Services facilitated this but commented that 'in some cases, your studies of interpretation and visitor management will overlap because we really consider them together'.

Investigation into the restoration and re-interpretation of the Peyton Randolph House (completed in 2001) indicated that while Williamsburg does not recognize a separation of activities into Interpretation (the intellectual exercise) and Presentation (the practical exercise) it is a fact that during their formal/structured preparation to receive visitors both are carefully investigated. For instance the historic significance of the new kitchen wing is translated by curators/historians into a theme for visitors. This is then transposed or interpreted into the practical act of devising a tour by a project team that includes costumed guides. In parallel, Visitor Management is involved when the 'mechanics' or logistics of movement of visitors is examined. The layout of the house dictates the traffic flow and order of presentation to visitors. Interpretation and presentation are influenced by traffic management which is a Visitor Management activity.

The restoration includes provision of essential technical services such as smoke detectors, heat detectors, minimal electrical services, and a discreetly placed wheel chair lift. Air conditioning is provided in some areas to protect artefacts from the high humidity of Virginia's summer. These are all technical services which might normally be provided by a facility manager in modern premises but sensitivity of placement, in order not to damage historic fabric or negate the Visitor Experience, require an appreciation of Interpretation and care in presenting (or hiding/screening) them. The wheel chair lift is placed in a lean-to structure at the back of the kitchen and is generally unnoticed.

The approach taken by Colonial Williamsburg to both Interpretation and Visitor Management indicates that all activities are strongly influenced by the quest for a good Visitor Experience. This is an Objective of the organization which strongly influences any design activity.

Having ascertained how Colonial Williamsburg prepared for visitors it was possible to establish that FM techniques play a supportive role. The Curator and other experts play a central part in Interpretation, and the FM has opportunities in both Presentation and Visitor Management. The interactions can be depicted as shown in Figure 4.

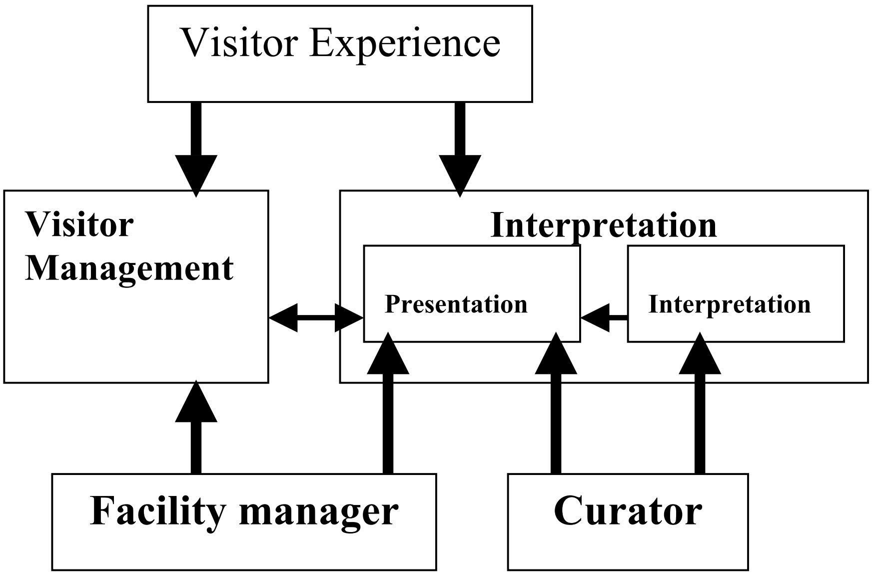

Figure 4: The Contribution of the Facility Manager and the Curator to the Visitor Experience.

While Interpretation, and Visitor Management afford an opportunity for the application of FM techniques the model offered in Figure 4 is not entirely satisfactory. The fact that Interpretation comprises the activities of Interpretation and Presentation is somewhat confusing.

The outcome of the deliberations of the Delphi Group (via the Questionnaires) on the depiction of Interpretation led to the adoption of the approach that these activities might be more usefully described as a) the Analytical/Intellectual Exercise undertaken by the Curator and b) the Practical Exercize of Presentation undertaken by costumed guides (or by facility managers in providing physical support through display cabinets etc.) Consequently the work of the Curator assumes the title of

Historic Analysis. This was subsequently developed as shown in Figure 5 where an elemental 'system' linking Visitor Management and Interpretation is devised for inclusion in the Final FM Model.

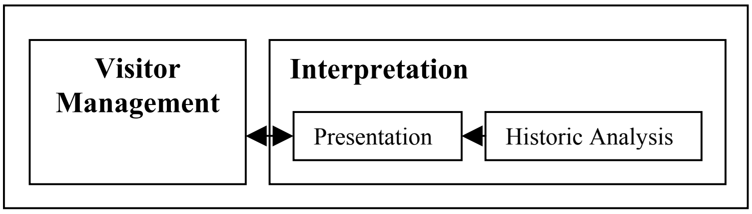

Figure 5: The Visitor Management/Interpretation System.

The Final FM Model

Space limits discussion of all aspects of the evolution of the Final FM Model but it is appropriate to discuss the change of the nomenclature of the focus of the research from Historic Building to Historic Structure. Delphi Group members, keen to widen the scope of application of the FM Model suggested a number of alternatives. These included Historic Site and Historic Resource. The intention was to permit coverage of not only individual buildings and their surroundings but also landscapes, archaeological features, and even historic battlefields where no structures might exist. The term Historic Site was not appropriate since 'site' already represents the grounds of a property in the FM Model. Historic Resource (the term used by the US Secretary for the Interior for historic buildings, related grounds etc.) had similar limitations. Historic Structure appears to offer the greatest flexibility and gives opportunity to cover most sites within the overall elemental framework of the model.

The Final FM Model incorporates the Elemental System of Visitor Management/Interpretation. Interpretation comprises Historic Analysis and Presentation. Other minor revisions are a) Management Support and Financial Support become an Elemental System and b) Condition, which is the Modern Provision and Preservation of (Historic) Fabric also receives this treatment for clarity. (One Delphi Group member expressed concern that Preservation of the Fabric, 'being in the bottom left hand corner of the model and therefore most distant from the historic structure appeared to be of low priority'. Within the systems view offered by the FM Model this was not the case, nevertheless a way of showing the value of the Historic Fabric was sought and the Condition System was instigated.

These changes are shown in Figure 6.

Who Provides Facility Management Services?

While Figure 4 above depicts the Curator and the Facility Manager, this is for convenience of explaining how duties of an FM nature might be attributed.

The objective of the research was to provide a model to show how FM could support historic buildings. It was recognized at an early stage that the actual allocation of duties to individuals might prove difficult and the final section of this paper will discuss what came to light on this subject.

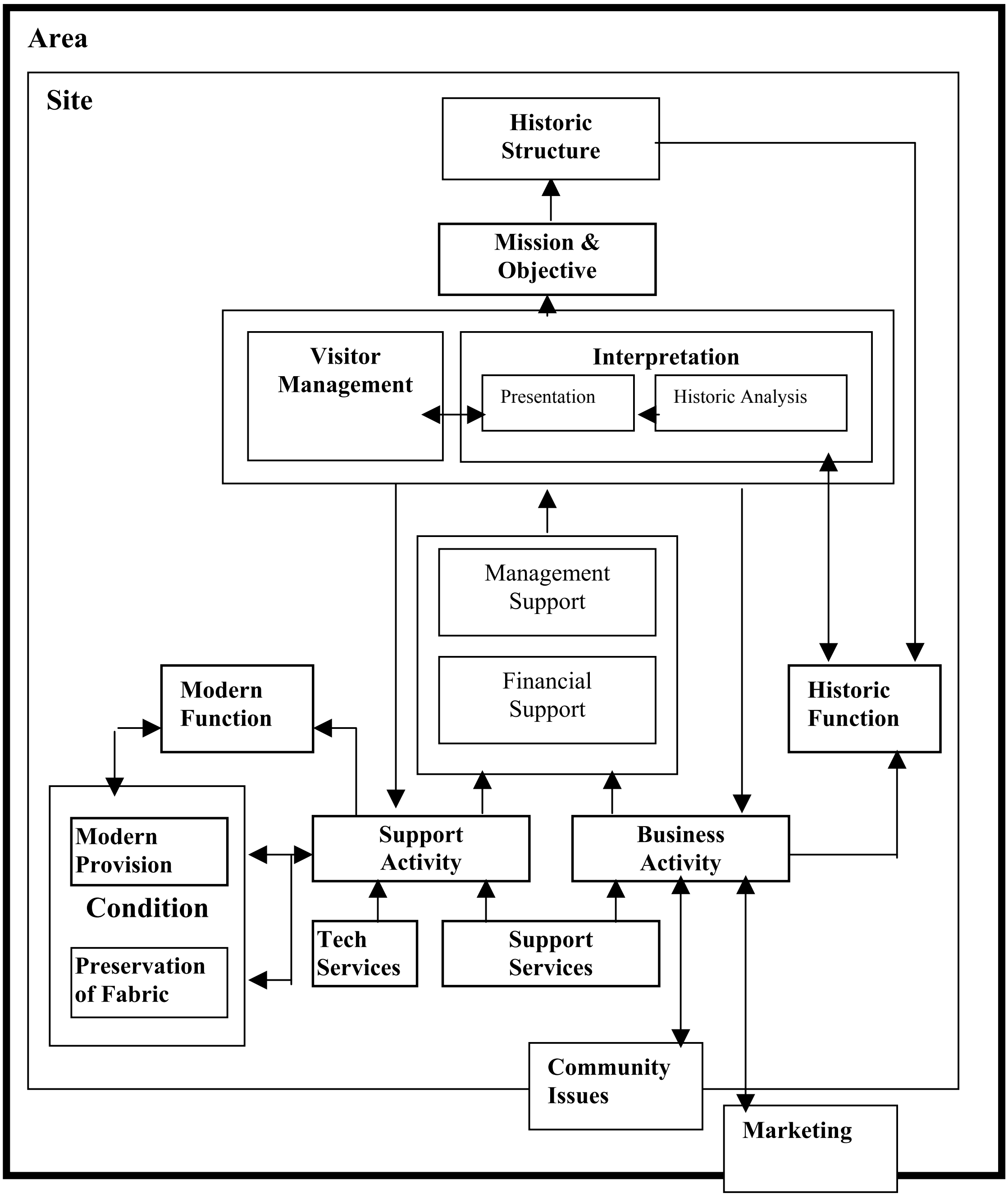

Figure 6: The Final Model

The question of affordability of a dedicated Facility Manager was discussed at Williamsburg. It was suggested by a Curator that only the largest historical institutions would be able to afford to employ one.

This problem of affordability was referred to the Delphi Group. They were asked to comment on alternatives to a dedicated Facility Manager based on discussions in Williamsburg. It was suggested to them that the Curator should be trained in FM while still at college. Alternatively existing Curators should undertake Continuing Professional Development (CPD) to obtain necessary skills. The upgrading of the knowledge of technical staff or the employment of a consultancy service offering part-time FM support for historic property might be considered. Finally the training of volunteers was proffered as a solution.

80% of the members supported the inclusion of FM in the academic studies of curators while 20% disagreed. 80% supported the introduction of FM in the form of CPD for Curators (7% disagreed). The upgrade of knowledge for technical support staff (such as maintenance personnel) received the same 80% support. The employment of a part-time Facility Manager gained 60% but commentary showed that some members had less than positive experience with such arrangements. The training of volunteers gained only 33% support while 60% disagreed with this direction.

Bearing in mind the suggested problem of funding for a Facility Manager, it is an anomaly that the two most obvious candidates to take on the FM duties (especially in small organizations) are the Curator and the Volunteer and yet they are not fully supported.

Conclusions & Recommendations

The objective of the research was to construct a facility management tool to assist in the preservation of historic property. This has developed, for the first time, an FM Model applicable to historic properties. It is consistent with the philosophy and practices of preservation of historic property. It has been validated by case studies and through Delphi process in consultation with practitioners and academics in preservation and FM. It can be used for tactical and strategic management and is applicable to a wide range of buildings, and sites. The research and validation has been undertaken in the UK and the US and, having a flexible systems structure, supported by a matrix of sub-elements and items specific to individual needs of an organization, the FM Model is applicable in both countries.

In considering who could undertake FM duties in the event that funds would not support employment of a Facility Manager the Delphi Group accepted the use of the Curator with reservations but rejected Volunteer staff. Bearing in mind that the Curator and the Volunteers, are the most likely candidates for the work, a further in-depth study is warranted. This is, perhaps, synonymous with investigations currently in train by the Heritage Lottery Fund in respect of Conservation Craft Skills.ix

Acknowledgements

The writer of this paper wishes to acknowledge the support given by members of Sulgrave Manor, Colonial Williamsburg, and the Delphi Group. Without out their willingness to give of their time and expertise the research described in this paper would not have been possible.

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Managing Health & Safety in Refurbishment Projects involving Demolition and Structural Instability

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Abstract
There is consensus among practitioners and academics that refurbishment projects are among the most complex, risky, dangerous and uncertain to manage. This situation is heightened where the works involve elements of demolition activities and where tenants are in occupation. As a percentage of total construction output, refurbishment works in its many disguises have increased substantially in the last 30 years. In many developed economies, it now accounts for over 50% of output. However, the growth in refurbishment works has not been paralleled by empirical research, especially in the management of health and safety. This paper attempts to improve our understanding and knowledge of health & safety in this very important area of construction work. The paper is based on an on-going study funded by the UK Health & Safety Executive (HSE). It investigates, inter-alia, the main risk factors and implications associated with the relatively high level of hazard and poor health & safety incident in refurbishment works involving demolition activities and structural instability. It also considers the health & safety management strategies in current usage, with the view of documenting best practices for the benefit of the industry. The study involves a comparative assessment of the situation in the UK with that of Italy, where there are many historic buildings with refurbishment works involving partial demolition. It employs a combination of research methods, including semi-structured interviews, review of archive documents and site visits to selected refurbishment sites in the UK and Italy. In this paper, it is shown that a variety of factors, which combine in complex ways, are associated with the high level of health and safety incidents in refurbishment. These factors include demolition design, planning & execution. Other factors are knowledge of site and structure, workforce supervision, selection and use of appropriate plant & equipment, selection of subcontractors, communication, and requisite safety information and training. It is also highlighted that existing health and safety management strategies for refurbishment in construction organisations range from many that are alarmingly poor to few enviable practices. It is therefore recommended that there is an urgent need to improve health & safety management practices for refurbishment, with targeted education and training and effective dissemination of best practices seen as vital in this regard. It is also suggested that there is ample scope for further empirical research in this very important area of construction activity.

Keywords: Demolition, Health & Safety, Refurbishment, Structural instability

Introduction

In the last 30 years there has been a significant increase in refurbishment works both in the UK and in the Italian construction industries. A variety of factors has given impetus to this, such as the increase in redundant and ageing buildings; shortage of available areas for new construction developments; social and technological factors making old buildings inadequate and obsolete; development of building standards and regulations - increasing the need for construction refurbishment to comply with new requirements. Italy also has a huge historical and architectural heritage, which is in need of continual refurbishment and restoration.

The refurbishment sector, in its many forms, accounts for more than 40% of the total UK construction output. Although in the UK, no official statistics on the actual value of refurbishment output exist, this sector has increased in the past 30 years from around 22% to 43% of total construction output. In Italy more detailed statistics are available. Existing data shows the increase in refurbishment work in the past 10 years. According to the statistics provided by CRESME (Research Centre on the Construction market) and ISTAT (Italian Statistics Central Institute) in 1995 refurbishment accounted for the 57.5% of total construction output, this percentage being composed of 30% of ordinary maintenance works. In Italy, in 1999, the refurbishment sector registered a 3% increase and the latest data available shows an 11% increase in the year 2000. The total volume of refurbishment output is composed of 60% private housing works and 40% public works.

The increase in refurbishment activity in the last three decades is, however, not paralleled by comparable empirical research, especially in the management of health & safety.

Although neither the UK nor Italy differentiates between new construction and refurbishment accident data, statistics suggest that refurbishment, in its different interpretations, accounts for a substantial amount of injuries and fatal accidents [HSE, 1988; CIRIA, 1994]. There appears to be little or no empirical and generally agreed data currently available. There, however, exist some anecdotal evidence. The Italian Accident Statistics Body (INAIL) is currently developing a new data collection system in order to separate accidents that occur on new construction sites from those that occur during refurbishment works. This can only be possible through the link between the accident reported to local authorities, Building Regulations and the planning permission of the site where the accident happened. This authorisation has, in fact, to show the nature of the construction site and the type of work performed (new construction or refurbishment).

In the context of the present study, in which demolition activities and structural instability are being investigated, refurbishment works are seen to involve particular and quite complex works (e.g. site and off-site based works involving specific design works) related to existing buildings. Therefore refurbishment works will involve improvement, adaptation, upgrading, rehabilitation, renovation, restoration and any extraordinary or unplanned maintenance. In this definition, however, ordinary maintenance (e.g. cleaning, painting and decorating), carried out on a regular basis, is not included.

Aims and objectives of the paper

This paper is based on an on-going one-year scoping study which, *inter-alia*, sets out to:

- Determine the main risk factors and implications associated with the relatively high level of hazard and health & safety incidence on refurbishment involving demolition works and structural instability;
- Investigate the health & safety management strategies in current usage, for refurbishment work involving demolition activities and elements of structural instability;
- Undertake comparative studies of the situation in the UK with that of Italy;
- Produce checklists of issues to consider in managing Health & Safety incidence on refurbishment projects involving demolition work, and also to identify areas where guidance should be provided;
- Make recommendations for further research in this area and on appropriate education and training provisions relevant to the key stakeholders associated with refurbishment activities involving demolition work.

In this paper, however, only some of our tentative findings will be discussed. These are mainly to do with the main risk factors and implications associated with the relatively high level of hazard and health & safety incidence on refurbishment involving demolition works and structural instability. The paper will also give cognisance to issues of prevention and control of health and safety incidence on refurbishment projects.

Methodology

Given the relatively meagre amount of studies that have given attention to this area of study, and the apparent lack of robust and authoritative statistical data, it was important that a combination of research strategies was employed to obtain the needed data set for exploration. These strategies included:

- Industry survey followed by case studies of selected large and small refurbishment projects in the UK involving demolition activities. This involved a root cause analysis to identify the key factors associated with the relatively high level of hazard and health & safety incidence on refurbishment involving demolition works and structural instability;
- Selected semi-structured interviews with general contractors undertaking such works, specialist demolition contractors, health and safety officers from contracting organisations, and representatives from the Health & Safety Executive (HSE);
- Review of archive documentation (reports, case studies) at national and regional levels from HSE;
- Study visits to Italy to undertake appropriate case studies of refurbishment projects involving demolition work;
- Preliminary risk assessment based on key factors identified at the design stage while developing safety plans.

Refurbishment and demolition

Demolition activities are often related to projects where structural alterations of the existing building are required. These alterations could be very different depending on the size of refurbishment works. They could include:
- total façade alterations;
- total removal of structural elements (columns, beams, slabs, walls);
- partial demolition of the building shell to build extensions;
- construction or enlargement of new openings.

Demolition and de-construction activities are gaining currency in this context, and beginning to be seen as very important activities in their own right. The issues of sustainability, material usage and waste management have brought these activities to the fore, together with unplanned collapses. Demolition works are among the most dangerous operations to be performed on site due to the high level of risk in which the workers are exposed. This paper particularly focuses on partial demolition, which involves carrying out works only on portions of the structure and maintaining structural stability for all the remaining parts during and after execution. Such structural stability can be provided with different methods (e.g. adequate structural analysis, temporary support structures, proper demolition method, schedule and equipment).

Partial demolition also involves other health and safety risks related to site organisation, which has to be properly assessed while planning refurbishment works. Whilst total demolition can be mainly carried out by mechanical equipment, partial demolition works require a larger number of workers employed on site especially for demolition by hand activities. A structural survey studying the interaction between structural elements to be removed and those remaining has to be carefully developed to avoid premature or unplanned collapse.

Unfortunately more accidents and fatalities tend to occur during partial demolition than during total demolition works, especially while carrying out small demolition activities. The appointment of non-specialist contractors and the lack of co-ordination and supervision of all the other activities conducted at the same time are two important culprits.

Given the fact that many accidents, during demolition works are mainly caused by partial or total collapses, this study sought to identify the key contributing factors to structural collapses. It also considered how this might be better addressed.

Some of the tentative findings from the on-going study are presented below.

Key factors associated with the relatively high level of health and safety incidence in refurbishment

Refurbishment projects are likely to be more difficult to manage than new construction works (Egbu, 1994; Marino, 2001). One of the main reasons for this is relatively high level of uncertainty associated with the works. This manifests itself in many ways, including leading to the large number of updates and adjustments (work methods, schedules, facilities, etc) needed due to the discoveries made while carrying on site works. This can be frequently put down to inappropriate surveys developed at the design phase. Nevertheless, site experience shows that full project information about the building being refurbished, such as structural material conditions can be available only during work execution. This lack of project and planning information influences the whole site organisation with a risk of an under-estimation of important factors such as:

- Site desk study and investigation;
- Contractors and subcontractors pre-qualification and selection;
- Supervision of refurbishment works.

With the increasing number of refurbishment projects being undertaken in the UK and in Italy, these factors, if not properly addressed and checked, could impact on the regular progress of refurbishment projects. This impact on refurbishment works could affect different aspects of the development of the project; most often those related to health and safety issues. The lack of detailed work scheduling, poor site organisation and co-ordination, or inadequate supervision of activities is amongst the main causes of accidents. At the same time the works may not be completed in compliance with project specifications.

The effect of an unplanned collapse impacts on workers' safety as well as the building being refurbished. Greater priority must be given to preventing accidents on site. The effects of an accident can impact upon the client, the contractor and their construction businesses in the following ways:

- Productivity and efficiency of the workforce can be affected as a result of injuries and people leaving work on sick leave;
- Project profitability could decrease due to delays in completing the job or due to structural damages caused by unplanned collapses. At the same time damage caused to adjacent properties need to be compensated by the client or the contractor depending on their responsibility for the damage;
- The impact that refurbishment works involving demolition activities may have on the environment should be assessed as well. Waste treatment, re-use and recycle of debris, hazardous materials disposal should be planned as carefully as demolition sequence. The impact on the environment, when such factors are not properly addressed could be so negative that it may affect the overall benefits achieved from a refurbishment project.

Our study so far suggests that there is a huge variation in health & safety management practices associated with refurbishment work. These range from many that are alarmingly poor to few enviable practices. The tentative finding from our industry survey suggests that the effectiveness and robustness of Health & safety strategies is related to the size of the consultancy/contractor involved. In larger firms it is possible to identify professionals who are specifically appointed to develop safety issues while carrying on their tasks (design activity, work scheduling, site planning etc.). At the same time project documents result to be integrated with construction instruction (e.g. demolition sequence) and safety procedures. In addition, there is some evidence that those consultants and contractors who do not normally bid for cheap tenders are selected for their best value and their Health & safety strategies can be assumed as an example of good practice.

Health & safety has a great influence in the design and the management of refurbishment projects, especially those involving demolition activities. It can be stated that health & safety is one of the most influential factors in selecting demolition methods to avoid structural instability and prevent structural collapses. Structural collapses have to be identified as events with predictable and unpredictable causes. Unpredictable causes are generally related to natural and catastrophic events such as earthquakes, avalanches and floods. Predictable causes, on the other hand, can be determined, controlled, reduced or removed.

Causes of collapse associated with demolition activities can be identified through the different phases of the building process (i.e. design, construction, use and refurbishment). The building process for a new construction project is quite similar in its scheme to a refurbishment project where a design and an execution phase can be clearly identified. At the same time, the approach to demolition works should be the same as the whole project, with a design phase that needs to be developed and an execution phase that needs to be planned. The demolition phase should therefore be considered as a sub-project where design, planning and execution phases must be carefully studied and assessed. When developing a study of these phases it is possible to determine the main causes of structural instability and therefore able to provide, in such phases, different methods and tools to prevent collapses.

Demolition design

Prior to carrying out any refurbishment works involving structural alterations a detailed and complete structural survey needs to be prepared. To develop this survey the following information needs to be available:

- Original structural design documents (e.g. drawings, structural calculations);
- Report of all structural alterations carried out on the construction in the past;
- Material samples taken form the construction site to test real structural conditions;

Upgrade of buildings and change of use may increase the loads on the ground where the structure is based. This can lead to subsidence of the foundations thereby compromising the stability of the whole building. An appropriate geotechnical survey is therefore required to identify whether geotechnical processes are needed or not (underpinning, pile foundations). The purpose of this survey is to determine the condition of the framing, floors and walls as well as weak structural elements so that measures can be taken to prevent the premature collapse of any portion of the structure. The interruption of a load path, the effect of gravity and the inability of the remaining structure to support any force redistribution may cause structural instability and therefore lead to an unplanned collapse. Any adjacent structure(s) or improvements should be similarly checked. The survey should indicate if the structure to be demolished has been damaged by fire, flood, explosion or some other causes. This can normally be determined after removing pavements and finishings from the structure.

When all the information about the structure is available, demolition techniques can be assessed and schedules developed accordingly. The sequence of demolition phases will be determined in order to maintain the structural stability of all remaining parts at all times. Key structural elements of the remaining parts do not have to be demolished or damaged by demolition activities. If the layout of the refurbishment project requires the demolition of any key structural elements (e.g. before reconstruction of a new part of the structure), temporary support systems should be investigated, designed and used.

When designing demolition activities it has to be recognised that collapses may be caused by activities induced during the execution of demolition works and not only by the removal of key structural elements. Therefore appropriate plant and equipment have to be selected to avoid excessive loads on the remaining parts of the construction (e.g. air compressor for pneumatic hammer on weak floors or mini-excavator on a weak structure).

Demolition planning

As already mentioned unplanned collapses are not only determined by an unsafe sequence of demolition activities. Other factors may contribute to structural collapses in a refurbishment work, many of them being related to site organisation. The British Standard code of practice for demolition (BS 6187:2000) in clause 7 gives clear advice about the importance of the “knowledge of the site”. This information can be obtained either form a desk study or from a site survey. A desk study will provide some information about site conditions that may effect structural integrity during demolition activities such as:

- ground conditions (e.g. water table, ground type, sink holes);
- location and type of services, above and below ground;
- traffic condition and site access;
- extent of buried features or above ground structures.

The investigation on site should extend the knowledge gained during the desk study and provide a more accurate understanding of the existing conditions of the construction compared to what is identified in drawings and documents. Such survey will point out any differences and alterations that may have taken place and if these changes have been reported within the building files. Site investigation plays an important role in the development of a structural design survey, as well as in the planning of all demolition activities.

After the selection of methods and plant for demolition, a work schedule has to be developed taking into account site-specific conditions. The noise level should be assessed as well. Noise assessment should take into consideration if people are occupying the facility being refurbished or any adjacent buildings. Noise levels should be checked for the health of site workers too. Such assessments may give cause for the work schedule to be modified in order to avoid the concentration of demolition activities or to avoid their execution during certain hours of the day. This can cause an extension in the duration of refurbishment activities and therefore must be taken into account while managing the whole project.

Demolition execution

Provided all the structural and site surveys have been properly developed, the demolition methods have to be correctly implemented. To control demolition, method execution supervision needs to be provided and managed. Prior to setting up a supervision activity through inspectors and safety professionals, the client must select contractors and subcontractors for demolition activities. The client should limit the number of subcontractors working on site to allow for easier control over subcontractors employed on site at any time. At the same time the client should be able to pre-qualify and therefore select contractors and subcontractors on their competencies and experience in demolition works.

On the other hand, contractors have to respect demolition methods assessment and the site-specific demolition health and safety plan procedures. A continual workforce control activity must be carried out by contractors' demolition supervisor to avoid workers deliberately executing unplanned activities. Workers should be informed of the risk arising from non-compliance with safety instructions. This may be carried out through training courses and toolbox.

The analysis of the case studies, the industry survey and the interviews conducted point to the need for contractors to employ specifically trained site supervisor for activities involving higher levels of risk. One of the most important roles is the “temporary works co-ordinator”, who is in charge of the supervision of the execution of temporary works on site (e.g. façade retention structures, scaffolding). One of his duties is to verify the compliance of the construction with temporary works design as well as safety procedures, he has also to check the structural stability of temporary and permanent structures during the refurbishment and demolition works.

Language barriers can be a serious problem especially in the construction industry where almost all the instructions, as well as emergency advice, are given verbally. Language problem also extends to the fact that refurbishment works seem to attract many nationals who move in and out of refurbishment and jobbing works because of its relatively short duration. This exacerbates the language challenges. Such barriers can be partially overcome through the use of illustrated safety instruction and signals.

After the analysis of demolition phases, from design to execution stage, the key factors reported in the flow chart in Figure 1 should be assessed and implemented prior to carrying out any demolition work.

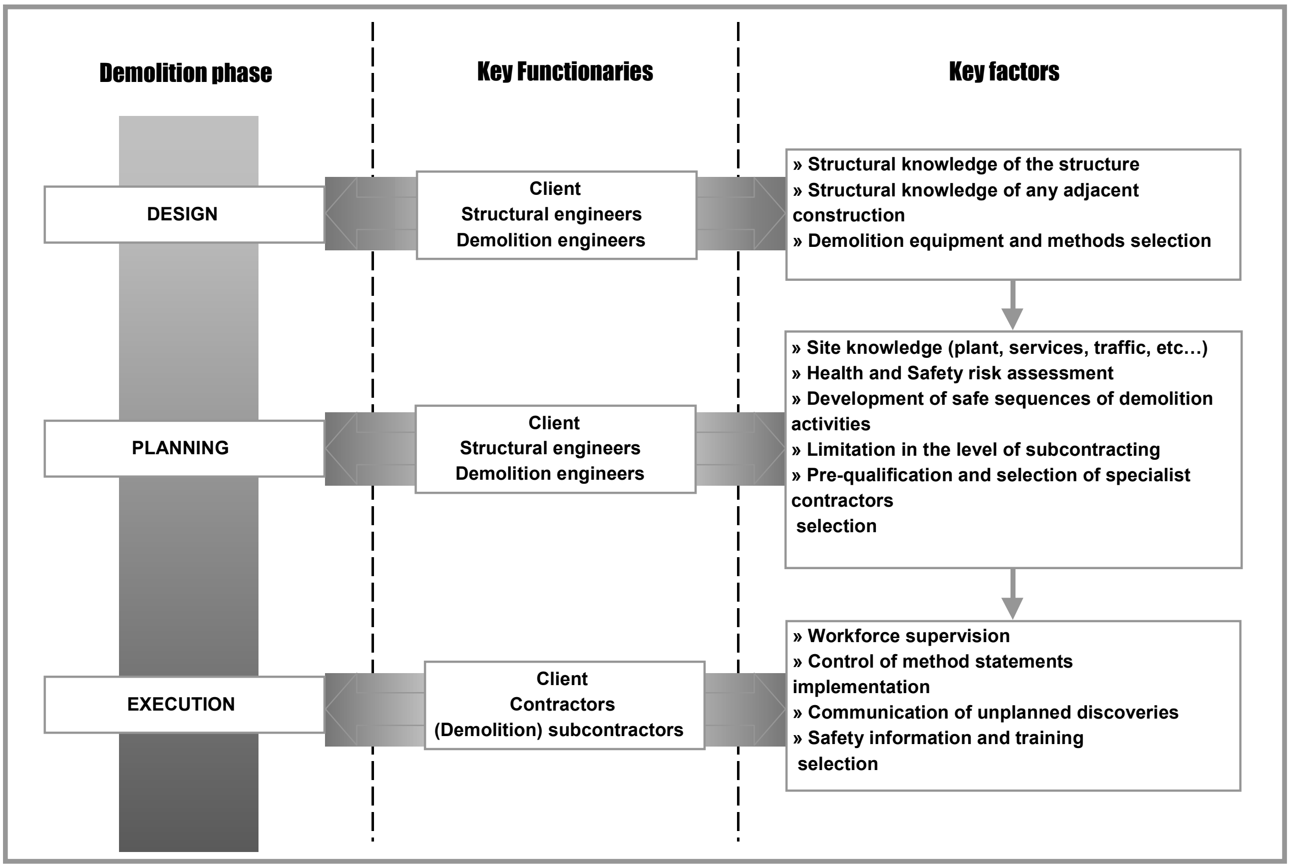

Figure 1: key factors to be assessed and implemented prior to carrying out any demolition works

Demolition methods and techniques

While investigating partial demolition in refurbishment projects; demolition methods, techniques and equipment must be identified and assessed. Depending on the structural elements to be removed or demolished and applying the principles of structural demolition as reported in BS 6187 "Code of practice for demolition" structural demolition methods can be identified as follows:

1. Progressive demolition;
2. Deliberate collapse mechanism;
3. Deliberate removal of elements.

Progressive demolition should be considered to be "the controlled removal of sections of the structure, whilst retaining the stability of the remaining part and avoiding collapse of the whole part of the building to be demolished" (BS 6187:2000). Therefore the key structural elements of the construction should be clearly identified as well as demolition sequence. The Italian safety legislation requires that the contractor develop a site-specific demolition schedule prior to the opening of the site. As reported in the code of practice, progressive demolition is the most commonly used type of structural demolition. This method seems to be particularly useful in confined and restricted areas.

Deliberate collapse mechanism should be considered to be the "removal of key structural members to cause complete collapse of the whole or part of the building or structure" (BS 6187:2000). When used in total demolition this technique should be employed on "detached, isolated, reasonably level sites". This requires sufficient space in order to move and place equipment and personnel at a safe distance. Before carrying out any partial demolition works, a structural survey needs to be undertaken to ensure that no structural instability will arise during demolition. This should avoid any unplanned collapse of the structure in areas where workers are present. In fact amongst the most common causes of structural collapses, it is possible to identify such culprits as activity induced, load induced (e.g. debris localised overloading), spontaneous collapse, remote activity and machinery impact.

The deliberate removal of elements is a demolition method used to remove selected parts of the structure by dismantling or deconstruction. Prior to the removal of any parts of the structure any potential instability or collapses must be assessed.

Focusing on partial demolition the health and safety risk assessment will be developed through the analysis of:

- Demolition method and techniques;
- Structural elements to be removed and their constituent materials;
- Equipment and tools.

While studying partial demolition in the refurbishment of old buildings, it was noted that structural elements are more likely to be composed of timber, concrete and bricks. Depending on the size, the type and materials of structural elements and on the extent of demolition works, proper equipment and tools have to be selected. When demolishing structural elements, such as beams, slabs or walls, vibrations induced by mechanical equipment could be dangerous for the integrity of the whole structure and of adjacent construction. If the structural survey assesses that the structure may show instability or damage after being exposed to vibrations, demolition by "hand method" is strongly recommended. Use of manual tools as well as electrical or pneumatic hammers is recommended in confined spaces and for internal demolition works due to the lack of space and of safe areas.

Demolition techniques such as demolition ball, demolition by explosives, blasting and bursting are mainly related to total demolition, therefore not discussed in this paper.

Earthwork machines with hydraulic attachments are frequently used when required by the size of demolition works and when permitted by structural conditions of the remaining parts of the structure. Excavators of different sizes and skid-steer loaders are among the most commonly used type of demolition machines. They are generally used in the demolition of steel, concrete and masonry buildings.

Hydraulic attachments have to be selected dependent on the materials that are required to be demolished. The most common hydraulic attachments are:

- Pusher arm;
- Impact hammer: pneumatically or hydraulically operated;
- Hydraulic shears;
- Pulverizer;
- Demolition pole;

– Grapple.

Through the study of demolition methods it is possible to develop a preliminary risk assessment that will identify those general risks involved in demolition operations. This general risk assessment will need to be further developed on the site-specific context to allow an effective development of safety procedures.

Most of the health and safety risks in demolition activities are related to an unplanned collapse of the structure; at the same time the incorrect use of a demolition tool can cause injuries as well as an unsafe site. Through the analysis of accident statistics it is possible to notice that a reported accident such as "*trapped by something collapsing or overturning"* can be related to the collapse of structural parts or uncontrolled discharge of debris. Using demolition machines involves risks such as being struck by moving vehicle or objects (e.g. excavator's attachments) as well as contact with moving machinery or material being machined.

Structures partially demolished should be bounded and danger signals should be provided to prevent workers from getting into dangerous areas. Falling from height (e.g. falling from a floor partially demolished) is among the most frequent kind of accident encountered (HSE, 1988). Risks related to explosions should be assessed when plants and services are still in use and therefore a temporary suspension of gas and/or electricity supply should be required during the execution of demolition activities. Even if the number of risks related to demolition activities seems to be relatively small, there are many factors that when not properly addressed may cause a serious injury or fatality.

Prevention and control of health and safety incidence on refurbishment projects – Some key issues

The relatively high level of health and safety incidence on refurbishment sites involving partial demolition activities can be attributed to some key factors as previously discussed. These key factors are related to the design phase of refurbishment projects as well as to the execution phase, and they involve key functionaries in the refurbishment and demolition processes, such as the client and the contractor. It is normally the case that the client is more involved in the design phase, therefore his supervision is very important to ensure that the key health and safety factors are properly addressed and assessed.

Some of the important activities of the client could be expressed in the following actions:

– to appoint a competent engineer to develop detailed structural survey on the construction to be refurbished;
– to appoint a competent planning supervisor for the control and supervision of all the safety aspects on site;
– to provide sufficient time in the project development to get all the necessary information for the structural survey, desk study and site investigations;
– to assess a reasonable time schedule to complete refurbishment works in order to ensure that the activities are performed in safe conditions;

- to pre-qualify and select specialist contractors with good experience and competence in refurbishment works;
- to ensure that project documentation is updated and/or modified following discoveries that may be made while working on the structure.

When contractors are selected to carry out demolition works they should obtain from the client all the information developed during the design and planning phase. For example the structural survey, the demolition method and sequence. The contractor's experience will be useful in integrating any safety procedures to the project safety documentation developed by structural and safety engineers.

During the execution phase contractors and subcontractors will have to contribute to effective safety management ensuring the following activities:

- providing appropriate information and training related to health and safety hazards during demolition works;
- using appropriate demolition machines and tools as indicated in demolition method statements;
- following demolition sequence and method as provided by demolition/structural engineers;
- to maintaining the site in a safe condition and in compliance with health and safety plan requirements;
- providing workers with all the appropriate PPE related to health and safety risks they are exposed to;
- appointing a supervisor to be on site during the execution of all the demolition activities; great attention must be paid to supervision in order to prevent the workforce from taking any initiatives which may lead to the execution of unplanned activities;
- communicating as work progresses to the client any modifications or structural diversities from what was found in the structural survey;
- providing illustrated statements and safety instructions when the workforce is composed of workers speaking different languages;
- removing waste and debris to avoid localised overloading of the structure.

Conclusion and recommendations

Refurbishment activities in the UK and in Italy have increased in the last three decades and now command a substantial amount of total construction output. Refurbishment activities are also perceived to be dangerous, with a high level of poor health and safety incident. The situation is heightened when such works involve demolition and structural instability.

This paper has addressed some important factors, which combine in complex ways to contribute to the relatively high level of health and safety incidents on refurbishment projects involving partial demolition and structural instability. These factors include demolition design, planning & execution. Other factors are knowledge of site and structure, workforce supervision, selection and use of appropriate plant & equipment, selection of subcontractors, communication, and requisite safety information and training.

The paper points to the fact that existing health and safety management strategies for refurbishment in construction organisations range from many that are alarmingly poor to few enviable practices. There is therefore an urgent need, especially for small-sized contractors, to improve health & safety management practices for refurbishment, based on best practices. Any meaningful Health and Safety management strategy should be robustly developed and should give due cognisance to the factors identified above. Targeted education and training and effective dissemination of best practices are vital in this regard. There is also ample scope for further empirical studies in this area for the benefit of the refurbishment sector and the construction industry.

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A Protocol for Handing over Buildings

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Abstract: *Buildings that are not properly handed over to new owners or managers are unlikely to operate efficiently, and there has been no formal handover protocol. This problem has now been addressed by a two-year 'Partners in Innovation' project called "Handover for Office Buildings Operation". The project, funded by industry and the DTI, aimed to develop a protocol for handing over buildings to a defined and agreed format. This paper outlines the project and the protocol that has been developed.*

An increasingly complicated combination of building services and control systems maintain environmental conditions in office buildings. Poor operation of these systems can negate the benefits of a well designed building. The continued successful operation of the building and its systems can only be ensured if the owners and operators fully understand the design.

Initially, case studies of current handover practices were used to identify improvements needed to the existing guidance. Although the requirements of the CDM regulations and the H&S file address many of these issues, the case studies still revealed large gaps in the process and numbers of dissatisfied facilities managers.

The handover protocol includes the appointment of a 'handover manager' at the earliest stages of the building design or refurbishment proposals. The manager then becomes responsible for the handover process, which must run in parallel with all phases of the building design and construction. The manager must collate all information ensuring that it is up to date and relevant. As the building nears completion the protocol requires the incoming occupant to have sufficient training to operate and maintain the building to the standard the designers anticipated.

Introduction

The 'Handover of Building Operations' (HOBO) project involved eleven project partners representing a wide-ranging constituency of building professionals and professional bodies. All the partners of this project have echoed the views widely held by architects, building services engineers and facility managers, that even well designed services are not properly handed over and the buildings cannot therefore be operated in the efficient manner that was intended by the designer.

Typically, information provided at the time of handover is a collection of drawings and manufacturers product literature delivered in compliance with the Construction Design Management (CDM) requirements for a health and safety file. In honouring this need, the material is often more suited to the detailed operation and maintenance of the plant. This is not appropriate for the day-to-day operation of the building by the owner or facilities manager. For their purposes, a more practical user-friendly 'building log-book' approach is required.

There is always a need for the new owner or operator of the building to be fully instructed in how to operate and maintain the building over its lifetime. Even if training is given at handover, there is no method for ensuring knowledge is transferred from one operator to another. A building with a life of 50 years could have numerous operators over this time. A robust method of ensuring efficient, lifelong building and services operation is required.

This project has attempted to address these needs by developing a protocol for handover that will enable managers to operate buildings as they were designed to perform.

The opportunity to develop a protocol for handover has been met with great enthusiasm within the industry. The British Council for Offices in particular is extremely keen on this initiative. To quote a member:

“..the work proposed under ‘Handover for Offices Building Operation’ fits very neatly in to the BCO Specification where we are calling for all buildings to have Log Book at completion. I would like to see this given the BCO badge and become a natural must for all building owners/incoming occupiers in exactly the same way as the BCO Guide to Best Practice gets raised in landlord/tenant discussions.”

The Development of the Protocol

The project began by investigating existing protocols and guidance for handover, the most significant of which are the Construction Design Management (CDM) Regulations (1995) and the Health and Safety at Work Act (1974). In addition to these Regulations there are two existing technical guides, published by BSRIA and CIBSE, to help the construction, design and client teams tackle the building handover procedure.

The CDM regulations came into force on the 31st March 1995. A significant part of the Regulations is the requirement for the construction team to produce a health and safety file that is passed on to the building user on completion of the building. This file should then be kept up to date and amended throughout the life of the building.

The requirement under the Health and Safety at Work etc Act 1974 (sections 3 and 6 as amended by The Consumer Protection Act 1987) that designers, suppliers, manufacturers and importers of plant and systems have a duty to provide adequate operating information for the user to ensure the plant will be safe and without risk when in use. The information must also include details on maintenance procedures for continued safe operation. This information forms the Operations and Maintenance (O&M) manual, which is included in the Health and Safety file.

The CDM Regulations have improved the handover documentation procedure and have gone some way to provide a structure to the process.

Case Studies

To understand the current practice regarding the handover process we carried out four case study investigations of recently handed over buildings. The aim was to assess the information and guidance provided to the building users on completion and whether they had any significant problems when operating the new building.

To structure the case studies we considered all the issues surrounding the building handover process and drafted questions that would encourage discussion. Our case study exercises included structured interviews with the facilities managers and in some cases members of the maintenance team in charge of running the buildings.

Each of the four case studies had different experiences during their handover, but there were also a number of common findings. They all reported that handover was considered far too late into the contract. As a result, insufficient time and planning was allowed for collating information essential for running the building operations. There was a general view that facilities and maintenance managers should be involved at the design stage, so they can add their experience to ensure the design is workable. They would benefit from hands-on demonstrations of plant during the commissioning phases.

There were complaints of poor Operations and Maintenance (O&M) manuals that were, in some cases, little more than disjointed collections of photocopies from trade literature with no index system to assist the users to find relevant information. A few facilities managers saw a need for training maintenance teams how to work with the plant installed into the building, putting a contractual requirement on the services engineers to arrange demonstrations and presentations. Other facilities managers thought training would be ineffective as the maintenance and facilities teams tended to change jobs on a regular basis.

The findings from these case studies, as well as our discussions with our industry based advisory panel, guided the drafting of the proposed protocol for building handover that will address these issues.

The findings have reinforced the view that there is a radical change required to the way a building is handed over. The published guidance available is seldom referred to and the norm seems to be to follow the very basic requirements of the Construction, Design and Management (CDM) Regulations 1994. It seems rare that building users are provided with a comprehensive O&M manual that fully describes how to operate the completed building. Drawings were sometimes provided in a form that is unhelpful, without indexing or reference in the O&M manual. This has, in some cases, made it hard for the facilities managers and maintenance team to operate and fine-tune the newly completed buildings.

With these findings in mind, the project produced a draft handover protocol that should address the difficulties raised in the case studies. The proposed protocol would provide advice on how to write an effective, user-friendly O&M manual and how best to record drawings and other relevant information. This draft protocol will be tested on four further case study buildings to enable us to review and revise the new documentation as necessary.

The Draft Protocol

A flow chart giving an overview of the HOBO protocol is included as Figure 1.

Handover is not an activity that can be left to the last weeks of the building contract. To be successful handover must be treated as a process that is started at the Final Proposals stage (RIBA work stage E). Handover activities must be well planned through the construction stages and sufficient time allocated to collecting information, preparing the health and safety files, writing the operations and maintenance manuals, producing the fire safety files, setting up the drawings register and providing training and demonstrations for the new building's users.

Handover Manager

The first stage to achieving a successful handover is to appoint a Handover (HOBO) Manager who will work alongside, and complement, the Planning Supervisor. The HOBO manager has very specific responsibilities, which are discussed in detail below.

The HOBO manager will need a broad understanding of design, construction, services, commissioning and also appreciate the needs of end users. To be effective the HOBO manager must have good planning, organisation and communication skills.

The HOBO manager will need to work closely with the client and the building's end user (if they are available during the construction phase). This will allow all the interested parties to discuss how they require the building's documentation, drawings and details presented.

HOBO documentation

The HOBO manager will oversee the collation of documentation that is both contractually required and desirable for the building user on practical completion.

The CDM Regulations (1994) require the planning supervisor to compile a Health and Safety file during the construction phase and provide this to the end user on practical completion. This file must contain all the information that is required for the safe operation of the building.

The handover manager will need to agree with the building user whether the building's operating manuals should be prepared in a paper format or an electronic format.

The choice between electronic and paper formats will be based on the size and complexity of the building and the needs of the end user. Where appropriate, the HOBO protocol encourages the use of electronic systems.

Electronic documentation allows quick and easy access, space saving, secure information storage, easier change management and links to CAD drawings, Building Management System and the Asset Register. It is also expected that the potentially higher initial cost of establishing an electronic O&M manual will be recouped by the time saved in using it.

Handover documentation must have the following to be comprehensive and helpful:
- A clear index of information
- Fire safety information
- Design intention of the building
- Drawings record
- Change management system
- Building Logbook
- Asset Register

Clear indexing will help the user to find items easily and will also aid the HOBO Manager to spot missing items during the compilation process. Cross-referencing is also important and features like colour coding and a numbering system can aid this process. Electronic systems must be equipped with a search engine.

The fire safety manual should provide the following:
- A full description of the active and passive protection systems in the building
- A full description of the assumptions and philosophies for the fire safety design
- A full description of the design aspects which have a direct bearing on the fire safety management of the building
- An operators manual for the fire safety systems
- An inspection, maintenance and repair manual for the fire safety systems
- Details on how the fire safety system may be linked with other systems, for example: security, building management, other safety systems etc.
- Information relating to fire certificates or licensing
- Continuing control and audit plans
- A building logbook of all events that happen during the life of the building that relate to fire safety.

The design intentions of the building should cover items such as the intended use of the building at the time of design, the activities that are anticipated, the size of the building and the number of occupants and the services in the building (e.g. naturally ventilated or air-conditioned. Some of these factors will differ for different areas of the building and these differences should be clearly described as different uses and occupation densities will have different impacts on the level of services required.

Providing this information to the building user should avoid the building being misused, or the building being used inappropriately. Or the users having unrealistic expectations of the building.

If drawings are to be submitted electronically, they must all be in a designated format that is compatible with the electronic O&M manual and be cross-referenced to it. All drawings must be accurate and be included in the 'drawings register' along with any updates and revisions during the life of the building. Copies of the drawings and details must be held in a secure location to avoid them being lost or destroyed.

The HOBO protocol recommends that a change management system be set up. This provides a robust way of tracking all the changes made to the building and ensuring these are recorded in the drawings and manuals for the building. These changes can be recorded in detail within the building's Log Book, which will also record all maintenance and repair activities. This Log Book will satisfy the requirements of Approved Document L2.

Retaining this information will ensure the building is continually running efficiently and meeting its design intentions.

The HOBO protocol recommends an asset register is compiled during the construction phase of the building. The asset register must be compatible with the format of the health and safety file to be effective. It must also be linked in with the O&M manuals and to the as fitted drawings.

Presentation of the Building's Information to Different Users

Three different user groups in the building will require handover documentation and information. These three user groups are:

1. The office users
2. Facilities team
3. Maintenance team

General office users

This group will include everyone working in the office building, for example: office workers, managers and others spending any amount of time in the office building.

The general office users will want sufficient information on the building to enable them to carry out their work tasks in comfort and in safety. They will require information in an easy to understand format and will not want too much technical information. The office user will also need important and useful information close at hand or posted in accessible locations.

The office users will need to know:

- Emergency information – the location of fire exits, fire extinguishers, muster points, fire alarm systems and fire fighting systems.
- Simple descriptive design intention of the building
- Information on heating levels in the building and how heating can be adjusted.
- Information on cooling in the building and how areas can be cooled (if appropriate)
- Information on ventilation sources and how ventilation rates can be increased or decreased.
- A list of contact numbers to the Facilities Team and or the Maintenance Team.
- A help-desk facility to report problems and request changes to the working environment if required.
- User groups. This will encourage the office users to feedback their experiences to the design and construction team via the handover manager.

In large office buildings this information may be posted on the company's Intranet system. Posters and notices can be an effective method of providing simple information to the building users. The handover manager will need to agree the most appropriate means of conveying information to the end users and arrange for the system to be set up accordingly.

Facilities Management Team
The facilities management team will want access to all the building's information including a general overview of the technical details on plant and services as well as schematics and detailed plans. This information should be produced in the form of a 'users handbook'. They will need this information to plan and advise on maintenance work and also check that the building is operating efficiently. The facilities manager will need quick access to all the information and will also be responsible for keeping the information up to date. The facilities manager must be trained how keep the building's Log Book up to date and how to keep the 'Change Management' system current.

Maintenance Team
The maintenance team will require all the technical information and plant specification material in great detail to enable them to carry out routine maintenance work as well as repairs and setting up the systems. The maintenance team will require simple and clear schematics for quick and easy reference.

If an electronic format is to be adopted for the O&M manuals and drawings it is important to ensure the maintenance team will be able to access relevant information quickly and accurately.

Building Handbooks
Maintenance and Facilities Management teams will benefit from small handbooks showing simple layouts and schematics of the plant and services that can be easily carried in a pocket for routine maintenance and repair work in the building. These pocket-sized handbooks will then refer to more detailed information held within the more comprehensive documentation for further reference.

Maintenance work will also need to be recorded in the building's logbook and signed off the planned maintenance system (if appropriate).

Training

It is important to have detailed training and demonstrations of the building's services, features and facilities. This will ensure the building users know how to operate the building and run it effectively and efficiently. The level of training and technical content will depend on the size and complexity of the building.

The maintenance teams should be involved, if practicable, at commissioning stages to take part in setting up the building's operations. This will give the maintenance teams hands-on practical demonstrations of the services installed within the building. The installers and the maintenance teams can discuss any technical issues and iron out any difficulties before practical completion.

The Facilities Management team and Maintenance teams will require practical demonstrations of the building and guided tours. The training and demonstrations should include:

- Emergency procedures, what to do in the event of fire, power cuts etc.
- Simulated emergencies, a physical demonstration of what happens when the power is cut off and how to evacuate the building in the event of a fire or another situation.
- A guided tour of the building to see its layout
- Demonstrations of the lighting, heating, cooling and ventilation systems in the building. This must include how to set them up and adjust them as well as how to fine-tune the systems.

The training sessions and demonstrations should be filmed and kept for future viewing when new members of the facilities team and some maintenance workers are employed or as refresher exercises. The training can be recorded digitally and included as part of an electronic system or be recorded onto DVD or videotape.

No Blame Period of continual commissioning

The HOBO protocol recommends the handover manager stays in close contact with the building for a period of a year after practical completion to make sure the building has been set up and operated correctly. It is likely there will be a few teething troubles with the systems and a need for some fine-tuning to make sure the building is running properly. A 12 months period of this continuous commissioning exercise will also enable the building's services to be tested in different seasonal conditions, for example the heating to be tested and adjusted in winter months and the cooling to be tested and adjusted in summer months.

Having a team set in place to monitor and adjust the building's performance will enable any faults or difficulties with operation to be rectified. This ultimately will lead to the efficient operation of the building and associated savings in energy and improved occupant comfort.

Continuous commissioning will also remove the 'blame culture' that can exist in the current 12 months defect liability period. Instead there will be a culture where all parties are working together to ensure the building is working as it was designed to do and meeting the needs of its user group.

HOBO recommends that handover should be finalised 12 months following practical completion. This final handover will be the final activity within the HOBO process.

Future Handovers

Approved Document Part L2 of the Building Regulations requires that the building's logbook is kept up to date. This way all information on the building remains current and relevant. The up to date heath and safety file, containing all the information relevant to the building will be readily available to be handed over to the next occupant.

It may be appropriate for future new users of the building to employ a handover manager. The handover manager will be able to train and demonstrate the building and ensure its continued efficient smooth operation.

HOBO through the life of the building

If the HOBO protocol is set up correctly and the principles are adhered to it should ensure that at any stage anyone taking over the building would have access to accurate and relevant information, manuals and drawings of the building.

Decommissioning

Finally the HOBO protocol recommends detailed advice and guidance is included in the health and safety file concerning the decommissioning and demolition of the building at the end of its life. This will be particularly important for the disposal of hazardous materials.

Costs of following the HOBO protocol

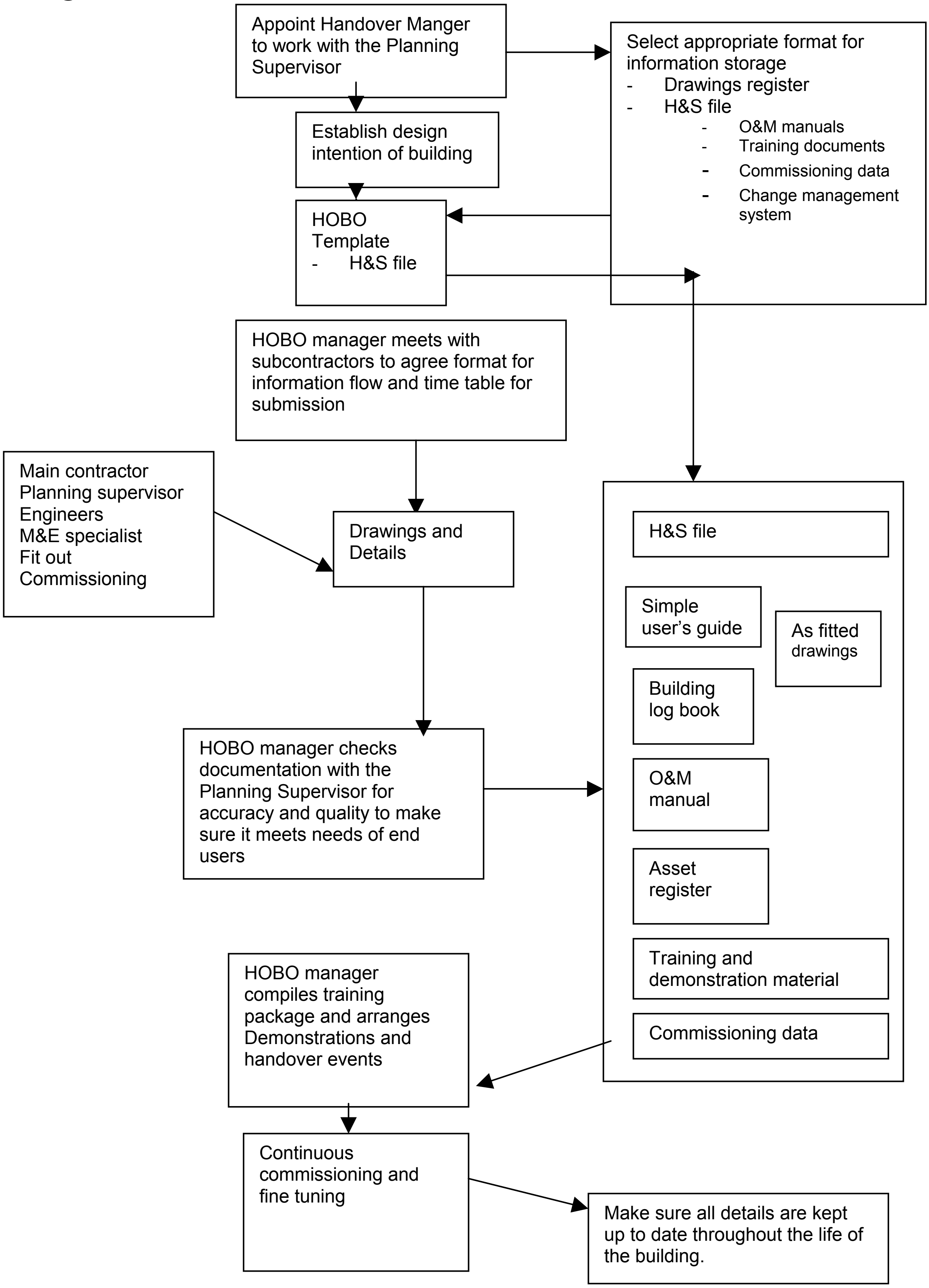
It is estimated that the cost and energy savings made by the building operating efficiently will recoup the costs incurred by following the HOBO protocol.

Conclusions

A draft protocol has been developed to aid the efficient handover of buildings. On-going trials will refine the protocol to ensure that it is useful and usable in ‘real’ projects.

The protocol will be published and the use of the protocol will be promoted through the project partners and through other publicity. It is hoped that the protocol will be a significant benefit to future building’s operations.

Figure 1: HOBO Protocol



Feedforward for improved performance of facilities

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Abstract:
The paper reports on progress with research into the continuous processes of handover and proving the performance of buildings, and the development of practical, standard web-based tools for the effective feedforward of knowledge, the transfer of risk and assignment of responsibility for performance, on behalf of the occupants, through the whole life of a building.

The paper reports on progress with the initial stages of the work in the Feedforward project, which takes an action research approach, and focuses on one aspect of the link between facilities and business performance - the measurement of workplace productivity. The first phase of the project has reviewed recent UK research into workplace productivity, has evaluated available survey tools and has conducted a series of best practice case studies of practical applications in leading office-based organisations.

The paper introduces the business context, describes the research context and methodology and provides a critical review of workplace productivity research. It presents a review of recent UK research and an evaluation of workplace productivity survey tools, describes the best practice cases and draws early conclusions and recommendations for the continuation of the project and for future research.

Keywords: Facilities performance, business performance, stakeholders, whole life, evaluation tools

Introduction

A business context

As organisations seek greater flexibility, they are reconsidering their approaches to providing workplaces to support the effectiveness of their workforce, and seeking to introduce ‘new ways of working’ to improve business performance. This is leading to a fundamental review of the role of property assets, to the development of integrated workplace strategies and has put greater emphasis on managing business risk through effective performance management. For example, two leading UK companies, have recently withdrawn from major new building projects, and have chosen to restructure their property departments, and develop flexible working practices, and facilities management strategies to meet their changing business needs.

Changing work settings to improve occupants’ overall productivity and health, requires all aspects of the work environment to be examined in combination to ensure that efforts to improve the work setting deliver the expected gains, and also that they are not defeated by unexpected and unwanted side effects.

A recent industrial tribunal has highlighted the potential difficulties associated with introducing new ways of working in organisations. The tribunal considered a case of constructive dismissal, arising out of a claim by a research worker, that the imposition of a requirement to ‘hot desk’, induced stress, which in turn led to clinical depression, and ultimately to the researchers resignation from an untenable position.

This emphasises the importance of evaluating the performance of the workplace as a whole. Many decisions, made at corporate level, are justified by improvements in productivity and, for knowledge workers in particular, it involves qualitative as well as quantitative factors that often prove difficult to rigorously define and measure.

Organisational issues, such as corporate culture and motivational factors, have the predominant effect on performance. Facilities and the environment must be in keeping with the corporate culture and not directly disrupt motivational factors (eg reward, responsibility, job security). Price (2001) suggests that the link to organisational culture, widely made in the knowledge management arena, is beginning to be appreciated in the workplace design arena. He believes that the business value of workplace initiatives is best considered as part of the wider question of managing and measuring knowledge work. Changes in workplace may enable changes of culture but only, perhaps, if they are accompanied by changes in managerial thinking and belief systems.

Ultimately decisions on the quality of the workplace demand informed judgement. Although there are no studies that can reliably predict the returns on such facilities investments, the evidence that a better work environment promotes better performance is compelling. Productivity improvement is commonly the justification for enhancements to the work environment. It would seem reasonable to assess the benefits of such expenditures by measuring changes in the productivity of the workers affected. Does the benefit justify the cost?

Making the business case

There is now much greater recognition of the importance of these business issues in the United Kingdom, and a combination of growing corporate awareness and active promotion by the Government is creating the climate for innovation and performance improvement. As Leaman (2002) has indicated, the UK Government has funded studies to foster a better understanding of the links between building and business performance and has included post-occupancy evaluation in its research plans. It is promoting performance indicators of all kinds (including sustainability and design quality) and has amended building regulations to include requirements for recording and communicating performance.

A business case for facilities management can be made in a number of different ways. The most common approach has been to make the case on grounds of efficiency, based on the ability to control and reduce costs or, alternatively, to improve the return on fixed assets.

Facilities managers have concentrated on reducing the office cost per employee and increasing the occupancy per square metre of office space without sufficient regard to the impact that this might have on people’s performance and the all-factor productivity of their organisation (Oseland and Bartlett, 1999). This emphasis on the office as an overhead cost has divorced consideration of the potential contribution to output from the equation.

However, facilities can be considered as a factor of production. Whole life ratios such as 1:5:200 - capital, operational and staff costs - have been computed and demonstrate the importance of staff satisfaction (BRE 2001). Other (unsupported) studies indicate a leverage ratio of 1:10:100 between the total cost of providing office space, staff costs and operating costs and the value of staff output.

Facilities can make a prime contribution to improving the effectiveness of individuals and teams, and to enhancing productivity. The importance of a building and support services in supporting the effectiveness and productivity of office workers has been underplayed, largely because of the lack of suitable tools and available evidence to support the business case.

Workplace performance appraisal

Facilities performance can be defined in three main ways:

Business performance (strategic)
concerned with the extent to which facilities support, or can be adapted, to meet the changing needs of an organisation';
Process performance (tactical)
concerned with effectiveness in terms of quality, value and risk;
Operational performance (operational)
concerned with efficient and economic service delivery;

Three key questions flow from definition of performance at these levels:

Performance – how well do the facilities support the organisation's business goals?
Process – how well are the facilities management team, and its outsourced suppliers integrated, as measured against their ability to manage within budget and a pre-defined programme, and the ability to meet the organisation's business goals?
Product – how well the facilities achieve a pre-defined fitness for purpose and do the systems, elements and components work?

Tried and tested tools and techniques exist for measuring the product and process, for example help desks, but there are few methods available for effectively matching business performance with facilities performance. However, feedback on the 'business' is as important as feedback on buildings, if not more so.

Tools that provide this feedback should contribute to assessing and managing the business risks associated with occupying buildings and delivering the services that support primary activities. Many of the organisations in the FM Foundation network use business excellence models, a balanced scorecard approach and use process mapping techniques to improve business performance. The tools used by sponsors, clients, users and facilities managers (the 'demand chain'), in construction, maintenance and operational processes, must be consistent with other business and management tools used in the organisation and be capable of integration with the organisations business processes.

Evidence from CFM research, drawn from amongst the Foundation membership (eg from major building projects in Powergen, Merrill Lynch, Standard Life and Boots) suggests that the representatives of the ‘demand chain’ are still not as closely involved in construction processes as suggested and recommended. The briefing process is inseparable from business planning and the boundary between the two is fuzzy yet often they are treated as being distinctly different. Project teams lead the change and then leave the stage. Post occupancy evaluation is rarely undertaken. Therefore continuity of decision making about building performance is rarely assured.

Responsibility for the performance of a building is passed amongst developers, owners, occupiers and operators (‘stakeholders’) in an ad hoc way, and further changes occur throughout the life of a building. Although some evaluation tools are beginning to emerge, there is no general framework to support the systematic organisation and transfer of building performance information.

To ensure that facilities add value to the organisation, more emphasis should be placed at the strategic level, on business performance and the contribution to excellence. In order to make the business case for improving the built environment and the quality of support services in organisations, facilities managers require practical tools that link facilities performance to key business performance measures. These tools must recognise the human, social and cultural dimensions of the workplace and enable an assessment of their impact on performance. Whole life processes for facilities must be developed and integrated with the business processes of the host organisation.

Productive workplaces

These business considerations of Facilities Management are reflected in the programme of action research undertaken by CFM on behalf of its membership. The programme of research, agreed by the membership, addresses three key themes - productive workplaces, innovative workplaces and sustainable workplaces (CFM, 2001). The research framework has also been adopted by EuroFM for development of its research forum and activities and for the open research symposium held at Salford University in May 2002.

The issues dealt with in this paper fall within the productive workplaces theme, which focuses on two key research questions:
What is the impact of the quality of environment and support services on organisational effectiveness and business success?
What contribution do facilities make to organisational success and how can we identify the value added through effective facilities management?

Facilities management aims to provide facilities and environmental conditions that meet the business needs and improves productivity. This theme explores issues relevant to optimising productivity within the facilities life cycle, whilst supporting business needs effectively, efficiently and economically. It covers a range of business topics including the nature of workplace productivity, organisational culture, workplace environment, 'fitness for business', work/life balance and 'a great place to work', and raises associated research issues.

The research theme considers what productivity is and the work environment in which it takes place. It considers how the workplace is designed, how it functions, and how it is measured, as well as the health and performance of the people who use it. It also looks at ways of enhancing this environment to boost productivity and control facilities costs.

Within this overall research theme, a long-term action research project is in progress called 'High Performance Workplace'. Companies participating in the Financial Forum are collaborating in the project and have identified key aspects of the workplace that impact on shareholder value. For each aspect output factors and performance measures are being developed.

Within the long-term project, a specific study, the 'Feedforward' project, investigates how case study organisations measure workplace productivity. The work recognises that productivity is only one of several measures of organisational performance, and it is not necessarily the most important one.

Research methodology

Each research project adopts a well-developed research methodology involving inter-related streams of work and using a mix of research methods. Case studies and a series of project meetings, workshops and conferences provide the focus for the research effort.

Preparation for each case study will include site visits, interviews and communication by phone, email and through the CFM's website. Data collection involves collation of documents and any survey data that is available, followed by structured interviews with key personnel and focus groups. The case material is collated and analysed using a standard descriptive model for presentation at a workshop.

Each case study is presented at an evaluation workshop, involving the participation of FM Foundation member organisations, organised as clusters of 'stakeholders' to represent the interests of owners, occupiers and operators of buildings. The workshops allow the group to evaluate the case study from different perspectives and provide the opportunity to share the knowledge and experience.

Additional reflective workshops consider the results of the case studies and 'best practice workshops. Undertaking a series of case studies enables comparison of the results in a cross-case analysis to assess if there are any lessons and trends that can be deduced.

Case material, results and reports are made accessible to the participants in the project on the CFM web-site, with the permission of the host organisation. A project web page enables discussion of issues raised and encourages the sharing of experience.

High performance workplace

The overall aim of the high performance workplace project is to support members in their efforts to add value to their client business (and where possible, to demonstrate contribution to shareholder value) by:

- Creating a framework to enable understanding of the ‘value imperative’ and components;
- Using analysis tools (research case studies / benchmarking) to share knowledge;
- Delivering new knowledge to members in ‘business-ready’ form, for ease of implementation.

The purpose of a ‘high performance workplace' is to significantly enhance the output of any occupying organisation. The challenge set by participants in the project is to demonstrate ‘best value’ in FM. The ‘value imperative’ - increasing shareholder returns

The research is founded on a number of basic assumptions:

- the member organisations of the CFM Financial Forum (within the bounds of individual budget restrictions) intend to provide a high performance workplace that will significantly enhance the output of their business units in office space;
- before embarking on (or perhaps on completion of) any major project to provide a high performance workplace a company will wish to set out a performance framework and measures with which to gauge the success of the project;
- for business units currently operating in office space, intending to provide a high performance workplace, it will be important to understand, analyse and improve the performance of churn management.

Two initial research streams have been identified - measuring workplace performance and churn and space management performance. The focus in the projects is on output, and the measurement of effectiveness and not just efficiency.

For the purposes of the project, ‘workplace performance’ is defined as 'the analysis, measurement and understanding of the output generated by the physical workplace (space and services), and the management of the workplace, that contributes in some way to the performance of an occupying organisation'.

Early discussions have identified the typical outputs of a ‘high performance workplace’ as:

- Staff retention / attraction
- Comfort
- Risk (Safety, Health, Environmental, Security & Workplace)
- Speed / minimum disruption
- Creative thought
- Communication / minimum interference
- Corporate image/'brand’

Measurement of workplace performance requires the development of a performance framework and key performance measures with which to analyse the success of a high performance workplace and to benchmark against other workplaces using the same measures.

The focus must be on understanding the key performance measures used to gauge success, and delivering a framework for use in all similar situations for example:

Q. Where a facility is known to attract/retain staff, how is this measured?
Q. Where the FM strategy aims for maximum comfort (heat, light, sound, ergonomics), how is this measured?
Q. Where risk (safety, environmental, security, etc.) is a corporate measure, how is this managed?
Q. Where the speed of change (e.g., form/re-form teams) with minimum disruption is key, how is this measured?
Q. Where it is known that a facility was designed, and is managed in a way, to stimulate creative thought, how is the success measured?
Q. Where a facility is aimed at maximizing communication and minimizing interference, how is this measured?
Q. Where corporate image/'branding' is clearly on the FM agenda, how is success measured?

Each of these questions are addressed through a standard case study approach involving:
- Definition of the 'workplace performance' project/problem/issue; (eg could be a new building, capital project, or management initiative)
- Data from the business (such as sickness, staff surveys, leavers interviews, recruitment data, cost of business operations, down-time spent dealing with premises issues);
- How this data was used to support a 'business case' for the workplace performance project;
- How this data was used to measure post-implementation success of the project;
- Critical success factors, and key performance measures; and
- Lessons for others to learn

Feedforward project

The aim of the Feedforward project is to evaluate productivity improvements in case study organisations, to record and assess the impact of the workplace productivity projects and to share methods for measuring and benchmarking productivity.

The objectives of the project are:
- to make available techniques for measuring facilities performance that is linked to business performance and, also, to demonstrate the potential contribution of facilities to business success;
- to further the understanding of relationships between people, work processes and work settings within an organisation through 'best practice' workshops and project conferences, involving stakeholders in the workplace and experienced senior facilities managers;
- to provide a framework, associated tools and practical guidance for the measurement and organisation of facilities performance, linked to business performance information;

A series of six case studies on workplace productivity are planned as part of a three-year research project with members of the FM Foundation. Initial case studies focus on organisations with experience in performance measurement, and which have undertaken specific initiatives and projects to improve workplace productivity.

Workplace productivity research

To provide a foundation for the research, a review of literature has been undertaken and a 6d framework created for considering workplace productivity. The framework recognises the need to consider all six dimensions - organisation, people, work processes, settings, service quality and time - in any workplace appraisal.

For purposes of the research workplace productivity is defined as - 'the relationship between the outputs produced during a given period of time and the inputs consumed to create them - for example, the value of the goods and services produced compared with the value of the resources (e.g. labour, capital, energy and materials) used'

There has been a considerable body of recent work in workplace productivity in the United Kingdom. Major studies have been reported in the past three years, including:

Office Environment Study (BRE/Building Use Studies, 1990)
PROBE (Leaman et al, 1997)
Office Productivity Initiative (Oseland and Bartlett, 1999)
University of Reading/Workplace Comfort Forum (Clements-Croome and Raynsford, 2000)
Post Office Holdings.

Each of these studies has been analysed and critically appraised as part of the research. A summary version of the research report will be available at the conference.

Oseland's (1999) review of this research and other field studies indicates quite large effects of the environment on productivity. It is generally accepted that typically the workplace design and operation can have up to 15% effect on performance (Wyon, 1993; Brill et al, 1984). 'The (Office Productivity Network) survey suggests that there is potential benefit in facilities managers proactively addressing the output effects of individual facilities and elements in the office. The survey indicates that productivity improvement of up to 13% is potentially accessible – the average proportion of staff time being wasted'.

The majority of this research effort research has sought to link human productivity and quality of the indoor environment. There is a long history of research addressing the impact that the environmental conditions such as lighting, ventilation have on people's health, and could contribute to sick building syndrome, there is now clear evidence of the relationship between a good working environment and improved productivity amongst staff. There has been much less attention paid to organisational structure and culture, as well as social and personal factors that impact on people's performance.

Markus (2001), whilst applauding the effort to find out how people feel about their physical environment and the means of controlling it, criticises the exclusion of 'other issues of built space which are known to affect personal and organisational well-being, perhaps to an even greater degree than the physical environment'. Markus goes on to suggest that to discover these broader relationships, 'one would have to pursue research and appraisal methods in which inextricable matters are left in their knitted together form, and in which it is analysis which teases out the power of individual factors'.

Workplace productivity survey tools

Through this work, and spin-off consultancy activity, there is now an increasing battery of workplace productivity survey tools available. The research has sought to evaluate current breed of tools for assessing workplace productivity.

In particular, five questionnaire-based, survey tools have been assessed in detail:

Probe Occupant Questionnaire (Building use studies) - for all-round building performance work with an equal emphasis on building services, facilities management and architectural aspects;
Overall Liking Score (Levermore/ABS) - surveys occupants opinions on how much or little they 'like' their working environment and the importance they place on each factor;
Office Productivity Survey (Office Productivity Network and UMIST) - occupant survey of physical conditions. Assessment of the workplace and its impact on staff satisfaction and performance;
Workplace Evaluation Survey - surveys user perceptions of office environments. Self -assessment of the effect of the office environment upon performance at work;
Workplace Effectiveness Appraisal (AWA) - measures the perceptions that users have of workplace aspects that effect their performance. To establish how well the workplace supports professional workers in performing their roles. It assesses the effectiveness of the physical environment, the services provided to the workplace and the technology supporting the individual;

A number of these tools are derived from the same base set of questions, structured primarily around environmental conditions and control, and using similar rating scales. A critical appraisal of present breed of tools is being undertaken, and has already highlighted some key deficiencies for evaluating the workplace:

- Focus on individual - fail to recognise increasing team and project work;
- Simplistic view of the workplace - concentrate on physical environment, inadequate consideration of other factors;
- Underplay importance of personal, social and cultural issues;
- Space dimension underdeveloped;
- Insufficient account of IT and support services;
- Changing nature of work - need for a better understanding of the nature of knowledge work (knowledge work archetypes);

It is clear that this breed of tools is an inadequate basis for the increasing complexity of office, and assumes a working environment and conditions that have long since been superceded, even in the least adventurous organisational settings.

A summary of the research report of the appraisal of the survey tools will be available at the conference.

Best practice workshops

First stage of the project has identified practical examples of the use of these tools in initiatives aimed at improving workplace productivity. Case studies are being conducted to capture and evaluate the experience, assess the use of survey tools, share best practice and generate discussion.

A pilot case study of the University of Salford was conducted as a demonstration of the case study methodology and to test-run a best practice workshop. The case study report and minutes of the workshop have been published and made available to participants on the project web-site. These reports will be publicly available as a complete set once the project has been completed.

Organisations	Metrics	Tools
PriceWaterhouseCoopers	Fee income	
Silverbeck Rymer	Fee earner output	
BT		Office productivity survey (OPN)
Pharmaceutical company	Satisfaction Perceived productivity	Office productivity survey (UMIST)
Tivoli Systems	Downtime	Workplace evaluation survey
NCR	Decision-making Innovation	Community-based planning

Table 1 Best Practice Case Studies

An update of the work and an indication of findings will be presented at the conference.

Conclusions

All dimensions of the 6d framework are undergoing fundamental change:

- Changing organisations - eg networked organisations
- Changing nature of work - eg knowledge work, team work
- Changing expectations of users - eg work-life balance, expectations of service
- Assimilation of new technologies - eg ICE technologies
- New concepts of service - eg service experience, infrastructure management
- Shortening business cycles - eg agile organisations

The climate of corporate awareness and government sponsorship in the UK provides a golden opportunity to make a significant contribution to business effectiveness;
Current practice is naïve and misguided - but support the effort and build on the enthusiasm;
However, lack of vision and understanding, fragmented processes and inadequate tools will continue to blight progress;
Need to develop new tools for evaluating, using workplace performance appraisal methods and advanced internet technologies;
An action research approach, using case studies and best practice workshops can address the innovation challenge through learning partnerships.

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Information Systems for Real Estate Management

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Abstract
The paper[1] concerns with information systems for real estate management. The information systems can be considered as the fundamental supports to set up and manage planned maintenance, to develop and to apply strategic asset management, to have a register of the real estate, to monitor the technical and performance conditions of buildings and facilities, to record all significant maintenance works, to foresee building components behaviours and maintenance costs during real estate life cycles.

The paper analyses the structure, the aims, the requirements, the development phases, the software, the information categories, the data sheets of Information Systems in order to define the general characteristics and the critical aspects of a model of collecting and processing data. These elements are analysed in their general aspects and are exemplified through some experiences carried out, inside Polytechnic of Milan, by a Polytechnic of Milan group of researchers operating about the themes of planned maintenance and its knowledge support systems. The experiences concerns with the development of information systems for the real estate of Polytechnic of Milan and of the public social housing in the region Lombardia.

Keywords: maintenance management, information system, real estate, planned maintenance.

1. Introduction

Planned maintenance is becoming a priority in real estate management. It depends on the increasing consciousness of unplanned maintenance effects on: economic value, non-productive time, administration costs, functions, performances and availability of the buildings.

Many real estate management organisations are trying to change their maintenance strategies with the aim of an improvement of efficiency and effectiveness in processes: from maintenance workload characterised by a large number of small jobs occurring in an unpredictable pattern towards long term maintenance programmes that are based on prediction capabilities and that develop strategic action plans.

One of the main problem in this innovation process is the information management; it is almost impossible to develop planned maintenance without a systematised knowledge regarding:
- quantity consistence, identification, functions and location of buildings;
- technical characteristics and performances of the buildings systems;

[1] *the paper comes from a team work of the authors; specifically chapters 1&2 have been elaborated by G.Paganin, chapters 3,5,6 by C.Talamo and chapter 4 by C.Molinari*

- behaviour of building materials and components (durability, reliability, failure rate, etc.);
- cost maintenance indexes;
- logistic of maintenance works (time, workers, means, procedures)

For many years in real estate management the information collection and filing have been not organized. So at present a common problem is the unsuitableness or the complete lack of information about buildings and both private and public real estate managers are increasingly operating to develop Information Systems for building maintenance.

At Polytechnic of Milan a group of researchers, that has been working for many years on the themes of planned maintenance, is now developing information systems for building stocks. In the last four years the group has worked to develop Information Systems for the real estates of Polytechnic of Milan and of the public social housing in the region Lombardia. Some aspects of these experiences seem to be particularly interesting:
- the link between the operating experiences of real estate managers and the knowledge and methodologies coming from academic studies;
- the relation between planned maintenance themes and Information technologies;
- the possibility to transfer the experiences into a UNI standard (UNI 10951 Systems of information for the maintenance management of buildings. Guidelines – July 2001) that is becoming a reference standard for real estate operators.

The observation and the analysis of many elements rising from the experimental cases allow to elaborate theories, references, rules, methodologies and tools useful for the development and the use of information systems.

2. Systems of information for the maintenance management of buildings

2.1 Definition

An Information System for the maintenance management of buildings can be considered as a support system for decisional and operational activities that allows to collect, to file, to elaborate, to use, to up date, to communicate and to transfer information about the buildings and their parts; its aim is the efficiency and the efficacy of maintenance management activities in technical, economical and logistical fields.

The logical structure of an Information System for the maintenance management consists of:
- a *data base* that contains organized information, coming from different sources, collected through data sheets and put inside registers or log books;
- *procedures* that guide the different uses of information;
- *tools* that support the input, the elaboration and the extraction of the information.

2.2 The aims

An Information System has to act as a support for four connected actions constituting the maintenance management process of planning and programming:

1. to *decide*. It has to supply data to define real estate policies, maintenance strategies and priorities;
2. to *operate*. It has to supply data to define work schedule, frequency, contents and logistic of interventions;
3. to *evaluate*. It has to supply data to compare building performances with reference quality standards or with legal requirements;
4. to *foresee*. It has to collect data from the operations in order to supply data to define the behaviour of buildings and the maintenance costs trends. In the time, increasing information reduce uncertainty of foreseeing.

Therefore, an Information System for the maintenance management has the aim to organize the knowledge in order to:

- centralize and rationalize all information coming from different sources and operators;
- keep together and constantly update, during the life cycle of buildings, all information regarding the consistence, the quality, the performances, the costs, the interventions;
- spread knowledge, allowing all the users to receive information according to their functions;
- collect data for statistical elaborations.

2.3 The functions

An Information System for the maintenance management has three main functions:

1. *the registry function*, whose aim is to collect and to make available information regarding the identity of buildings. It is possible to have three registry levels:
   1.1. an *identification level*, regarding quantities (areas, volumes), functions, locations;
   1.2. a *technical level*, regarding the technical configuration of buildings, at different scale of analysis (from the complex to the details);
   1.3. an *administrative level*, regarding the administrative and legal aspects of buildings (e.g. the presence of encumbrances, legal constraints, etc.);

2. the *monitoring function*, whose aim is to collect and to make constantly available information about buildings quality coming from inspection and testing activities. It is possible to notice three kinds of buildings quality checks:
   2.1. the *technical performances*, noticing degradation phenomena, failures, failure modes, non compliance to quality or mandatory standards;
   2.2. the *functional performances*, noticing non compliance of rooms to functional or mandatory standards;
   2.3. the *environmental performances*, noticing different quality factors (e.g. thermo-hygrometric conditions, natural and artificial lighting, acoustical conditions, air quality and indoor pollution conditions);

3. the *historical function*, whose aim is to collect information coming from transformation and maintenance activities in order to keep the history of the buildings and of their parts, to draw deterioration processes and maintenance costs trends, to evaluate life cycle costs, to analyse materials and components behaviours.

3. Operators and development process

According to the experiences carried out in Polytechnic on Milan about Information System for the maintenance management, it is necessary to point out some aspects related to the operators and to the development phases.

3.1 The operators

An Information System for the maintenance management has to be strictly connected to the physical characteristics of the buildings, to the objectives and the policies of the real estate owner, to the strategies and to the work methodologies of the management structure (*figure* 1).

So it is to remark that an Information System for the maintenance management cannot be a generic knowledge management system, but it must originate from the specific real estate context and requirements.
In the experiences carried out in Polytechnic of Milan four subjects have been present during the whole process of development, each one bringing his proper skill and requirements:

1. the *client,* with the task to define property policies and economical aims;
2. the *maintenance management structure* that has knowledge about the buildings, that has the skill and the responsibility for the real estate management, that has specific needs coming from decisional and operational activities and that will use the system of information;
3. a *research group*, that studies the themes of planned maintenance and that has the task to transfer the different requirements inside the Information System structure;
4. an *information technologies structure*, operating in the field of software-based solutions, that has to support in the computerization process.

It is advisable that these four subjects are, in different ways, all present in the development phases of the Information System.

3.2 Development process

It is possible to state that the development process of an Information System for maintenance management is composed of four main phases:

1. the *brief phase* defines the guidelines for the system of information. In the brief phase all the maintenance management requirements are declared, all the uses of the Information System are settled, the financial resources and aims are defined, the software-based solutions are analysed;

2. the *design phase* that represents the setting up of the system and that is composed of three actions:
   2.1. the *definition of the logical structure*, that includes the determination of the data model, the development of forms and procedures, the individuation of contents and detailed levels of information;
   2.2. the *computerization*, that consists in turning the logical structure in a computer based system;
   2.3. the *test*, that consists in choosing one or more sample buildings through which it is possible to apply and verify the Information System functioning. From the test phase may arise problems that demand to change some parts of the system. This phase is also important to get information about the time (work hours) and the means (human resources, skills, tools, etc.) requested for data collection and data entry, in order to define a correct scheduling for the entire project;

3. the *implementation phase* that consists in collecting and inserting data about all the buildings. The collecting action depends on the state of knowledge and documentation available. In the case in which only few information are present, it will be necessary a long and probably heavy task of research and arrangement of information;

4. the *use phase* must be considered in its four components:
   4.1. the *utilization*, that regards all the actions of data extraction, consultation and elaboration;
   4.2. the *modifications* that can be necessary if problems appear during the utilization. The modification can regard the data model, the cataloguing modes, the widening level of information;
   4.3. the *updating*, that is a fundamental activity for the system of information. Without a constant updating action the Information System may became obsolete in few months. The updating must regard all interventions changing the original configuration (new realizations, transformations, replacements);
   4.4. the *registration of information* coming from maintenance activities (inspections and interventions), that is a very important action necessary for the growing of knowledge of the system.

   Inside use phase also the action of system *increase* must be considered; over time the Information System structure can grow according to new requirements, to new resources, to the evolution of maintenance strategies.

On the base of the experiences carried out it is possible to evaluate the different engagements in man/hours for each phase, as it is shown in *figure* 2 *and in figure* 3.

4. Suitable information, graduality strategy and flexibility for Information System for maintenance management

The effort for development and use of an Information System for maintenance management can be very heavy for a real estate management staff. Often it happens that Information System too complex and wide became soon obsolete and unused because there are not sufficient resources for a continuous updating activity. So, for the success of the system it should be right to assume three important rules:

1. *suitable information*. The quantity and the widening level of information must be suitable to the specific maintenance context (*figure* 1). The best Information System for maintenance management is not the most complete, wide and in-depth one, but those one that has been developed according to the maintenance management resources and uses, as defined in the brief phase;
2. *graduality strategy***.** It is very difficult to succeed in developing the whole system once and for all. On the contrary a successful strategy is to plan the growth phases of the system of information, according to the available financial resources and to the evolution of maintenance strategies (*figure* 4). At the beginning, the system consists only in a identification base, with few essential information and it is referred to corrective and emergency maintenance strategies. In the time the information coming from further surveys and from inspection and intervention activities will add knowledge useful for programming the maintenance interventions with an improvement of diagnostics and logistics, in order to achieve a rationalisation of corrective maintenance and condition based maintenance strategies. The information coming from maintenance activities increase the system knowledge allowing to execute statistical elaboration and to get preventive, periodic and predictive maintenance strategies;
3. *flexibility.* An Information System must be able to follow in the time the modifications and the evolutions in the maintenance management (staff, organization model, contractual procedures, requirements, etc.) in the real estate consistence and characteristics and in the references (laws and standards). It must be possible to adapt the Information System without loosing its logical structure and information already collected.

5. The Information System structure

According to the experiences carried on, an Information System for maintenance management can be defined through four aspects:

1. the logical structure;
2. the data collecting model:
3. the data sheets system;
4. the software;
5. the information form.

5.1 The logical structure

The way the real estate is represented defines the data organisation. In the experiences carried out by the research group, a hierarchic model has been assumed.

The real estate is subdivided according to different levels, from the most aggregate level (e.g. the whole real estate), to lower levels (e.g. the quarter or the block) till the building and its parts levels. *Figures* 5 and 6 illustrate the hierarchic model assumed for the Information System of the Polytechnic of Milan real estate, where the hierarchic model is articulated till the rooms functions and till the components and their parts.

Information are allocated at the different levels and can be transferred to the other levels according to the necessities.

5.2 The data collecting model

The data are collected according to two different ways:
- the identification information (i.e. the information regarding the location, the quantity consistence, the age, the functions, the technical description, the administrative data) are collected permanently inside *registers*;
- information coming from different sources (i.e. from maintenance interventions, price lists, work procedures, operating instructions) are collected inside *files*, and can grow in time according to the connection to other sources and to new interventions.

Elaboration has to be possible through the extraction and the relationship of information coming both from registers and files.

5.3 The data sheets system

The information are collected through the support of different data sheets.
For the maintenance management of the Polytechnic of Milan real estate the group of research has developed and implemented the following data sheets, according to the three system functions:

1. Register function=
   - *identification data sheet*, reporting the description data of each building (location, age, number of floors, etc.);
   - *functions data sheet*, reporting the destination data of each building and of its rooms (uses, users, facilities, use parameters standard, etc.);
   - *technical data sheet*, reporting the description of each building main construction and technologies:
   - *technical sub-data sheet,* reporting the technical description of some parts of the buildings;
   - *diagnosis data sheet*, reporting data about the main failure modes, defects and causes, predicted life span;
2. Monitoring function=
   - *diagnosis survey data sheet*, reporting data about buildings technical performances noticed during diagnosis surveys;
   - *functional survey data sheet*, reporting data about the functional performances of rooms noticed during surveys (regarding didactic equipments, devices, some building systems);
   - *environmental survey data sheet*, reporting data about environmental performances of rooms (thermo-hygrometric conditions, acoustical conditions, natural and artificial lighting, air quality and indoor pollution conditions, electromagnetic pollution);
3. Historical function=
   - *execute work data sheet*, reporting data coming from interventions or inspection (number of operators, hours worked, materials, tools, costs, maintenance strategy, etc.).
   - *calls and complaints data sheet*, reporting data coming from call centres (calls for maintenance, notice of failures, etc.)

5.4 The software

Once the Information System structure has been fixed, it is very important to choose a suitable computer based application.
It is possible to define two main strategies:

1. a *relational data base*. This strategy means the organisation of information collected inside tables and usable through pre-fixed links;
2. an *object oriented software*, that means operating according to a logical model represented as a hierarchical structure, constituted by objects. To the objects are allocated attributes (the information). The queries of the system happen in a very free way, by looking for, selecting and connecting objects on the basis of their attributes.

In the experiences carried on for the real estates of Polytechnic of Milan and of the public social housing in the region Lombardia, the research group has opted for an object oriented software, considering very important, for the maintenance management context, the flexibility of use and the possibilities of increase of the system allowed by this kind of computer based application. In these experiences the group of researchers has used the object oriented software X-World distributed in Italy by Harpaceas company, that has acted as a partner in the development of both the experiences.

5.5 The information form

Inside the information system two different forms of information can be present:

1. *alphanumeric form*, i.e. texts and numbers;
2. *graphic information*, i.e. drawings (raster and/or vectorial computer based drawings).

These two kinds of information can be present and processed inside the information system in different ways:

- only information in alphanumeric form are present. The reference to the drawings is carried out through the mention to some information about them (i.e. reference number, location, scale, author, etc.). This strategy has been assumed in the information system of the public social housing in the region Lombardia*,* where many and heterogeneous information were present spread in the different provincial administrations. Therefore the effort has been concentrated on the collection and standardisation of available descriptive information, instead of trying to transfer to computer a too large load of drawings. This can be considered a level of the Information System common to all public social housing in the region Lombardia. Afterward, some provincial administration, if interested, will add graphic information, according to graduality criterion;
- information in alphanumeric form and in graphic form are present and linked but not integrated, i.e. elaboration regards only alphanumeric information;
- information both in alphanumeric and in graphic form are present, are linked and integrated, i.e. elaboration acted on alphanumeric information are transferred to graphical information. For instance, it is possible to select some data (e.g. all buildings that are forty years aged, or all the rooms with didactic function) and to visualise all the drawings containing that information (*figure* 7); vice versa by selecting a drawing, or a part of it, it is possible to know and to elaborate all the related data. This strategy has been assumed in the information system of

Polytechnic of Milan, where already many information were present inside the maintenance management structure and most part of drawings were computerised.

6. Conclusions

In real estate management, Information systems are an essential support for all the processes regarding both the control of technical performances and economic values of buildings, and the optimisation of interventions logistic. In Italy, the delay in spreading planned maintenance strategies in real estate management is mainly due to the lack of practice in collecting and processing information about buildings quantity consistence, characteristics and behaviours.
Different conditions are necessary for a change in the real estate managers behaviours:
- the *involvement of all the operators in the process of information production*. Architects and engineers should include inside their projects all information and documentations necessary to know and to maintain the buildings; maintenance operators should record their activities; real estate managers should request and collect all information regarding buildings performances and maintenance activities; components and materials suppliers must declare behaviours and maintenance needs in the life cycle of their products. All these operators need to have reliable references about the kind of data and the way in which the information regarding their activities have to be arranged;
- the *availability of information system models* to which the real estate managers can refer to develop information systems suitable to real estate characteristics, to maintenances policies and to management models;
- the *availability, inside real estate management staffs, of skills and professional figures* able to manage information systems and to link data to maintenance processes.

These conditions are now coming true, step by step, through an evolution process regarding some aspects as:
- Researches and experiences – like the ones described in this paper and others realized both in public and private real estate (see references 1- 6) - have been developing during this years. These experiences may work together to define common models of information systems and to spread a general cultural approach to information management.
- UNI (Italian national standard organisation) is collecting many contributions arising from academic and operational fields and is developing an important base of reference (see references 7-10) in connection with European standardisation context,
- The themes of planned maintenance and of information system have been assumed inside many different Italian didactic organizations (to give some examples, Masters, Specialist Degree and PhD courses in Real Estate management in Polytechnic of Milan and Specialist Courses in University of Naples “Federico II”).

In the next years it will be very important to go on in this process of spread of experiences and contributions and it will be necessary, through new studies and debates, to deepen some aspects still problematic as the following ones:
- the role of Information systems inside Total Facilities Management approaches;

- the information system management with respect of outsourcing policies and in the presence of Global Service contracts;
- the links between Information systems and Decision Support Systems
- the role of information system as a key tool to monitor the performance of the processes of maintenance management within the frame of quality management system.

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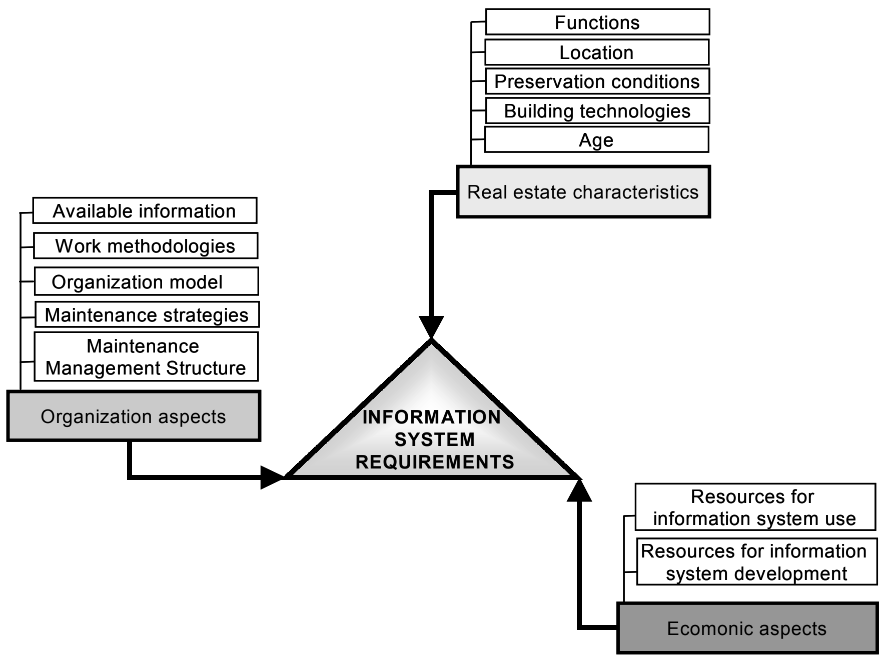

Figure 1. The set of aspects conditioning information system requirements

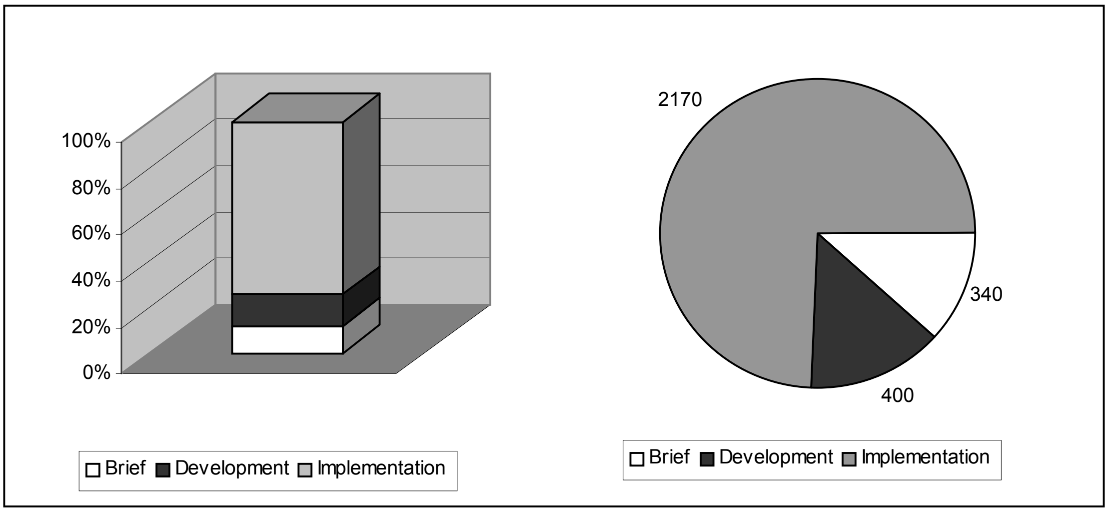

Figure 2. Man/hour (in percentage and absolute value) for each phase of realization. The data of sample regards approximately 300.000 square metres of an university real estate composed of a heterogeneous stock of buildings.

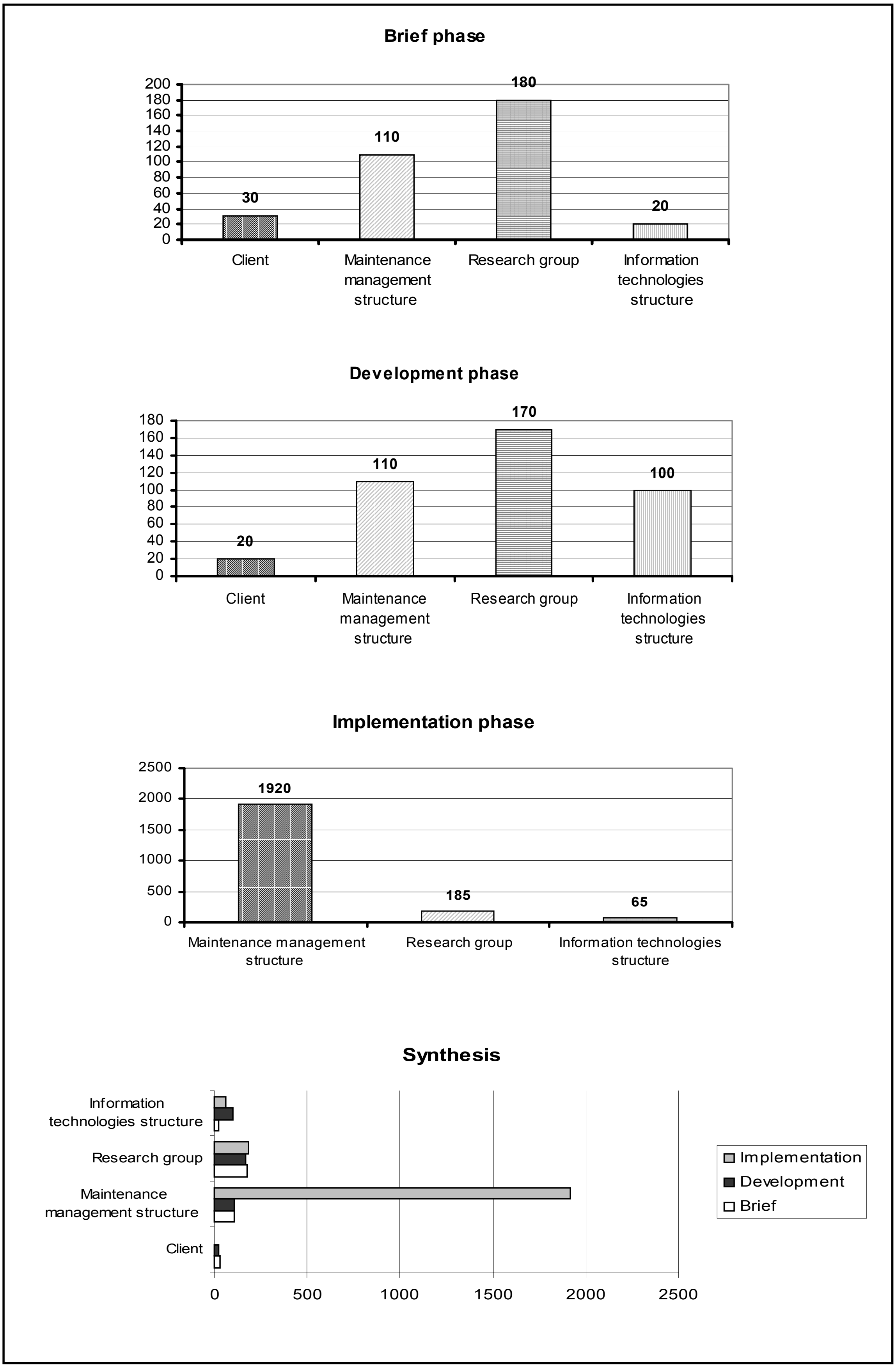

Figure 3. Man/hour of task for the four roles in each phase of realization. The data of sample regards approximately 300.000 square metres of an university real estate.

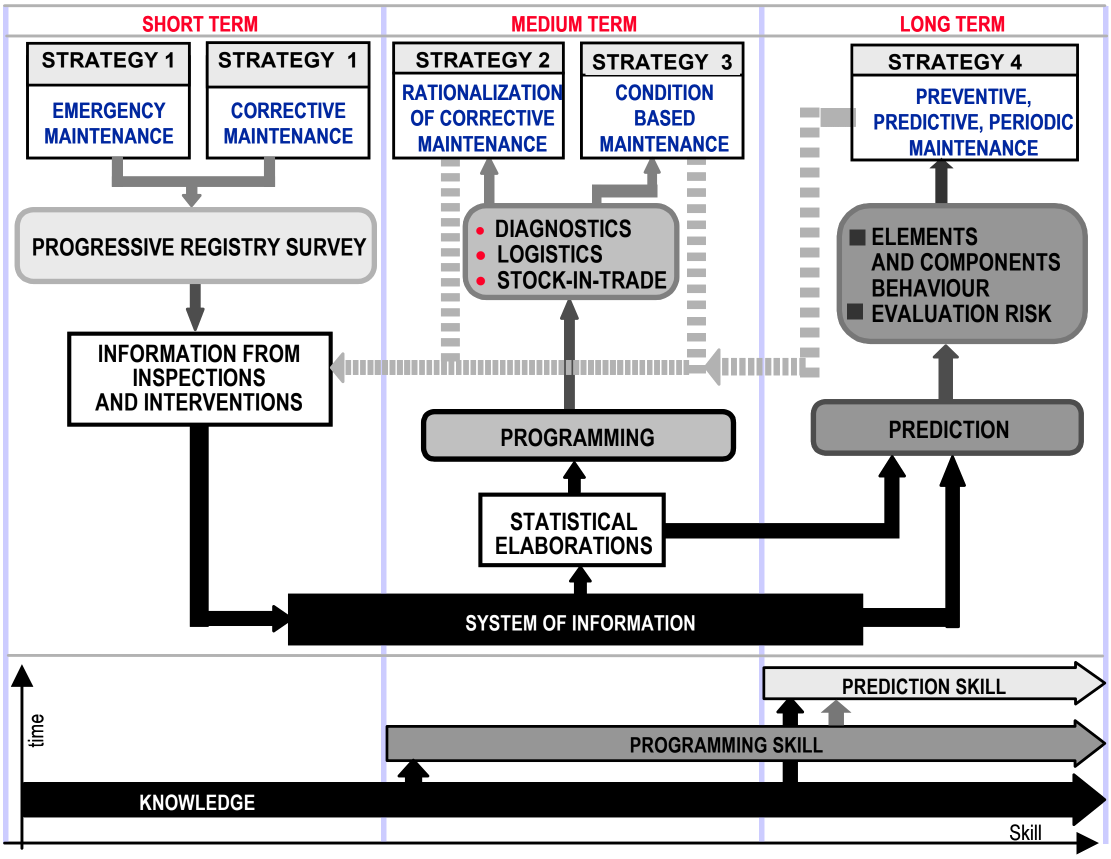

Figure 4. Graduality in information system development: the relationship between evolution of maintenance strategies and information system growth.

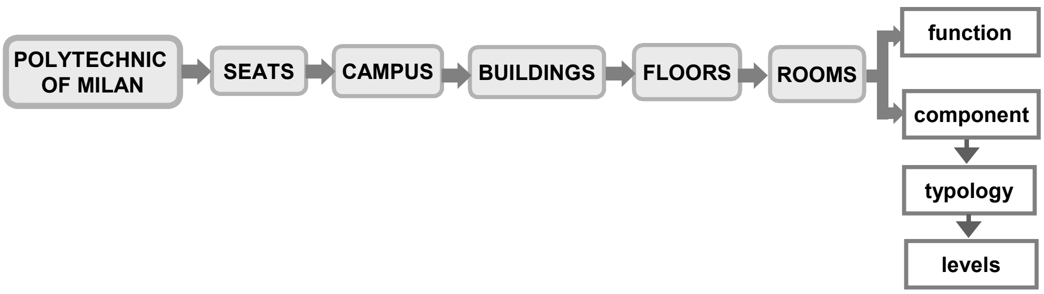

Figure 5. Example of hierarchic structure assumed for the design of the information system for the Polytechnic of Milan: logical scheme.

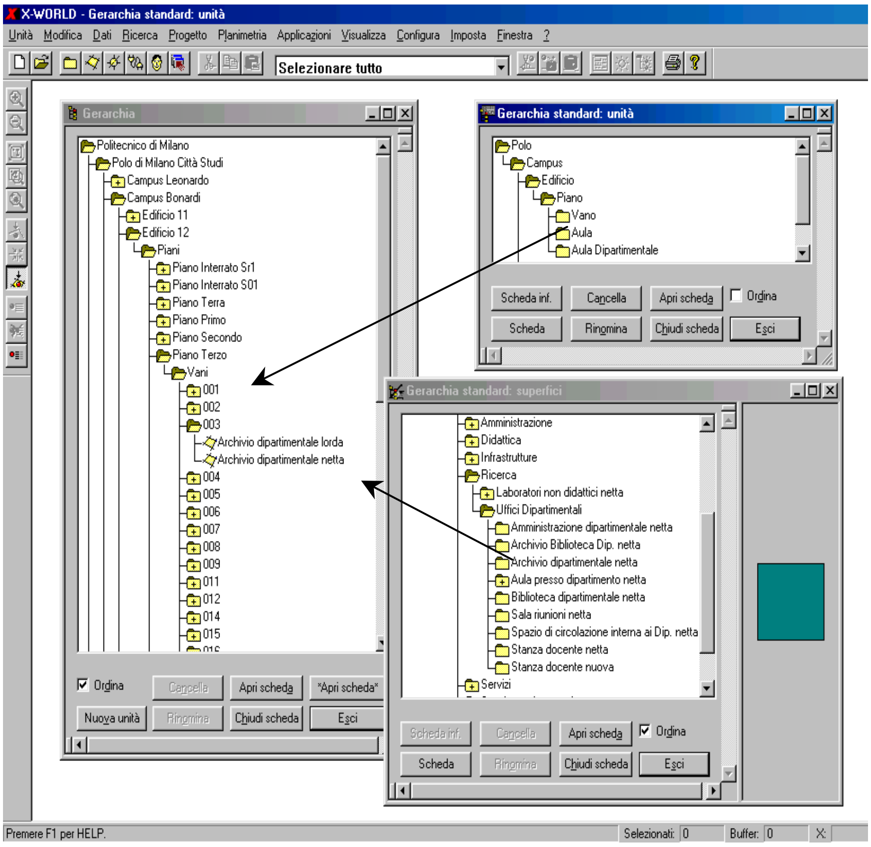

Figure 6. Example of hierarchic structure assumed for the design of the information system for the Polytechnic of Milan. application of the hierarchic structure through the software X-World.

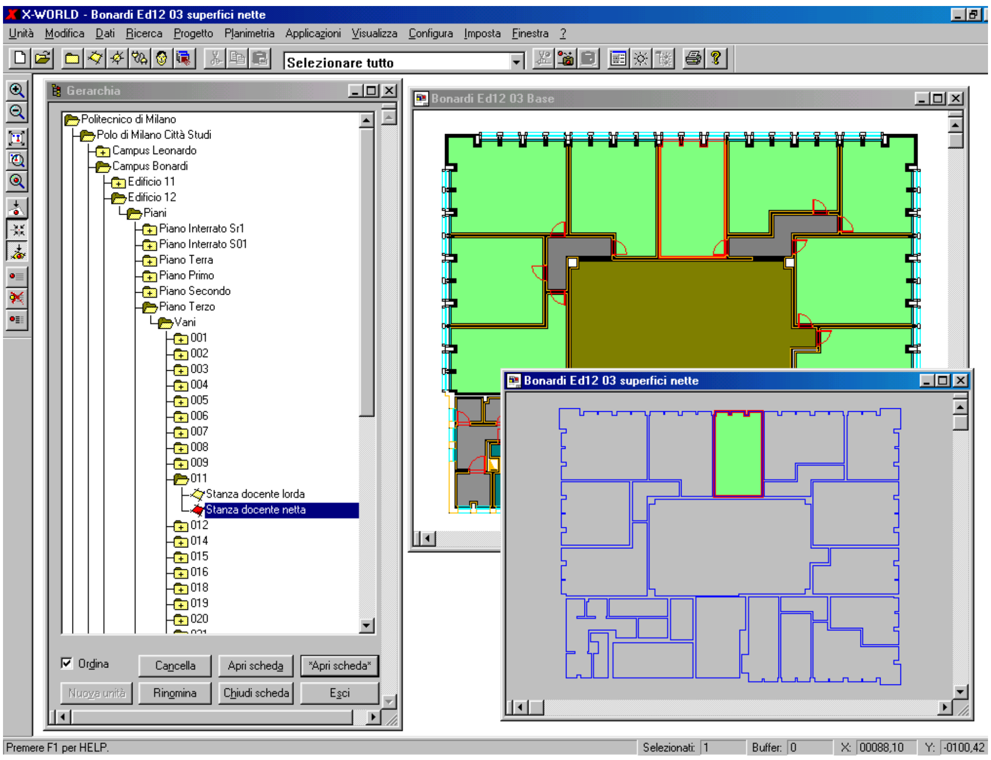

Figure 7. Example of interaction between information in alphanumeric form and drawings, derived from the information system for the Polytechnic of Milan. Computer based application with the software X-World

Workplaces

Better value and safety for refurbishment projects through use of new standards

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Abstract
Accident statistics in the UK show that in the construction industry the current trend is for a high proportion of fatalities to occur during some form of refurbishment or renovation activity, and this is often after some form of collapse of part of the structure where work had been taking place. This reflects to some extent the growth in the industry where more and more projects are related to work on existing buildings and structures than new build, whether green field or brown field. A British Standard was published towards the end of the year 2000 that provides significant assistance to those involved in refurbishment projects, such as clients, developers, consulting engineers, architects, contractors, and including those companies involved in refurbishing their own premises. It has been found in a current research project that many of those involved in refurbishment are not aware of the standard because it is called a Code of Practice for Demolition and thy do not see removing parts of a structure is a demolition process even when the work can affect structural stability. The contents of the standard are written, however, to significantly contribute to works where there is partial demolition or partial removal of a structure, such as in refurbishment projects. This paper describes some of the contents of the standard, which are of benefit to those involved in refurbishment and building rehabilitation works. The paper also introduces another standard, which is European Standard, which is due to be published in 2003. It will be the first such document to include design criteria for the assessment of structural stability for refurbishment works. The author of this paper was chairman of the technical drafting committee that produced the British Standard Code of Practice on Demolition (BS 6187:2000), and which is believed to be the only such document of its type world-wide. He is also chairman, or convenor, of the European drafting committee that is developing prEN1991-1-6 Actions during execution.

Keywords: refurbishment, health and safety, structural stability, demolition, design criteria, standards

Introduction

Industry culture

Investigations have shown that where there is work that requires removal of part of a structure where buildings or other structures are being refurbished or renovated, those involved do not usually see those removal operations as demolition. Also they may possibly not even see it as a structural engineering activity and therefore one that requires effective design coupled with appropriate management which may include monitoring during the removal activities. Terms such as deconstruction and dismantling are used, and these are not related to the activity of demolition. In one research workshop example there was a group of senior managers representing various interests in refurbishment projects. They included speculative developers, designers such as consulting engineers and architects, main contractors, specialist contractors, clients and companies who were involved in refurbishing their own premises. They were involved in larger scale refurbishment jobs usually on older buildings where there was usually removal of a significant part of the structure such as when facades only were to remain. Other examples of projects, however, were of multiple dwellings such as rows of town houses. They did not feel that were involved with demolition because they saw demolition as an imprecise activity that removed whole buildings or structures and probably using a demolition ball. Semantics within the culture therefore becomes important. They felt that even where substantial demolition activities, such as where whole buildings were removed except for façades were to be retained, the process was still not demolition. Some terminology used can be seen in Table 1.

	Refurbishment		Development		Deconstruction
	Renovation		Enlargement		Dismantling
	Rehabilitation		Extending		Disassembly
	Rebuilding		Augmenting		Demounting
	Remodelling		Conservation		Partial demolition
	Reconstruction		Modifications		Removal
	Redevelopment		Alterations		(Demolition)
	Restoration		Structural alterations		*
	Renewal		Upgrading		*
	*		*		*

Table 1: Some terminology used where there were demolition activities

In the workshop the planning and the management activities they talked about prior to operations, as well as the actual operations undertaken in the process were an inherent part of the UK British Standard Code of Practice on Demolition, BS 6187: 2000. It was shown that it would have been a substantial advantage to them in their work to be aware of the standard. It was thought that BS 6187 was one of the best-kept secrets in industry! Perhaps the truth is that because of their view of what demolition comprised they did not enter that word in their database searches when seeking information for their refurbishment activities.

This paper contributes to the “unlocked” of some of those “secrets”.

Advice through standards and codes

A standard is under development that will complement BS 6187: 2000. It is part of the Structural Eurocodes suite of documents being developed for the European Standards Body – Comité Européen de Normalisation, or CEN as it is usually known.

The standard deals with loads and loading conditions to be taken into account when planning and designing construction processes, processes that include refurbishment and partial demolition. The latter processes have now been specifically included in the current draft of that Eurocode. This is a first recognition of these activities in an international standard, and particularly where they are part of a designed process, it is believed. The standard will be known as prEN 1991-1-6 Actions on structures – Actions during execution. It is currently due for publication in the year 2003.

Both standards take account of refurbishment and partial demolition activities to different levels, and this paper outlines those aspects of both standards. It will describe the significant contributions, and thus the benefits, that can arise from implementing their use for the planning, execution and management of refurbishment projects, where some alterations to the structure will take place.

Accident background

There are many examples where refurbishment works have, unfortunately, resulted in deaths and serious injury, usually to the workforce, but which also includes management and supervisory levels, and also occasionally to members of the public. Collapses also occur where, luckily, there is no personal injury but properties are left in partially unstable states and where the degree and extent of instability has to be managed to a point of safety. This can, of course, mean removal of material by remote demolition machines, but can also mean introduction of some means of creating temporary stability pending further works to improve longer-term stability. The latter in itself can create further risks in order to enable the continuation of the refurbishment activities. Such events can of course be extremely expensive and also cause delays, sometimes of a significant nature to the remodelling of the premises and thus a delay in bringing the newly refurbished property into service and thus into a revenue earning stream.

An understanding of the activities where fatalities have occurred in the UK in the year 2000 to 2001 are shown in Figure 1. They are indicative, and give a feel for where types of occurrences occur.

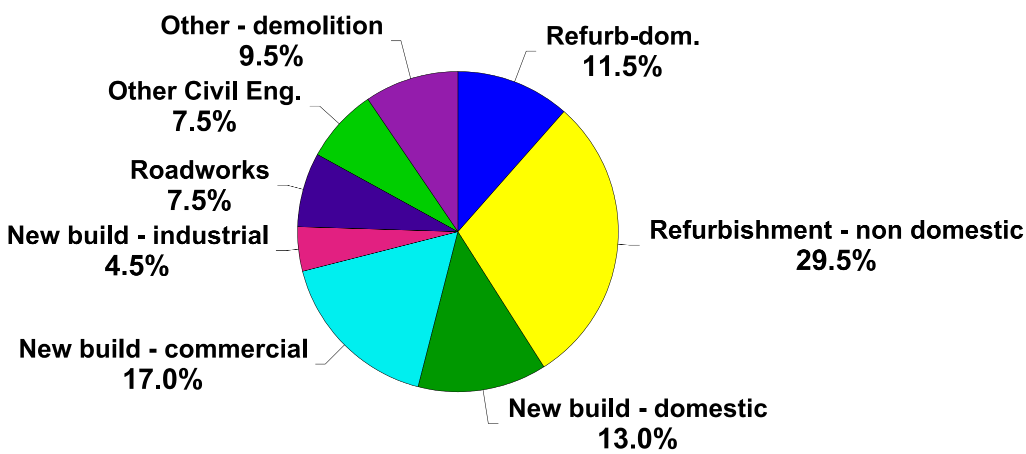

Figure 1: Indication of proportion of different activities undertaken in UK when fatalities have occurred in years 2000 / 01

It can be seen from the figure above that the provisional indicative fatalities in refurbishment for 2000 to 2001 account for 40.5% of fatalities in the construction industry. Further indications are that they occurred on an approximate 50/50 split between large sites and small sites, and a split of approximately 20% to large contractors and 80% to smaller contractors. Indicative figures for 2001/02 are that the number of fatalities on new build sites has decreased, but that the figures on refurbishment sites has remained at the about the same level.

Risks in refurbishment

So why the higher risk in refurbishment and partial demolition projects compared with new build projects? They tend to be:

- Increased activity - more sites.
- More, smaller, one-off clients.
- Smaller companies undertaking the operations.
- Different levels of competencies of those companies undertaking the work (for example, they may be quite competent for construction works without any partial demolition but the presence of some partial demolition may not be within their competency to deal with – which they may not even realise).
- Management and workforce issues – easier to deliberately cut costs and time, as not all work can be seen so easily.
- Even more essential to have a greater and intimate knowledge of the building and its structure.
- Poor communications, including the variety of terminology used and the potential for misunderstandings.

The rise of more sites with this type of work can in part be linked to the sustainability and environmental agenda where there is less of an inclination to fully demolish structures and where there is more of a climate in which older structures are renovated and rehabilitated. Whereas this can be seen as a generally acceptable agenda to pursue, the health and safety issues should not be compromised and need to be properly taken into account and effectively managed.

Risks are introduced through working closely with, and within, the structure and include breaking out and removal of material, some of which may weaken structural elements – and thus compromise structural stability. Activities may also be to add material, possibly for structural strengthening, or just as part of the fabric of the renovated structure. There can also be an extremely complex proximity relationship between different trades and activities, particularly at the removal and construction interfaces. The important health and safety issues with this type of work is that people are not safe by distance alone. Safety by distance tends to be the way in which full demolition projects are now managed by using remote working techniques with suitable machines – that is, a philosophy of removing people from places of (potential) danger.

What are the main problems? Structural instability and health issues are seen as the two broad main issues. Under structural instability the main problem areas are non-deliberate and premature collapses where any portion of the structure from small to large could collapse. Under health issues the problems tend to be inherent in the structural materials such as pressure treated timber and those introduced by former occupiers such as pathogens and needles used by drug addicts. Other potential health problems may arise from the more well known dust, noise and hand arm vibration issues, for example. Thus managing these away would greatly improve the health and safety statistics on such projects.

The types of structural instability that occur include localised smaller portions of buildings, progressive collapses leading to large portions of structures perhaps being reduced to rubble, and disproportionate collapses where the initiating event are seen to be quite minor compared with the extent of the collapse outcome.

Collapses tend to occur for either one reason, or a combination of reasons, from the following:

- Over estimation of structural integrity;
- No estimation of structural integrity;
- Accumulation of smaller weakening activities; and
- Inappropriate weakening which can be progressive, intermittent, random or major.

So what needs to be done? The answers may be obvious, but implementing them is not always easy. Simply, to prevent unplanned collapses, which may be premature collapses, structural stability needs to be assured. There is a need to design for foreseeable events which can be anticipate, and then obviate any which may be harmful. In other words all those responsible should "*reduce the opportunity for error and thus for unplanned collapses*".

During its life of course a structure often suffers from diminishing factors of safety through for example:

- Extent and effectiveness of maintenance, where poor cases may allow ingress of water, for examples;
- Deterioration, such as corrosion and rot;
- Dilapidation;
- Alterations and/or modifications resulting in poor quality;
- Misuse for example overloading of floors of vehicle impacts;
- Environmental effects such as flooding and climatic actions;
- Movement for example subsidence and vibration.

Structural stability during execution requires effective management using the criteria mentioned above. Effective communications is essential and the need for feedback of unexpected discoveries (of the structure) as work progresses is essential. Communications need to be reliable and predictable – and within this context, two way. Factors to be taken into account when planning effective communications include:

- Workforce / management language barriers;
- Workforce/management ability for misunderstandings, including semantics;
- Extent of the number of levels of sub-contracting for control;
- Number in chain for control to pass through;
- Importance of workforce not taking their own initiatives for what could be described as unplanned activities.

Structural stability, design needs to be considered on a risk basis. Such design should include, as appropriate, for pre-weakening design which should include temporary works design; pre-strengthening design which will include temporary works design; and planned collapse breakout design which should include design for stability remaining parts.

Specific and positive thought needs to be given to what will be holding the structure, or parts of the structure, in place when they are specifically required to be in place. These could include adjacent structures and the need for any temporary or permanent works both on the structure being refurbished as well as any adjacent structures. An example would be the construction of buttresses at gable ends. Temporary structures, or auxiliary structures, could include falsework solutions such as façade retention systems and varying through to simple propping such as screw jacks.

Competencies of contractor's workforce can be difficult to assess but need to be known for an effective job to be completed. A competent person could be seen as "a person who has training and experience relevant to the matter being addressed and has an understanding of the requirements of the particular task being approached". Thus questions to help in the assessment of competency could include:

- Previous experience of the exact type of work – and duration;
- Which sites have personnel worked on?
- Which sites have the contractors worked on?
- How long ago was this work experienced?
- What were the outcomes and were they successful outcomes or not, and what were the details?
- What were their particular responsibilities?

The succeeding degrees of competencies in the management chain need to be examined. Perhaps an important question would be to ask what degree of confidence can those responsible have in the continuing health and safety, including structural reliability, during the refurbishment activities.

Advice through standards and codes - to help reduce risk

An overview of two codes giving advice on relevant health and safety practice are described. One is a relatively new UK code, and the other is a developing European document, currently due for publication during 2003.

British Standard BS 6187:2000 Code of Practice for Demolition

The standard addresses many issues in the refurbishment, partial demolition and demolition processes. These are from procurement through to completion. It deals with many aspects, in addition to health and safety, to help in the efficient and effective planning and running of a job. It helps those responsible to identify and manage the real hazards and the real potential risks involved.

The philosophy and aims of the standard include being relevant to all those involved in the process, including clients, and clearly describes responsibilities, including those for predemolition activities. It also includes advice for now and for the future, including new technologies and new law. As with any standard however it is not a textbook, but sets out the prime factors to be considered for any such project. Topics in the Standard include:

- Project development and management;
- Procurement;
- Knowing the site including site assessments;
- Risk assessments;
- Decommissioning procedures;
- Environmental issues;
- Structural stability before and during activities, including façade retention;
- Safe working areas and exclusion zones for work activities.

The format of the code is designed to make the information readily accessible. The format generally follows the flow of the process and can be used in an in iterative way, starting with the client where, for example, tender processes are expanded once a contract has been let. A full contents list can be seen at Appendix A. An innovation in the British Standard is the use of route maps to guide the user swiftly to the points of advice that they require. Figure 2 shows an example of a route map and Appendix B gives a list of the figures included in the BS.

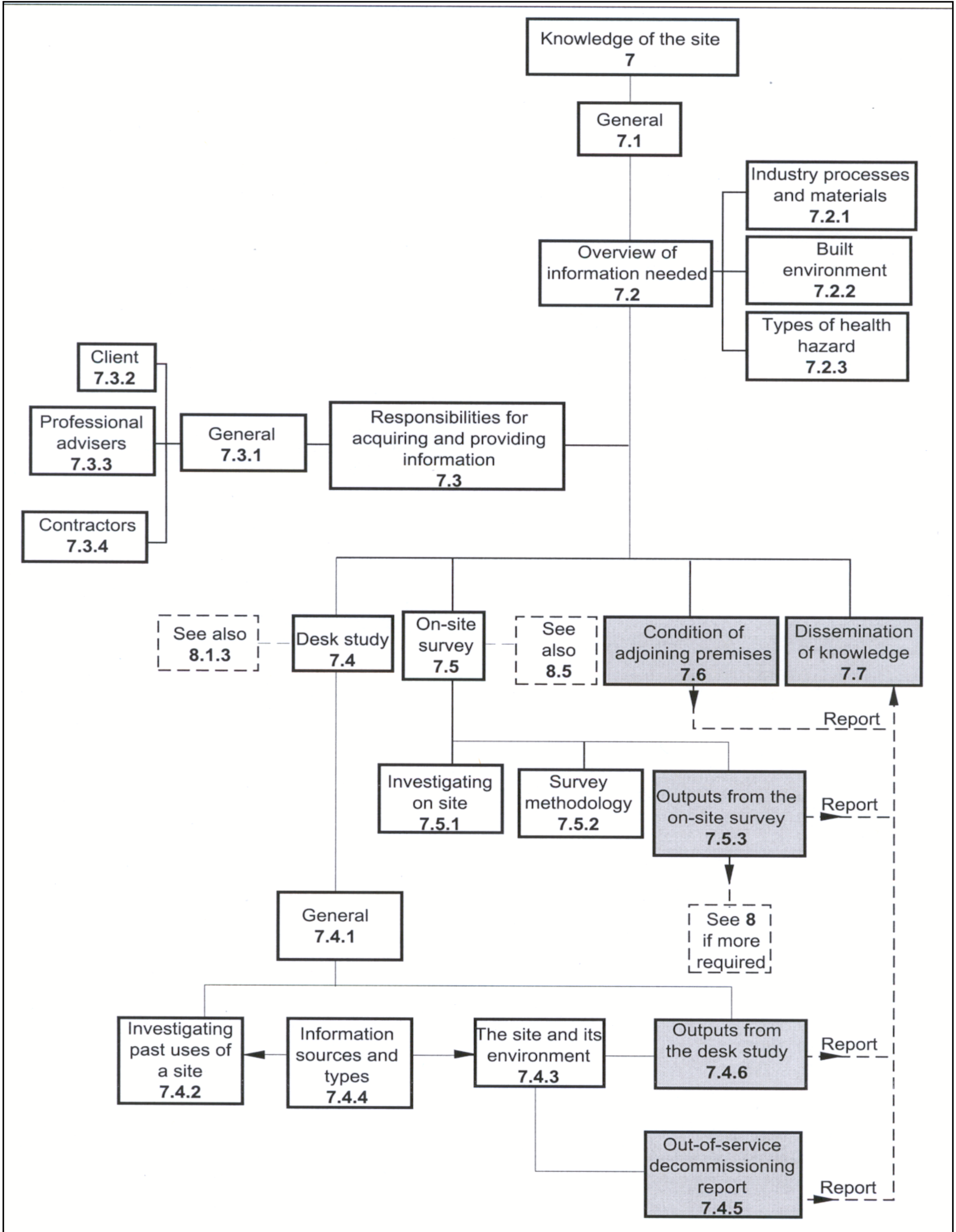

Figure 6 — Route map for clause 7

Figure 2: An example Route Map in BS 6187: 2000 which demonstrates the essential initial activities for the start of a refurbishment project

As in refurbishment work the proximity of people working on various activities can affect each other, the awareness of the effects on others needs to be planned, with safe working spaces adequately implemented. Significant guidance is given in BS 6187: 2000 with respect to safe working areas and exclusion zones. Specific advice includes:

- Purpose of exclusion zones;
- The zone as part of the safety regime;
- Applications of the zone;
- Designing the zone:
  - Assessment;
  - Areas of exclusions zones;
  - Hazards to be considered;
  - Reduction of zone sizes.

Structural Eurocode EN1991-1-6

The Eurocode prEN 1991-1-6 *Actions during execution* gives actions (or loadings) to be considered during construction and other related activities. As so far drafted, it provides principles and general rules for the assessment of actions, climatic and environmental influences which should be considered, and designed into the execution stages of buildings and civil engineering works, including structural alterations such as refurbishment and rehabilitation. The term “construction” therefore should be seen the wider context of the industry as a whole in that it includes more specialized activities such as partial and full demolition.

Significantly, as well as being applicable to “permanent” structures, the Eurocode also applies to “auxiliary” structures. Auxiliary structures are considered as non-permanent structures, as well as any other works associated with the main activities which are to be removed after use (e.g. falsework, façade retention systems, scaffolding, propping system, cofferdam, bracing, launching nose). However, the code does not give design rules for these structures. These are being developed under a different series of CEN Codes by different teams. Those codes will, however, refer to EN 1991 for actions to be considered for their design when all the relevant codes are completed.

Principles and application rules are given in the Eurocode for the determination of actions and also for environmental influences that are to be considered during execution stages of buildings and civil engineering works. These actions include:

- selfweight of structural and non-structural elements;
- geotechnic actions;
- prestressing;
- predeformations;
- temperature, shrinkage, hydration effects;
- wind actions;
- snow loads;
- water actions;
- atmospheric ice loads;

- construction loads;
- (some) accidental actions;
- seismic actions.

Actions are to be classified for climatic and environmental influences as well as construction loads, for example. Construction loads are those that can be present during the execution activities, but are not present on completion of the works. Construction loads are deemed to be those, which are caused, for example, by cranes, equipment, auxiliary structures and these are to be classified as fixed or free actions. Where construction loads are classified as free, the limits of the area where they may be moved or positioned shall be determined. Where construction loads are classified as fixed, tolerances for possible deviations from the theoretical position shall be defined.

Construction loads are described in the document and include:

- working personnel, staff and visitors, with small site equipment;
- storage of movable items (e.g. building and construction materials, precast elements, and equipment);
- non permanent heavy equipment in position for use (e.g. formwork panels, scaffolding, falsework, machinery, containers) or during movement (e.g. travelling forms, launching girders and nose, counterweight);
- moveable heavy equipment in free movement (e.g. cranes, lifts, vehicles, lift truck, power installation, jacks, heavy lifting devices);
- loads from parts of the structure under execution before the final design actions take effect, (e.g. fresh concrete, loads due to the process of construction such as assemblage);
- accumulation of waste materials (e.g. surplus construction materials, demolition materials).

A full contents list can be seen at Appendix C.

Conclusions and recommendations

The basis of responsibility for safety can be summed up as “the risk creator should be responsibility for ameliorating the risk”. In other words the initiator of a refurbishment project should be aware of any risks created, and thus their direct responsibilities for their duty of care, as well as their criminal duties. Where required they should ensure that they receive adequate professional advice. A summary of critical factors in refurbishment and partial demolition projects includes:

- Knowing the structure;
- Assessing what to do;
- Deciding the way to do it, bearing in mind all appropriate responsibilities;
- Communicating what should be done;
- Managing what should be done to ensure what is planned actually happens;
- Ensure contingency planning for the unexpected.

To help discharge obligations and to help an efficient and effective job BS 6187: 2000 Code of Practice for demolition and prEN1991-1-6 Actions on structures: actions during execution, provide excellent assistance. It is important, however, that terminology used in the industry does not restrict access to available helpful documentation, the use of which could lead to benefits such as improved value and safety levels. The above codes are documents that have been written on the understanding however, that the execution of its provisions are entrusted to appropriately qualified and competent people. This is important and as it is seen that the clients have prime responsibilities, and have the prime power to ensure good and effective jobs. The contents of the above Codes of Practice are recommended to them and all those involved in the refurbishment process.

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APPENDIX A

UK standard, BS 6187: 2000 Code of practice on demolition

Contents

Annexes

APPENDIX B

List of figures in BS 6187: 2000, including the Route maps, which will help with refurbishment projects

Figure 1	Outline route map
Figure 2	Flowchart for the maintenance of structural stability during demolition
Figure 3	Illustration of the definitions of base machine, equipment and attachments
Figure 4	Legislative overview route map
Figure 5	Planning and managing projects route map
Figure 6	Knowledge of the site route map
Figure 7	Decommissioning procedures route map
Figure 8	Structural hazards route map
Figure 9	Health hazards route map
Figure 10	Protection of the environment route map
Figure 11	Health and safety of persons on or off site route map
Figure 12	Safe working spaces and exclusion zones route map
Figure 13	Terminology of designed exclusion zone and its constituent parts
Figure 14	Example of designed exclusion zone showing practical application
Figure 15	Example of design exclusion zone (phased and partial demolition)
Figure 16	Example of reduced exclusion zone by the use of containment
Figure 17	Example of safe working space within an exclusion zone
Figure 18	Principles of structural demolition route map
Figure 19	Avoidance of unplanned structural collapses route map
Figure 20	Temporary structures for stability and access route map
Figure 21	Demolition techniques route map
Figure 22a	Typical demolition methods for various types of structure route map
Figure 22b	Typical demolition methods for various types of structure route map

APPENDIX C

CEN Structural Eurocode, prEN 1991-1-6 Actions during execution

Contents

Evaluating workplace utility

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Abstract: *Acquiring office buildings that provide the required level of utility, and retaining them in that state, is an important management function for any organisation (Bruhns and Isaacs, 1992). Failure to do so may result in increased rates of churn, reduced productivity, higher employee turnover, increased staff absenteeism and rising health care costs related to on the job stress (Building Research Board, 1993). There is, however, no single measure of utility for office buildings (Salway, 1986; Bannock et al., 1992). This paper discusses the results of research, the aim of which was to develop a valid and reliable scale for measuring the utility of public sector office buildings. Data collection involved the use of focus groups and an on-line survey of 1800 building occupants. The findings show that the workplace utility construct can be described by a 22-item scale and is comprised of four dimensions:*

- *Appearance (aesthetics of building interior and exterior);*
- *Configuration (quantity and layout of space);*
- *Environment (occupant comfort and control of indoor environment);*
- *Functionality (privacy and adequacy of workspace).*

Before concluding, this paper highlights potential applications of the scale and describes its use in current research.

Keywords: Factor analysis, Focus group, Office building, Public sector, United Kingdom.

Introduction

Office buildings are a key resource for all types of organisations, both public and private (Gibson, 1994; Bruhns and Isaacs, 1992). There is a common understanding of an office building as a workplace that accommodates the information and knowledge processing activities of an organisation, including filing, planning, designing, supervising, analysing, deciding and communicating. Office buildings developed from the need to plan, coordinate and administer these activities (Aronoff and Kaplan, 1995). Acquiring suitable office buildings, and retaining them in that state, is an important management function for any organisation (Bruhns and Isaacs, 1992). Failure to do so may have an adverse affect on building users. The users of office buildings include occupants (employees who work in the building), senior managers or executives in the organisation (who may not necessarily work in the building) and visitors, including members of the public, who have business in the building (Gray and Tippett, 1992).

Occupants are the true end users of office buildings. The notion is slowly taking hold that occupants should be treated as valued customers by the providers of the office facilities they occupy (Szigeti *et al.*, 1997). High priority should go to meeting the needs of occupants, ensuring that their workplaces provide the required level of utility at an acceptable cost. The word 'utility' is used in this study to indicate 'usefulness or a potential capacity to provide a service' (Salway, 1986; p.50). Over time the level of utility provided by an office building will vary as shifting political, economic, social and technological conditions result in changing occupant expectations (Ohemeng and Mole, 1996). When the level of utility falls below that required by occupants, there is a risk that organisations will experience increased rates of churn, reduced productivity, higher employee turnover, increased staff absenteeism and rising health care costs related to on the job stress (Building Research Board, 1993).

This risk is of concern to public sector organisations in the UK. Public sector office buildings are valuable assets that can provide long and high-quality service if managed effectively. Public sector organisations have a responsibility to make best use of their office buildings in order to optimise returns on public assets; failure to do so may impose significant costs on building occupants and, ultimately, the public at large (Building Research Board, 1993). In many public sector organisations this responsibility rests with facility managers, since they are concerned with workplace issues that immediately affect building occupants (Avis *et al.*, 1993). The dynamic nature of change within the public sector means that it is critical that facility managers are able to determine whether office buildings are providing the level of utility required by occupants, thereby enabling management attention 'to be drawn to or prioritised in relation to areas of potential obsolescence' (Bottom *et al.*, 1999; p.355).

The divergence of actual utility from required utility presents two problems for facility managers: first to identify and secondly to quantify the difference in utility (Aikivuori, 1996). Techniques such as Post-Occupancy Evaluation, ORBIT 2.1, Real Estate Norm, Serviceability and Building Quality Assessment have been developed to provide consistent, reliable measures of various facets of office building performance (Baird *et al.*, 1996). However, none of these techniques are suitable for measuring workplace utility as defined in this study, and if they were, they are, in the main, expert-based techniques (Bottom, 1996). In defining workplace utility there is a degree of subjectivity on the part of occupants, as the utility of a building is a function of individual perceptions and expectations (Williams, 1985). At the same time, it is often difficult for occupants to articulate their expectations and perceptions in language that can aid facility managers (Gray and Tippett, 1993).

The overall aim of the research underpinning this paper was to develop a scale that could be used by facility managers to elicit the opinions of occupants regarding the utility of their workplace. This paper presents the results of the research. It begins by explaining the background theory underpinning the measurement of utility in the research. This paper then discusses the data collection methods used for selecting and revising the scale items. The third section of this paper discusses the data analysis used to identify the critical factors and significant scale items. Before concluding, this paper discusses the results of the research, the potential applications of the scale and outlines areas for further study.

Background theory

In order to develop a scale that could be used to measure workplace utility it was necessary to fulfil two measurable objectives: first, to develop a valid and reliable scale for measuring the utility of public sector buildings; and second, to test the scale by evaluating the utility of a public sector office building. The method employed in the research was based on Churchill's (1999) procedure for developing multi-item measures of social constructs (Table 1). This procedure was used to ensure that the final scale was both valid and reliable. The first stage of the procedure (Table 1) entailed specifying the domain of the construct being studied. This involved defining the concept of utility.

Stage	Description	Technique or coefficient
1	Specify domain of construct	Literature search
2	Generate sample of items	Focus groups with building occupants
3	Collect data	Survey of building occupants
4	Purify measure	Cronbach's alpha, factor analysis
5	Assess reliability	Cronbach's alpha
6	Assess validity	Split/multiple samples
7	Develop norms	Statistics summarising distribution of scores

Table 1: Procedure for developing multi-item scales (Churchill, 1999; p.463)

In the broadest sense of the word, utility is 'the state of being useful, profitable or beneficial' (Pearsall, 2001; p.1580). Bannock *et al.* (1992, p.436) are more explicit, describing utility as 'the pleasure or satisfaction derived by an individual from being in a particular situation or from consuming goods or services'. Utility is, then, the 'ability of things to satisfy human requirements' (Leiashvily, 1996; p.6). Something only has utility when people see in it the possibility to satisfy their needs and expectations. Utility is not solely about things, therefore, but the relationship between people and things (Leiashvily, 1996). Nevertheless, despite the apparent consensus over it's meaning, there is still no single measure of utility (Bannock *et al.*, 1992). For example, in economics the measurement of utility has provoked long debates over the competing theories of cardinal utility (measured through direct judgements) and ordinal utility (measured through preferences) (Rutherford, 1992; Abdellaoui *et al.*, 2001).

When applied to buildings, the word utility has traditionally been 'used in the every-day sense of indicating usefulness or a potential capacity to provide a service' (Salway, 1986; p.50). If a building is not felt to be fulfilling its utility, it is considered obsolete (Smith *et al.*, 1998). According to Williams (1985) the utility of a building is a function of the objectives and perceptions of its users. User objectives vary enormously, placing a wide variety of potential demands on buildings. Even for a generic activity, such as office work, certain tasks place special demands on the physical environment in which they occur. Some users work in ways that are unique in certain respects and set them apart from others (Gray and Tippett, 1993). Moreover, 'within individual user objectives, differing priorities will exist relating both to aspects of the use of the building and to subjective values, such as perceived aesthetic qualities' (Williams, 1985; p.84). This means that the minimum standard of accommodation will vary with each user; one user may expect a high level of environmental control, high quality finishes and specialist arrangements, whereas other users may only expect the minimum level of shelter and security. A building that may be unsuitable for one user may therefore yield a high level of utility for another (Williams, 1985).

The utility of a building is also influenced by individual user perceptions. Williams (1985) argued that perceptions relate to all aspects of the building and its environment, and are affected by the following factors:

- Relativity – relative conditions are easier to perceive than absolute conditions, this being in direct proportion to the magnitude of the relative difference. For instance, it is easier to judge that one building is in better condition than another than it is to judge the condition of a building in isolation;
- Significant aspects – some aspects of a building are easier to perceive than others. For example, the decorative state of repair and the internal thermal environment are easier to perceive than structural performance or the adequate provision of fire exits. These aspects may have a disproportionate influence on the overall assessment of utility;
- User knowledge and past experience – these are important where the user has particular knowledge relating to the building itself or the activity in question. The user's experience of other buildings will also influence their perceptions of a building;
- Level of involvement of the user – infrequent visitors are likely to perceive change as being at a higher rate than the occupants due to their discontinuous view of the building. Occupants may overlook lesser changes that would be perceptible to infrequent visitors. Visitors and occupants are also likely to perceive different aspects of the building;
- Social context – where judgements are made by a user, either as part of a group or individually, but with knowledge of the group consensus, then the user's perception will tend to concur with that consensus more than if the user's perceptual judgement was formed in isolation. Hence, if a building has a poor reputation, it is likely to be perpetuated;
- Tastes and fashions – fashion permeates all facets of life and experience suggests that whatever the long term view about a particular style, it will invariably fall out of favour in the medium term; changes in fashion provoke an adverse reaction against styles that characterised the preceding era (Salway, 1986).

Clearly, the assessment of the utility of a building with regard to the user's expectations is a complex decision-making process that is strongly influenced by individual user perceptions. The expectations and perceptions of building users are therefore a significant factor in measuring the utility of a building, and ultimately in ascertaining at what point a building is obsolete (Williams, 1985).

Data collection

The second stage of the research (Table 1) involved conducting focus groups to generate a sample of items for inclusion in the scale. Focus groups are a qualitative research method in which a small number of participants discuss elected topics as a group for approximately one or two hours, whilst the interviewer focuses the discussion onto relevant subjects in a non-directive manner (Tynan and Drayton, 1986). 'This method assumes that an individual's attitudes and beliefs do not form in a vacuum. People often need to listen to other's opinions and understandings in order to form their own' (Marshall and Rossman, 1999; p.114-115). Focus groups are therefore a useful vehicle for establishing intersubjectivity - ordinary descriptions of reality shared by participants. Participants are able to obtain feedback on their views of reality and can respond to other or differing views; the researcher can also experience a reality in the same manner as the participants (Frey and Fontana, 1993).

In this research focus groups were used to identify the criteria by which occupants evaluate the utility of their workplace. Three focus groups, representing a total of 20 people, were conducted with occupants a public sector office building. An interview guide, containing ten questions, was used to direct the discussion. The results of the focus groups were recorded, transcribed and analysed using NUD*IST qualitative analysis software. In total, the focus groups generated 87 items representing the workplace utility construct. Each item was recast into two statements – one to measure occupant expectations of office buildings and the other to measure perceptions of the particular office building being assessed. A seven-point scale accompanied each statement, ranging from 'Strongly Agree' (7) to 'Strongly Disagree' (1), with no verbal labels for scale points 2 through 6. An additional category, 'Not Applicable' (0), was also included. The expectation statements were grouped together and formed the first part of the survey instrument, whilst the corresponding perception statements formed the second half.

Feedback from a pilot study suggested three changes to improve the survey instrument and facilitate completion. First, the number of statements was reduced from 174 to 110 by eliminating and combining certain items. Second, the perception statements were placed before the expectation statements. Third, the survey instrument was designed to be completed on-line. The survey instrument can be viewed at http://www.shu.ac.uk/schools/sed/teaching/jp/usersurvey.htm. Stage three of the research (Table 1) involved collecting data from a sample of office building occupants to enable refinement of the 55-item scale. The URL[1] of the survey instrument was e-mailed to the 1800 occupants of a public sector office building. The e-mail also served to explain the rationale and background to the study. Respondents were given two weeks in which to complete the survey instrument. Of the 1800 recipients, 355 people responded within the specified time period, a 20% response rate. This could be regarded as 'low'. However, when placed into context with response rates from comparable data collection methods, for example the postal method, it is to be expected. Factors believed to have had an impact on the response rate include the length and repetitive nature of the survey instrument and the inability to personalise the e-mail inviting respondents to participate.

Data analysis

The fourth stage of the research (Table1) involved analysing the survey data to produce a valid, reliable and parsimonious scale. Raw data used in the analysis were in the form of difference scores, with values ranging from 6 to -6. For each of the 55 items a difference score U (representing utility along that item) was defined as $U = P - E$, where P and E were the ratings on the corresponding perception and expectation statements, respectively. The idea of using difference scores in purifying

[1] The standard way of specifying the location of a web page on the Internet. URLs are the form of address used on the World Wide Web (Howe, 1993).

a multiple-item scale is not new and has been used in developing scales for other social constructs (Ford *et al.*, 1975; Parasuraman *et al.*, 1988; Hoxley, 2000). Missing data[2] were recoded and a missing value analysis was conducted using SPSS, which revealed that missing data were randomly distributed across the data matrix. Mean series values were then calculated and used to replace missing data, thereby maximising the number of valid cases in the analysis (Hair *et al.*, 1995). The replacement of missing data has the effect of 'smoothing' individual variables so that the influence of extreme values is diminished. This approach could be regarded as 'conservative', but given the potential drastic decline in cases due to the combined impact of missing values it was regarded as justifiable.

Analysis of the empirical data entailed examining the dimensionality of the 55-item scale using factor analysis[3] and testing the reliability of the set of items using Cronbach's alpha. Values of Cronbach's alpha, the most widely used reliability coefficient, can range from 0 to 1, with higher figures indicating greater scale reliability (Hoxley, 2000). Cronbach's alpha was calculated before and after the factor analysis. A total scale Cronbach's alpha of 0.96 indicated that the scale had very good reliability prior to factor analysis. However, values of Cronbach's alpha across the 55 items ranged from 0.35 to 0.66, suggesting that deletion of certain items would improve alpha values. Corrected item-to-item correlations were used to decide whether to delete an item (Churchill, 1979). Corrected item-to-item correlations were plotted by decreasing order of magnitude. None of the items had very low correlations (near zero), nor did they produce a substantial or sudden drop in the plotted pattern (Churchill, 1979). All 55 variables were therefore included in the factor analysis.

The suitability of the data had to be determined before factor analysis could be used. Inspection of the correlation matrix, which shows the correlations between the variables, revealed a considerable number of correlations exceeding 0.30, suggesting that the matrix was suitable for factoring (Hair et al., 1995). The anti-image correlation matrix was also examined, indicating that all measures of sampling adequacy were well above the acceptable level of 0.50 (Coakes and Steed, 2001). Finally, the Bartlett test of sphericity, a statistical test for the presence of correlations between variables, was significant and the Kaiser-Meyer Oklin measure of sampling adequacy was 0.93, well above the acceptable level of 0.50 (Coakes and Steed, 2001). These measures all indicated that factor analysis was appropriate.

Factor analysis of the 55 variables, using principle axis factoring and oblique rotation, revealed 32 variables loaded across 8 factors, representing 62% of the total variance. All 32 variables had a communality of 0.50 or more and a factor loading of 0.25 or more; variables with factor loadings less than 0.25 were considered insignificant. Interpretation of the pattern matrix (Table 2) resulting from the factor rotation revealed 4 definable factors, representing 22 variables. This suggested that workplace utility could be measured along 4 dimensions:

- Factor 1 was concerned with space 'configuration' issues, such as amount of informal meeting space, potential for chance interaction and ease of circulation;

[2] Values of 0, representing 'not applicable', were recoded as 'system missing' to prevent extreme scores skewing the results.
[3] A statistical technique for condensing many variables into a few underlying factors or dimensions.

- Factor 2 was loaded with 6 ‘environment’ related variables, such as adequacy of ventilation, degree of individual control of temperature and responsiveness to changes in temperature. This grouping is not surprising, since previous research (Leaman and Bordass, 2000) identified these as being key variables in the evaluation of office facilities;
- Factor 3 was concerned with the ‘appearance’ of the office building, and includes variables such as the modernity of interior areas, exterior appearance and tidiness;
- Factor 4 was comprised of 6 variables that relate to the ‘functionality’ of the building, including the level of conversational privacy, adequacy of workspace and potential to work free from distraction.

Variable	Factor 1	Factor 2	Factor 3	Factor 4
Convenient access to informal meeting space	0.555			
Sufficient amount of informal meeting space	0.552			
Adequate amount of space for team projects	0.437			
Common areas that allow chance interaction	0.384			
Layout that enables circulation movement	0.261			
Functions at a comfortable temperature		-0.884		
Functions at a comfortable humidity		-0.813		
Feels well ventilated		-0.795		
Responsive heating/cooling system		-0.775		
Control over the temperature of office		-0.692		
Control over the ventilation of office		-0.631		
Looks modern from the outside			0.816	
Has a modern appearance			0.791	
Is visually appealing from the outside			0.732	
Is visually appealing			0.696	
Is tidy in appearance			0.423	
Conversational privacy in office				0.708
A place where can work free from distraction				0.638
Visually privacy in office				0.638
Conveniently accessible storage space				0.452
Adequate amount of storage space				0.377
An adequate amount of workspace				0.367

Table 2: Factor loadings of variables

The final part of the analysis involved assessing the generalisability of the results to the population and reliability of the 22-item scale for use in future research. Reliability was evaluated by calculating Cronbach’s alpha for each of the four dimensions and for the scale as a whole (Table 3). These figures were all high and comparable to those of other survey instruments developed using this procedure (Parasuraman *et al.*, 1988; Nelson and Nelson, 1995; Hoxley, 2000). The total scale alpha of 0.93 indicated that the scale has very good reliability. Validation of the scale involved splitting the sample into two samples and re-estimating the factor models to test for comparability and generalisability. The two factors solutions were by and large comparable across the four dimensions, boosting confidence in the generalisability of the results to the sample population.

Dimension	Factor	Number of items	Cronbach's alpha
Configuration	1	5	0.83
Environment	2	6	0.90
Appearance	3	5	0.87
Functionality	4	6	0.87
Entire scale	All	22	0.93

Table 3: Scale reliability

Discussion and further research

The 22-item scale developed in the research can be used by facility managers to evaluate the appearance, configuration, environment and functionality of public sector office buildings. The utility of an office building can be determined by dividing perceptions scores by expectations scores, an approach that has been used in previous building evaluation research (Bottom, 1996). Mean values can then be computed for each of the four factors. The resultant values range from 0 and 7, where values higher than 1 represent above minimum acceptable utility (perceptions exceed expectations), 1 indicates minimum acceptable utility (perceptions match expectations) and values less than 1 represent below minimum acceptable utility (expectations exceed perceptions).

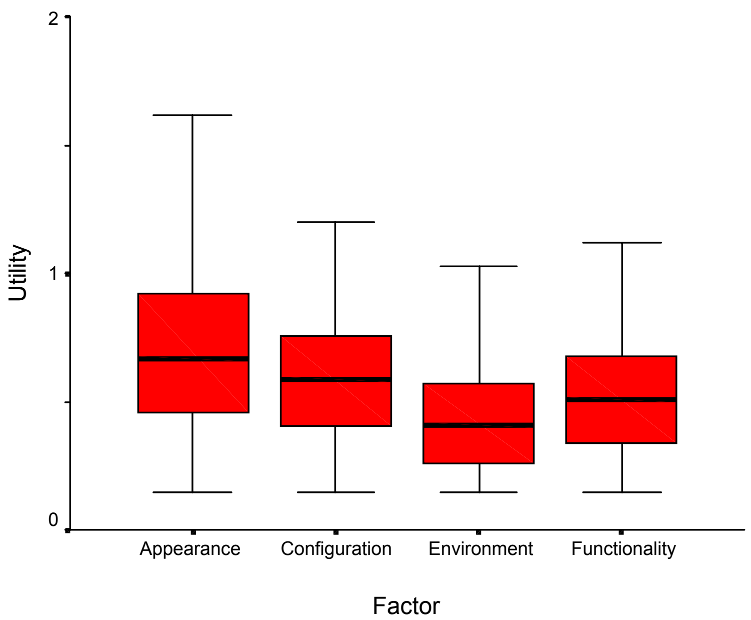

Figure 1: Utility measurements from the pilot evaluation

Figure 1 illustrates the distribution of data from a pilot evaluation, showing the distribution of scores (cross-hairs), interquartile range (box) and median values (middle line) for each of the four factors. Interpretation of Figure 1 indicates that for the majority of occupants, the office building exhibited below minimum acceptable utility across all four factors. There is, however, variation within and between factors. Comparing the four boxplots, there was much greater variability in the utility of the first factor (appearance), its median value was higher (0.67), as was the number of scores with a value greater than 1 (minimum acceptable utility). The third factor (environment) had the least utility of the four factors, with the lowest median value (0.46) and the highest number of scores below 1. The variation within and between the four factors could be further analysed by comparing the differences between occupant expectations and perceptions for each of the 22 items.

The pilot evaluation served to test effectiveness and usefulness of the scale developed in the research. However, the conclusions that can be drawn about the utility of the office building are strictly limited. This is because a raw score on a measuring scale is not particularly informative about the position of a given object on the characteristic being measured since the units in which the scale is expressed are unfamiliar (Churchill, 1979). To assess the position of an object on a characteristic it is necessary to compare the object's score with the score achieved by other objects (Churchill, 1979), a process known as 'developing norms' (Table 1). The scale developed in this study should therefore be used to evaluate the utility of a larger sample of public sector office buildings. This would enable the determination of standards to explain what scores on the scale constitute 'high', 'low', 'standard' and ‘optimum’ utility, and confirm whether or not the scale is generalisable to a wider population.

According to Churchill (1979) it is often necessary to develop distinct norms for separate groups of respondents. Hence, in future research the 22-item scale should be administered with an additional set of questions to ascertain specific information about the objectives of respondents, such as their job characteristics and working practices[4]. This would enable the researcher to account for possible variations in perceptions and expectations arising from occupant specific factors, such as knowledge and experience, level of involvement or social context. A further weakness of the pilot evaluation is the inability to properly explain variations in utility across for the various aspects of the office building. Future research could address this problem by collecting data on the physical characteristics of the office building(s) being evaluated. These data could then be correlated with results from the utility scale to try to identify physical characteristics that give rise to particularly 'high' or 'low' levels of workplace utility (Pinder and Wilkinson, 2001).

Conclusion

The utility of an office building is a measure of its usefulness, and is a function of the expectations and perceptions of the building’s users. The objectives of the research discussed in this paper were to develop a valid and reliable scale that could be used to measure the utility of public sector office buildings, and test the effectiveness of

[4] A revised instrument containing the 22-item scale and additional questions for identifying sub-groups is currently being used to evaluate the utility of 100 local authority office buildings.

the scale by conducting a pilot evaluation. These objectives have been fulfilled. The 22-item scale developed in this study can be used to elicit the expectations and perceptions of occupants regarding the appearance, configuration, environment and functionality of their office accommodation. Further analysis showed the scale to be both valid and reliable. Application of the scale in a pilot evaluation served to highlight variations in the utility of the 4 different aspects of the office building. The results of the evaluation indicated that the internal environment, in particular, failed to meet the expectations of the building's occupants. However, further research is required to test the generalisability of the scale to larger population of public sector office buildings and to provide a benchmark for the pilot evaluation.

Acknowledgements

The research discussed in this paper is part of an ongoing doctoral study funded by Sheffield Hallam University. The authors would like to thank Joe Cassidy at the Department for Education and Skills for his assistance in conducting the research.

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Office space change among growth companies in the service sector: case studies in Western Sweden

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Abstract: *How growth companies actually manage their space needs has seldom been studied. Researchers who have analysed the internal dynamics of growing companies distinguish typical phases of their growth paths, but the facility resources of companies have received little attention. The purpose of this investigation is to analyse how growth companies in the Gothenburg region have changed their office space use in the 1995-2000 period. Six growth companies have been selected among those who had less than 25 employees in 1995 and between 50 and 500 employees in 2000. Site visits with retrospective interviews have been used. Results indicate that growth companies tend to relocate when passing from an entrepreneurial to a managerial phase. Once having relocated within the region, these companies tend to plan for multisite operations with new small offices. Spatial expansion seems to be triggered when no more than 20 sq.m are left per full-time employee. When density rises, these companies avoid raising the proportion of remote work. This may reflect that security is a crucial issue, and a concern with protection would also explain an emphasis on creating office boundaries for visitors.*

Keywords: Offices, growth phases, growth companies, space management

Introduction

How growth companies actually manage their space needs has seldom been studied. Researchers who have analysed the internal dynamics of growing companies distinguish typical phases of their growth paths, but the facility resources of companies have received much less attention than issues of general management and competence. The purpose of the present investigation is to analyse how six growth companies in Western Sweden have changed their office space use in the 1995-2000 period.

Growth is commonly measured with reference to annual turnover or the number of employees of a company. Since we study the spatial consequences of growth, increase in employment has been chosen as our criterion for growth. And since we suspect that sudden advances in telecommunications and information technology in the mid-1990s and later have had a strong impact on office space use, we focus on companies with a recent history of growth.

After having presented how growth companies were defined and identified, the actual sample and the survey method with questionnaires and interviews are explained. This is followed by a quantitative and qualitative analysis of spatial development, where we highlight influences on the choice of layouts, in particular how the issue of visitors and security is reflected in the workspace. Geographical spread of offices and the use of external service providers are discussed before conclusions are drawn.

The work presented here is part of the ‘Interfirm Relations in Facilities Management for Growth Firms’ project under the national Swedish research program ‘The client with the customer in focus’, launched in 2000, involving several universities and

supported by the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas).

The survey method

Six growth companies were identified for this investigation. The method used for selecting the companies and how the field studies were conducted is described here.

Selection criteria: identifying growth companies

Government statistics in Sweden as in most other countries do not allow us to identify individual growth companies. Other databases have to be used. The total population of growth companies from which we draw our cases is defined by us as companies with between 1 and 25 employees in 1995, having grown to more than 50 employees within Sweden in 2000, and with their head offices located within 80 kilometres from the centre of Gothenburg.

These criteria have been applied by us to two currently available growth lists: the Gazelle list of growth companies (Jeppson, 2001) and the Tillväxtlistan Sverige 2001 (Ahrens, 2001; Petersen, 2001) in versions that use financial data taken from company annual reports for the year 2000. Among the financial criteria for inclusion in the Gazelle list, there is that the company should show a profit as well as constant increase of turnover for the last three years, amounting to at least a 100 per cent rise during three years, and be creditworthy. The criteria in Tillväxtlistan include a minimum turnover of MSEK 5 in 1995 and an average organic growth in turnover of at least 25 per cent, and no less than 20 per cent during two years. Companies have to give their consent to appearing on Tillväxtlistan; only about 25 per cent of all eligible companies that meet the Tillväxtlistan criteria are found in the list as published. Relying only on the Tillväxtlistan could have introduced a bias in our survey, if companies that give their consent to appear on the list are atypical also in their choice of office settings.

Applying our geographical criterion, 22 companies on the Gazelle list remain and 8 on the Tillväxtlistan; four out of these appear on both lists. Given that neither list had 1995 employment as a criterion, all 26 companies thus identified were asked to provide this figure. The outcome was a set of eleven companies, nine of which can be classified as belonging to the service sector and two companies as manufacturers. Since manufacturing companies can be thought of as having a hidden internal service sector, mirrored in their need for office space, we decided to include the two manufacturers for comparative purposes. By randomly drawing four out of nine service companies, we obtained a set of six companies that reflects the sector proportions of all Swedish growth firms on Tillväxtlistan.

Due to internal turbulence, one of the selected service companies withdrew from our investigation, and another one was drawn at random as a replacement. Three of the final six companies appear only in the Gazelle list, two in both lists and one appears in Tillväxtlistan only.

Investigation procedure

Site visits, retrospective semi-structured interviews, drawings and other facilities related documents have been used in our survey of the six companies. After an introductory letter to the managing director of each company, these were first contacted by telephone, and in three cases, the managing director agreed to an interview in person; in the remaining three cases, the managing director chose a staff member to participate. Interviews, which were held in early 2002, lasted between two and three hours and were tape-recorded. One company was visited twice.

A ten-page questionnaire was given to the interviewee at the start of each interview but was filled out by the interviewer. Available floor plan drawings were overlaid with transparent paper, and the interviewee was asked to sketch how surface use had developed over time. For one of the companies, information from lease contracts was used in the absence of drawings. When a company had branched off during the period, all its office locations within the defined 80 km radius were studied, including data on staff numbers at each branch. Walking through at least part of the offices took place after each interview, often including photographs being taken. In four cases, complementary information was received from the company after the interview.

The six companies

The size of the selected companies ranged from 4 to 35 employees in 1995, and in 2000 from 65 to 320. To protect their identity, the six companies have been assigned fictive names reflecting their business orientation: CONSUMPROD, TELPROD1, TELPROD2, CONSULT1, CONSULT2 and TRAVELSERV.

CONSUMPROD

The founder and his colleague, who still manage the company, set up CONSUMPROD in 1994 in a suburban area dominated by small industries. The company both manufactures and trades goods; logistics are crucial. Products are sold both nationally and internationally by a network of sellers. E-business was introduced in 1998. In 2001, the company was reorganized under four functions with a manager for each function. Since the start-up the company has chosen to have all facilities at a single location in order to monitor activities and accumulate critical knowledge. Due to dissatisfaction with the original environment and a shortage of office space, activities were relocated in 1997 when the management bought the present property. New construction was made not only to cover expected space needs but also to maximize the use of the property under local planning regulations. During the first year after relocation, a tenant leased a major part of the office and inventory space. Sufficient expansion space for the company remains at its present address.

TELPROD1

The company was founded as early as 1965 and manufactured simple consumer products for many years. The founder family still owns 15 per cent of the company. In the 1990s, the IT and telecommunications breakthrough led to radical change when the company began supplying a major Swedish group with products that were much more refined and precisely delivered. Both specialization and vertical integration followed. The surrounding areas permitted rapid expansion with a building erected each year. International spread of manufacturing activities mitigated the 2000 downturn in demand, while causing a space surplus in TELPROD1 facilities in Sweden. Planning for new building projects was interrupted.

TELPROD2

Three engineering students founded TELPROD2 in 1988. Being close friends, they wished to go on working together somehow in a trading business rather than focusing on a single, well-defined business concept. Since 1998 TELPROD2 is partially managed by professional board members. Two of the founders are still active in TELPROD2, which today also holds three subsidiary companies, all housed in the same building. After relocation in 1995, TELPROD2 has expanded in the same building by taking over adjacent space when opportunities for expansion arose. It seems that they are able to capture new market opportunities rapidly, as evidenced by the growth of a R&D unit, while they are also adept at leaving less profitable lines of business such as, in their case, outsourcing of services.

CONSULT1

CONSULT1 was set up in 1994 as a spin-off company. However, already in 1986 the founders of CONSULT1 began working together. CONSULT1 was managed professionally from the outset with of external management being engaged when competence gaps were identified. Since 1994, main activities have take place in the same multi-user building with expansion into adjacent office space. Two partners out of originally four are still active in CONSULT1. Small offices in a few other cities in Europe and America have been established. Today with over 100 employees, top management has begun questioning spending on increasingly unoccupied and expensive workplaces.

CONSULT2

The still active owner established CONSULT2 in 1986 as a technical consultancy. At first, the company was located in an industrial zone with lower attractively than since relocation in 1994. Since 1997, the company has activities in three fields of specialization, and recently, one field has been subdivided into three niches activities. Initially, the owner thought that the company should have less than 15-20 employees. Further expansion was begun when the owner found that survival would depend on a greater scale of activities and a path of steady growth. Most of the CONSULT2 employees work in the offices of their clients, and when they work in the CONSULT2 office, they often do so in project oriented group settings. The office reflects constant change as expressed by temporary work groups with shared workplaces, but some employees work individually in cells.

TRAVELSERV

TRAVELSERV was formed in 1989, and today it is a group today with a head office staff of only three persons, who coordinate the activities of three subsidiaries.

TRAVELSERV has over 100 employees now, and the founder still leads the group despite radical changes in ownership. The organizational structure has been flat since the start in 1989, with a policy emphasis on employee participation. Another policy was to avoid big offices, and for each address, a limit of 20 employees was set. Consequently, expansion has implied geographical spread. New office space has been rented when needed. All offices have a common layout where teams of 2-4 persons work under frequent interaction. Internal exchange and rotation among employees are encouraged as a part of the quality management policy of the group.

Analysis of spatial development

While staying at the same address, a company can increase or adjust its space by expansion to adjacent spaces, reduction of space needs or inner reconfiguration. More radical space changes can be made by partial or complete relocation to a new address. All companies have moved all their activities at least once to a new address, except TRAVELSERV.

Intensity of space use

Table 1 shows the density of occupation for the six companies. CONSULT2 is the only one to rely heavily on remote work for staff, which is clearly reflected in low per capita areas. Disregarding CONSULT2, we find that the density range in 1995 was much smaller than in 2000, when space use in the five companies had diverged. There seems to be a lower limit at about 20 square metres, and when companies approach this limit, space change is imminent. This indicates that these companies all follow an incremental strategy (O'Mara, 1999). It is less easy to identify a common upper limit, which appears to lie in the 50-70 square metres interval. Over the years, densities among the two manufacturers, TELPROD1 and CONSUMPROD, have varied more than at the service sector companies.

Company	Year						Standard deviation
	1995	1996	1997	1998	1999	2000	
CONSUMPROD	43.2	43.2	45.6	64.4	45.8	32.7	*10.3*
TELPROD1	54.0	39.3	22.7	26.3	60.8	71.9	*19.6*
TELPROD2	45.4	50.9	38.5	36.3	30.6	29.2	*8.4*
CONSULT1	30.8	34.9	28.6	37.9	26.8	20.3	*6.2*
CONSULT2	7.9	13.4	10.8	12.0	9.7	8.7	*2.1*
TRAVELSERV	40.5	27.0	33.4	28.7	22.2	21.5	*7.2*

Table 1. Offices: gross internal area per employee [sq.m/person]

Phases of company growth

Bröchner and Dettwiler (2002) have reviewed general theories of growth companies in the tradition that began with the Penrose (1959) resource-based view of the firm, later combined with phases (Greiner, 1998; Garnsey, 1998), and linked this to architectural theories of space use, proposing a model with three phases. According to this model, growth companies pass through three phases: the entrepreneurial, the managerial and the consolidation phase, each with typical consequences for space use.

In the *entrepreneurial phase*, the growth company tends to focus strongly on its core activities and on which market paths it shall follow. Assuming that the founders suffer from financial constraints, their facilities policy can be expected to emphasize functional needs rather than spending on symbolic features, which might even do harm to their relation to investors. In this early phase, reliance on frequent, informal and face-to-face contacts implies that occupational density should be high. However, uncertainty regarding the company future - and a lack of access to professional knowledge of space management - may cause overcrowding and badly chosen timing of relocation. We assign CONSUMPROD to this phase, since the founder still has a dominant role and wishes to keep company activities in-house. Just as in its first location, CONSUMPROD keeps manufacturing, inventory and office space together at the same address.

When the growth company enters the *managerial phase*, professional management has largely taken the place of founders. Focus is still on developing the core business. Workspace layouts can now be assumed to reflect hierarchical tendencies when staff roles are increasingly specialized and defined. New problems occur in developing the business, requiring specialists who may express special space requirements. Geographical spread with multiple sites complicate the provision with facilities and facilities related services. Since management has its focus on the core, issues regarding facilities and support services are dealt with only intermittently. Support costs and the gap between facilities and organizational practice may easily be thought to increase during this phase. To this phase, we assign both TELPROD1 and TELPROD2, because of their manifest weaknesses in anticipating changes in space needs. At CONSULT2, we identify a general awareness of space management issues, but also a lack of proactive behaviour in the face of geographical spread and management change. Perhaps CONSULT1 should be assigned to this phase. We note that five out of six companies have relocated when in transition from the entrepreneurial to the managerial phase.

The *consolidation phase* implies continued growth at a steady rate or a plateau. Management is now more efficient and sophisticated than in the second phase, and the ability to match support to core business needs has improved markedly. Whereas the managerial phase could be associated with a lack of focus on facilities and non-core activities, the consolidation phase has its paradox in a greater rate of internal change. While skills in facilities management are available and used more continuously in this phase, they are often matched by higher rates of churn as competition and technology in the core business are subject to change. Reliance on cross-functional teams and calculated experimentation with teleworking and other alternative work practices in this phase can be expected to imply layout changes. In common with the entrepreneurial phase, informal and frequent face-to-face communication is more important than in the managerial phase. It is in the consolidation phase that we expect to find uniform facilities management procedures at multiple sites. Again, CONSULT1 exhibits characteristics that belong to this phase: experiments with office settings and an awareness of facilities management. In the case of TRAVELSERV, we find a strong awareness of space management, something that has been present since the early days of the company.

Most writers on facilities management deal with the conditions of large and mature organizations, which can be assumed to belong to the consolidation phase or even later in the life cycle of companies.

Influences on the choice of workspace layouts

Table 2 shows how companies characterized their work patterns and the importance of spatial features. One way to analyse the relation between work patterns and spatial patterns in offices is to classify settings according to the degree of interaction and the degree of autonomy, mirrored in four layouts: den, club, hive and cell (Laing et al., 1998; Duffy, 1997). We should expect that perceptions of the relation between interaction and autonomy to be reflected in the den-club-hive-cell pattern for each company.

Company	Workspace layout determinants					
	Interaction	Autonomy	Teamwork	Presence	Function	Symbol
CONSUMPROD	4	4	4	4	4	2->4
TELPROD1	5	2	4	2,4	5	4
TELPROD2	4	4	2,4	5	3->4	2
CONSULT1	4	4	2	5	4	2
CONSULT2	4	3	5	5	4	4
TRAVELSERV	5	5	5	3	5	5

[Scale: 1 = unimportant, 5 = very important]

Table 2. Office work aspects, importance as reported by the six firms

All four layouts are represented among our six growth companies (Table 3). Two or three patterns are found in each company, except for TELPROD2, which fits only the den pattern, and in this company, work groups seldom interact and employees do not share workplaces. Given the interaction and autonomy ratings for TELPROD1 in Table 2, we should expect it to appear as a den in Table 3, which is not the case. The reason appears to be that TELPROD1 is organized according to the matrix principle. This is reflected in a combination of cell and club features.

Applying the den-club-hive-cell model is not always straightforward. There is a need for a typology that covers more aspects of knowledge work (Gjersvik and Blakstad, 2002). At first, the CONSUMPROD call centre might look like a typical hive. However, although they perform routine work, employees in the open plan interact to verify their rapid decisions with colleagues and to integrate new staff members. They also have access to cells for confidential telephone calls and other special occasions. Other parts of CONSUMPROD show an odd mixture of den and cell, which reflects a process based on autonomous work in cells with bursts of informal but necessary interaction. Thus there are conversations lasting between half a minute and almost half an hour, held in corridors and a conference room. As a contrast, TRAVELSERV depends on face-to-face interaction in its core business relation to customers. Since all employees have their individual workplaces while intense work is performed in teams, TRAVELSERV exhibits the characteristics of a den. On the other hand, a high degree of autonomy, transactional knowledge work and a continuous creation of new group settings lend the workspace the character also of a club. To take a more traditional setting, managers of CONSULT1 have accepted an original cell structure of the office spaces they rent, but they have engaged in experimentation with small bar-like pausing areas for coffee breaks and informal standing meetings. CONSULT1 has recently moved further from the cell towards the club.

Going back to Table 2, we find no club setting in companies that we assign to the entrepreneurial phase, which might indicate a relation between office setting and the growth phase of companies.

Interaction	Autonomy	
	Low	High
High	**DEN**: found at CONSUMPROD, TELPROD2, CONSULT2, TRAVELSERV *Companies per phase:* 1 E, 2 M, 1 C	**CLUB**: found at TELPROD1, CONSULT1, CONSULT2, TRAVELSERV *Companies per phase:* 0 E, 2 M, 2 C
Low	**HIVE**: found at CONSUMPROD *Companies per phase:* 1 E, 0 M, 0 C	**CELL**: found at CONSUMPROD, TELPROD1, CONSULT1, CONSULT2 *Companies per phase:* 1 E, 2 M, 1 C

[Phases: E = entrepreneurial, M = managerial, C = consolidation]

Table 3. Dens, clubs, hives and cells

As could been suspected already from the density data in Table 1, CONSULT2 depends on shared workplaces and rapidly established, temporary group settings, since about 70 per cent of staff work at client offices; the high importance ascribed to presence (Table 2) refers to presence at either the CONSULT2 office or the office of a client, as opposed to telecommuting. Rapid changes are significant also for TELPROD1 although employees all have their own workplaces (Table 4). It should be noted in Table 4 that employees working in manufacturing and goods handling are included in data for CONSUMPROD and TELPROD1. Data for TRAVELSERV relate to all sites within the region.

Company	Year					
	1995	1996	1997	1998	1999	2000
CONSUMPROD	6W,2N	6W,12N	19W,11N	32W,23N	45W,35N	63W,42N
TELPROD1	8W,24N	11W,34N	19W,61N	30W,78N	45W,140N	55W,265N
TELPROD2	10W	13W	24W	38W	51W	65W
CONSULT1	23W	27W	33W	51W	72W	95W
CONSULT2	4W,31S	6W,36S	6W,46S	6W,70S	6W,81S	11W,86S
TRAVELSERV	4W	6W	18W	21W	28W	37W

[Access: W = individual office workplace, S = shared office workplace, N = no office workplace]

Table 4. Full-time employees per company and year, according to workplace access

How the companies perceived the relative importance of functional and symbolic features in the workspace is also found in Table 2. Here, it is obvious from our interviews that office location can be more important than the character of office interiors. Both CONSUMPROD and CONSULT1 have looked closely at the quality of urban surroundings when choosing where to move; CONSULT1 also emphasized transportation infrastructure for their international contacts as well as their own spread of activities. The interview at CONSUMPROD led to the impression that symbolic features had gained in importance at the end of the period. Two companies, CONSULT1 and TELPROD2, did not appear to be much concerned with symbolic features, while the intensity of customer interaction may explain why TRAVELSERV rates both symbolic and functional features highly. CONSULT2, which follows a policy of remote work with customers, nevertheless appears to be aware of symbolic issues; when employees do work in their office, managers wish to see that the space is bristling with activity.

Security, visitors and remote work

The survey includes questions related not only to the extent of remote work but also to how the number of visitors has developed during the period, as we expected office settings to reflect external relationships. Almost all visitors were either customers or suppliers. Insourcing of temporary staff was a rare exception. Results are found in Table 5.

Company	Year					
	1995	1996	1997	1998	1999	2000
CONSUMPROD	5.0(1.5)	20.0(1.5)	35.0(1.5)	50.0(1.5)	65.0(1.5)	80.0(1.5)
TELPROD1	1.0(1.0)	2.0(2.0)	3.0(3.0)	4.0(4.0)	5.0(5.0)	6.0(6.0)
TELPROD2	2.5(2.5)	2.5(2.5)	2.5(2.5)	2.5(2.5)	5.0(2.5)	9.0(4.5)
CONSULT1	2.5(0.5)	2.5(0.5)	4.0(1.0)	4.5(1.5)	5.5(1.5)	6.0(2.0)
CONSULT2	3.5(3.5)	3.5(3.5)	3.5(3.5)	3.5(3.5)	3.5(3.5)	3.5(3.5)
TRAVELSERV	10.0(10.0)	10.0(10.0)	20.0(20.0)	20.0(20.0)	50.0(20.0)	60.0(30.0)

[Number of visitors passing by the reception desk in parentheses]

Table 5. Estimated average number of visitors per working day

None of the six companies had an average figure for daily visitors in excess of the number of full-time employees, although the ratio between visitors and employees has increased in recent years, particularly for CONSUMPROD and TRAVELSERV. However, these two companies have chosen different policies: CONSUMPROD clients are not allowed to leave the entrance area, while the TRAVELSERVE offices may lack a reception desk, allowing visitors to walk around.

Ward and Shabha (2001) identify control loss as a teleworking disadvantage perceived by employers, and our interviews confirm this. At CONSULT1, remote work became more prominent towards the end of the period, but employees kept their individual workplaces, unlike the policy at CONSULT2 with its dependence on work in customers' offices.

Geographical spread

The need for multisite operations was felt differently by different companies in our survey. While CONSULT2 finds present-day IT and telecommunications sufficient for most of their customer contacts, they would consider geographical spread to support further specialization and focus in parts of the organization. However, as we have seen, CONSULT2 differs from the other cases in spreading their individual employees to the offices of their customers. Dependence on face-to-face contacts with customers, as well as their wish to preserve a work style typical of small offices, appears to explain why TRAVELSERV has chosen to work from several sites throughout the region.

Moreover, our interviews reveal that if and when the single-site companies in our survey exhaust their possibilities to expand at their present site, they prefer to consider opening a second office elsewhere in Sweden or in a neighbouring country rather than relocating their entire operations to another site in the same region. CONSULT1 has already followed such a policy and has small offices on two continents, while the majority of staff has remained in a single location.

Use of external service providers

None of the companies had contacted a facilities manager or even heard of the concept of facilities management. The managers themselves or their purchasing staff have procured facilities related services individually (cf. Table 6), as well as assessing needs for spatial expansion. And before their relocation in 1997, CONSUMPROD staff cleaned their office. Two companies had bought architectural services, while the other four had relied on competence provided by their landlords.

Company	Year					
	1995	1996	1997	1998	1999	2000
CONSUMPROD	-	-	C,S,E	C,S,E	C,S,E	C,S,E
TELPROD1	C,S	C,S	C,S	C,S	C,S	C,S
TELPROD2	C,S,R	C,S,R	C,S,R	C,S,R	C,S,R	C,S,R
CONSULT1	C,S	C,S	C,S	C,S	C,S	C,S
CONSULT2	C,S	C,S	C,S	C,S	C,S	C,S
TRAVELSERV	C,S	C,S	C,S,T	C,S,T,IT	C,S,T,IT	C,S,T,IT

[Services: C = cleaning, S = Security, R = Repair, E = Exterior cleaning, IT = IT advice, T = telecom advice]

Table 6. Regularly acquired facilities related services

Conclusions

There are obvious reasons to be careful when generalizing from the experiences of only six companies during half a decade and in a particular region. Nevertheless, our survey findings allow us to outline a set of hypotheses that concern both the process and principles applied by growth companies when they manage their office space needs.

The first observation is that growth companies tend to relocate when passing from the entrepreneurial to the managerial phase in our three-phase model of growth. It is less clear how, or even if, they move between the fields of a den-club-hive-cell model when they go on to a new phase.

Second, once having relocated within the region, these companies tend to plan for multisite operations, creating new small offices outside the region, sometimes on other continents.

Third, spatial expansion seems to be triggered when densities rise so that no more than 20 square metres are left per full-time employee. When density rises, growth companies do not resort to a higher proportion of remote work. It seems that managers of these growth companies wish to retain control and therefore discourage teleworking.

Fourth, a reluctant attitude to teleworking and to insourcing of temporary staff may be a symptom of security being a crucial issue for growth companies. This concern with protection would also explain an emphasis on creating office boundaries for visitors. Growth seems to be related to the creation of innovative products and services that need physical seclusion; sometimes, new ideas are to be formally protected by patents while in other circumstances patents matter less. The ability to sustain a high rate of innovation can be the source of competitive power, but also a strong reason to use physical protection of activities. Protection through seclusion not only affects how offices are planned, but also the ability of companies to expand distance work. Handling sensitive information from a distance, including from where staff live, can be unattractive for growth companies as opposed to mature companies with settled routines and little dependence on unprotected innovations.

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Quantifying the Complex Adaptive Workplace

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Abstract *Despite well-publicised successes and failures, the evidence base for the impact of a workplace on an organisation's business performance remains small and confused. Theoretical perspectives are, with few exceptions, limited to matching physical environment to task. The 'edge of chaos' at a critical density of connectivity (Kauffman's K) between the agents in a network may explain how workplaces enable, or retard innovation. Formal rectilinear open plan offices are conceived as freezing occupants in a state of connectivity as low as traditional cellular designs. Offices without minimal acoustic or visual privacy (high K) may create chaotic stress and reversion as individuals seek to recreate safety. In between are offices known to have enhanced informal conversation between their occupants and resultant innovation. Do these represent edge of chaos conditions? The hypothesis can be justified by reference to examples. A first test of the hypothesis is reported identifying an interaction / disruption factor valid to varying degrees for all categories of work*

Introduction: New Workplaces Fact or Fad.

The term Facility Management (sic) was coined in North America during the late 1970's to describe a developing field of study into the design and management of workplaces and their impact on the business of organisations that occupied them. In crossing the Atlantic the same putative body of knowledge became known in the UK as Facilities Management and the original sense of workplace design came to be confused the with the provision, and especially the outsourcing[2] of building support services, (Price, 2002a). Early commentators stressed a complex and 'ecological' stance on new workplace design (Becker, 1990; Becker and Steele, 1995) but the message has been largely lost and the current workplace debate focuses on 'open-plan' versus 'cellular' space (Haynes et al., 2001), retains neo-Taylorist overtones (Duffy, 2000), is uncritical and apparently unaware of the post modern organisational discourse (Cairns and Beech, 1999) without evidence of impact on all but the most mundane measures of productivity (Haynes et al, 2001) let alone a theoretical framework for understanding same. Facilities, as opposed to Facility Management has become a discipline, and industry, dominated by building operations and maintenance (Lord et al., 2002)

Yet there are well publicised descriptions of successes (Coutu, 2000), and of failures (e.g. Berger, 1999) and the suggestion, in a work of reasoned critique outside the main facilities literature, that physical space may be the most important, yet least appreciated, tool of contemporary knowledge management (Ward and Holtham, 2000)

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2 'Facilities' is the older term having been employed originally to decribe the outsourcing of data processing activities from 1968.

As new management tools, or fashions (Abrahamson, 1996), gain a niche in organisational discourse they attract proponents, managers, consultants and academic groups among others, whose interests are served by the continued spread of a particular fashion. Organisations emerge whose existence depends on propagation of the fashion involved (Price, 1999). One measure of the process is the growth in the number of publications devoted to the subject as publishers, and authors, spot the new niche (Abrahamson, 1996; Abrahamson and Fairchild, 1999; Scarborough and Swan, 1999; Price, 2002b).

With some confusion of terminology between issues of workplace design, flexible working, and teleworking the trend may be seen in the current literature on workspaces. Occupiers are urged towards mobile or flexible futures. Perhaps even the continuation of the commercial office is in doubt (Bayliss, 1997; Becker, 1990; Becker and Steele, 1995; Bertin and Denbigh, 2000; Clements-Croome, 2000b; Duffy, 1998; Duffy, Laing, and Crisp, 1993; Eley and Marmot, 1995; Harrison, Loe, and Read, 1998b; Horgen et al., 1999; Laing et al., 1998; McGregor and Then, 1999b; Myerson and Ross, 1999b; Oseland and Bartlett, 1999; Raymond and Cunliffe, 1996; Stredwick and Ellis, 1998; Thomson and Warhurst, 1998; Turner and Myerson, 1998a; Verity and Shircore, 1996; Vischer, 1996; Wineman, 1986; Worthington, 1997; Zelinsky, 1998).

The argument for flexible offices has been well established with Becker (1990) and Duffy (1990) as the most noted pioneers. Offices or workstations are notoriously under utilised, even during normal working hours so their use by more than one person makes apparent economic sense. Different forms of work require different forms of space, so provision of same should raise effectiveness. Work is increasingly a series of formal and informal projects, requiring groupings of individuals for limited and variable periods of time. Space can facilitate such groupings; moving people but not fixtures.

At a more abstract level, modern organisations are increasingly perceived as ecosystems rather than machines: systems in which tacit knowledge is developed and exchanged through conversations, formal and informal. Space that encourages such conversations might speed up organisational learning. Knowledge management theory is beginning to regard the level of informal connection in organisations as an important part of the knowledge creation process (Palmer and Richards, 2000). Some degree of interaction in an office environment may be essential to enhance peoples' knowledge of the organisations they work for. Even call centres that have successfully introduced have found provision of opportunities for agents to visit 'the office' an essential part of the mix.

Yet the evaluation of workplace flexibility remains contentious (Vischer, 1999). Some go so far as to argue for a return to private offices (Olson, 2002). Independent academic studies (and they are few) are cautious. Cairns and Beech, (1999a; 1999b), while taking care not to "*seek to deny that any of the concepts of flexible working may be truly valid and applicable",* highlight the advocacy bias in many speeches and presentations on the subject. The revolution foreseen by the pioneers of FM has not materialised (Duffy, 2000) and the glittering prize remains out of reach for most office workers (Nathan and Doyle, 2002). Issues of organisational culture, foreseen by Becker (1990) remain under appreciated (Hörgen *et al*., 1999). Managerial attitudes are seen by those who have succeeded or failed with flexibility initiatives as the single most common determinant of the outcome (Lupton and Haynes, 2000; Price, 2001b).

A fuller review (Haynes et al. 2001) and a working paper (Price, 2001a) can be found on the www.occupier.org resource. Our concern in this paper is to develop a theoretical stance which offers, we believe, a new means of explaining successful office designs, then to indicate, with early results, how that frame can be tested.

Towards a new theory

What went wrong?

Clearly some would criticise the question. If flexible office design is not the panacea it's proponents promised then, if anything went 'wrong' it was merely the attempt to implement changes that were inappropriate. Alternatively, as successful cases suggest, more innovative workplaces may stimulate more innovative work, while helping attract and retain more innovative workers. If so, then in the knowledge based economy such workplaces should indeed be a lever to improved organisational performance; Ward's (2000) and Ward and Holtham's (2000) *'most neglected resource in contemporary knowledge management'*.

Francis Duffy, recently (2000) reflected that the changes he and others anticipated twenty years ago have not come to pass.

"The skill of managing office space may have developed but the office environment itself remains very much as it was."

Duffy attributes the failure to conservatism by suppliers, to lingering Taylorism and associated hierarchical cultures in organisations, but most of all to a cost focus on the part of both Facilities Managers and design professionals.

"Programmes of research could have been initiated, using comparative data from cumulative case studies, to demonstrate the effectiveness, as well as the efficiency, of using the design of the working environment to achieve strategic business purposes."

Missing from this analysis is any theoretical framework concerning the impact of workplaces on the behaviour of those who use them[3]. The designer is still assumed to be an expert who knows what best suits the individual[4.] Even if Taylorist ideas are criticised, work is assumed to be something that can be planned and managed. Despite anthropological, Steele's (1988) 'caves and commons' (Hurst, 1995) and biological, Becker's (1990) 'workplace ecology', metaphors in the early workplace literature much of the debate is still framed in terms of 'open-plan' versus the private office. Design is still predominantly considered as a rational rather than an emergent

[3] The best known, Duffy's own model of hives, dens, cells and clubs imposes its own solutions arguing that the design of the office matches the degree of autonomy granted the worker and the interaction demanded for the tasks they are required to carry out.

[4] For a notable exception see Hörgen *et al*., (1999) who advocate 'process architecture' an engagement by the designer with the unwritten rules of the organisation.

process. An epistemological stance which sees management and design as distinct activities (Leaman, 1992) still predominates in the professions concerned.

Beyond the rationalist paradigm

Parallel developments in evolutionary approaches to organisational sociology (e.g. Hull, 1988; Aldrich, 1999) and Complex Adaptive Systems theory (e.g. Waldrop, 1994; Price and Shaw, 1998; Maquire and McKelvey 1999; Pascale et al. 2000) are gradually coalescing to offer an alternative paradigm of organisations and their 'management'. They may be less intentional creations in which a dominant group exerts power over subordinates and more emergent phenomena maintaining boundaries. While they keep a niche in a social and economic ecosystem organisations replicate particular schemata or memeplexes (Price, 1995; Lane, 1996; Gell-Mann, 1996; Carney and Russell, 1997; Price and Shaw, 1998; Blackmore, 1999). The debate, and its implications for management practice, can be conceived as happening along a spectrum of explanations of what organisations are and how they should best be managed. One end of the spectrum is the traditional 'mechanical' perspective. Management is a rational process of setting desired parameters, planning how an organisation will perform, and ensuring compliance. The other sees organisations as 'living' systems, not just metaphorically but literally. Management is the act of creating contexts from which new knowledge and new results emerge. Particular events and actions are bound to be unpredictable and performance is judged in terms of whole system outcomes, not inputs.

Equivalent debates can be found in other branches of social science. Economics is developing, some would say redeveloping, an 'evolutionary' approach (e.g. Loasby, 2001) and behavioural research is even beginning to command attention in property valuation (Diaz, 1999). Psychology wrestles with the extent to which behaviour is 'hard-wired' or socially constructed (Ashworth, 2000). However, despite the calls of some pioneers (especially Becker, 1990) most workplace research (such as there is) has stuck within a narrow, rationalist framework where hours saved or sheets of paper processed are seen as measures of productivity (Haynes et al., 2000). It is the authors' hypothesis, based on this review that pushing harder and harder at what has not worked is unlikely to succeed. We need research, which starts with a different underlying paradigm, if we are going to reach any understanding of the interrelationship between workplace, organisational culture, and business results.

The alternative may be found in the emerging synthesis of evolutionary and complexity perspectives. There is obvious resonance between the complex systems perspective and the ecological view of workplaces proposed especially by Becker. Such evidence as does exist for success stories points to links between a critical mass of informal interaction and faster knowledge creation (Haynes et. al., 2000). Can studies that start with that as a hypothesis explain the contribution of workplace to organisational success?

Connectivity in the workplace

Kauffman's (1993, 1995) NK networks and the edge of chaos have become one of the enduring messages, or metaphors, of complexity. In essence, according to his simulations, the behaviour of a system of N agents, each of which can have at least two states (e.g. on /off), depends on K: the proportion, or number, of agents whose current state influences the change of state of another. With low values of K systems are 'frozen' to a particular state. As K approaches 100% (or N-1), behaviour becomes completely erratic with no sustained innovation. Maximum adaptation and emergence of new forms occurs in the narrow zone of critical connectivity (Figure 1): labelled 'The Edge of Chaos. The term gained its niche in organisational commentary, but has not, at least so far as search of current literature has revealed, been used to analyze office environments[5].

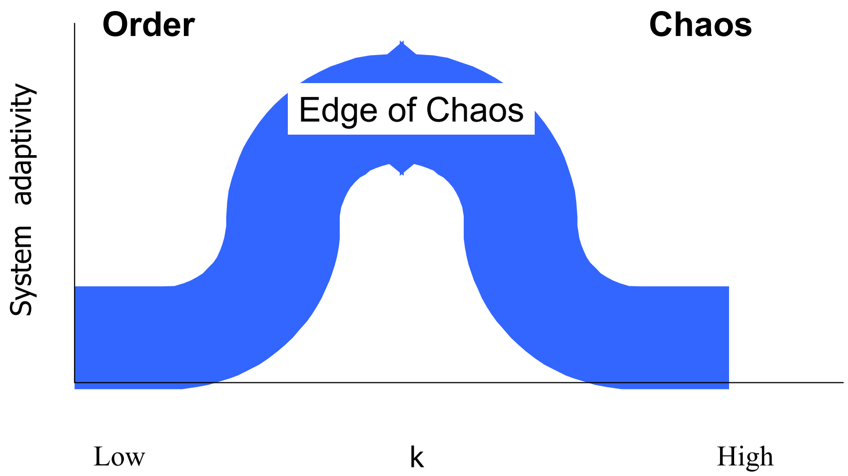

Figure 1. The concept (modified from Kaffman, 1993, 1995): A zone of maximum adaptability occurs at some critical density of connectivity. Can offices be visualised in these terms?

Much of the literature on 'new ways of working' is framed in terms of open-plans and hot desks versus traditional cellular offices. Yet many open-plans reproduce rectilinear layouts in which individuals or small groups are provided with, or create for themselves, spaces that are as enclosed and private as the prevailing environment permits[6]. They reflect a pattern towards the mechanical end of the spectrum. Meetings are conceived as formal events for which people go to a meeting room, not part of the routine of work. 'K' would seem to be low and not changed by any move from one to the other.

Sustained examples of offices in which 'K' approaches N-1 are harder to find, perhaps because of individual reactions. A total open plan, with no acoustic privacy and an expectation of every worker at his/her workstation most of the time might fit the bill. Is this why certain call centres suffer such high rates of agent attrition, and its

[5] Ward and Holtham's (2000) conception of knowledge management and knowledge environments as Complex Adaptive Systems comes closest but ultimately goes in a slightly different, albeit interesting direction. They cite Swedish research by Tornquist (1983) as arguing for creative milieux having a certain density of communication with a kind of overcrowding and chaos.

[6] Space prevents the inclusion of examples here. They have been illustrated (Price 2002c) in a longer version of the theoretical part of this paper and included in the conference presentation.

economic consequences (Citex, 1999)? More usually staff perhaps build there own 'walls', again using furniture but typically in a more random manner. The organisation reverts to a more disorderly but equally rigid arrangement.

An online case study (Lake, 2000) of a success story in flexible working, one which provides a variety of work spaces and has sets of workstations used by different teams on different days shows the difference. It was one in which the design team acted as facilitators rather than experts (pers. comm. to IP 1999) and since its implementation the users have gained a reputation for innovation with their customers. Connectivity, while people are in the office, is high but home, and various ‘caves’ offer privacy. Visually it projects an image that is somewhat disordered but not chaotic or frenetic. Is it at the edge of chaos[7]?

Connectivity can also be seen in the alternative debate on new workplaces: the one which distinguishes 'caves and commons' and private rows (Steele, 1988; Becker and Steele, 1995; Hurst, 1995; Hargadon and Sutton, 2000) rather than open plans and private offices. In 'caves and commons' designs individual workstations - or offices - surround or share informal common space in which frequent informal interaction occurs. Work is a system of fluid conversations and workers move to whatever environment is needed for a particular conversation, or simply find themselves exchanging information by chance[8]. Again some critical mass of connectivity is achieved9. The Complex Adaptive Workplace perspective would argue that caves and commons sustain a higher degree of connectivity.

Research

Hypotheses

The above model leaves the following to be hypotheses to be tested

1. New Workplace Initiatives succeed when they enable some critical density of spontaneous interaction. Too much and the distractions outweigh the benefits. Too little and benefits are not seen. That critical density may vary with sector and type of work.

2. Realising the success will depend on the culture of the organisation and will be greatest in organisations who have most successfully adopted 'new' managerial patterns. Contrast Turner and Myersons' (1998) mould breakers, those who have succeeded because they challenged, or were unconstrained by, the traditional patterns of a particular sector, from their modernisers, those who changed the office but not the thinking that went with it. The success to be realised will be a factor of the

[7] Our own offices in FMGC (also profiled online) are designed on similar principles.

[8] The view that professionals get 80% of their ideas through casual interaction (Liebson, 1981) has been much repeated but I have not found it further researched.

[9] Undoubtedly other factors, especially culture and management attitude (Haynes and Lupton, 2000; Price, 2001c) are important. Turner and Myerson (1998) refer to 'modernisers', corporations who have moved to fashionable new offices but where *"Staff shuffle uneasily down foliage filled avenues unsure whether sitting and chatting to a colleague over a cappuccino on a designer bench will be interpreted as slacking or having an informal meeting"*

extent to which 'new' cultures are a contributor to relative organisational success. Those who have implemented new office and workplace initiatives without changing old cultures will see less value (and perhaps negative returns) from the investment.

Methods

Where studies of occupants perceptions of their office environment have been published they have tended towards either a purely positivist occupier survey or to a blend of such surveys with either physical or cost based assessments of building performance (Bottom et al., 1999; Lorch, 1999). Phenomenological, or at least phenomenologically leaning, studies of workspaces or the interplay of workspace and culture are only beginning to appear (Hörgen *et al.,* 1999; Lupton and Haynes, 2000). Observational research is conspicuously absent from the 1990's literature (Haynes *et al*. 2000). In part the problem may reflect the multi-faceted nature of FM research, blending as it does the research traditions of economics, sociology, building physics and psychology. The hypothesis, expressed mathematically, is that:

Innovation = f(commonality, culture, connectivity)

Fully testing such a model is clearly multifaceted and requires, *inter alia*, analytical tools for space classification, assessment of work cultures, and the elusive ‘holy-grail’; a means of measuring the rate of knowledge creation in organisations. Price (2001, 2002c) has a longer discussion). An opportunity to assess the possible role of connectivity, was however provided when, during work for FMGC’s Local Government Research Forum, we were asked to develop an indicator for assessing the impact of office facilities on productivity.

In doing such research, which is almost inevitably questionnaire based for reasons of practicality, analogies can be drawn from the literature on customer expectations and quality (Robledo, 2001) where one school, the disconfirmationists, regard importance and satisfaction as independent variables, hence SERVQUAL (e.g Parasuraman et al. 1988). In contrast perceptionists would hold the two to be simultaneously measured by questions of relative performance; Cronin and Taylor’s (1992) SERVPERF.

Previous evaluations of office environments have tended to a disconfirmationist approach: i.e. have sought to measure the expectations of occupiers and their satisfaction in separate instruments. In the process links to productivity have become indirect. We opted instead for a perceptionist approach devising a research instrument which asked respondents to assess their perceptions of 27 variables on their individual productivity. The questionnaire provided scope for each to be assessed on a five point Likert scale from very negative to very positive. A series of categorising variables sought information on the individual respondents in order that results could be analysed by job type. Questionnaires were distributed in 27 Local Authority offices, introducing the possible bias in that participating Facilities Managers were volunteers. A total of 996 completed returns equated to a 22.9% response rate; acceptable in work of this kind (Hussey and Hussey, 1997).

Initial Results

Overall a Cronbach Alpha of 0.9485, pointed to high internal consistency and indicated reliability of the test instrument. A correlation matrix revealed a substantial number of correlations greater than 0.3 and a commonalities table showed 89% of commonalities scoring more thasn 0.5. These and a significant Bartlett test of sphericity all pointed to responses from a population of independent variables suggesting Factor Analysis as an appropriate analytical tool.[10] A Principal Component Analysis was chosen as we aimed to determine the minimum number of factors needed to account for the maximum identifiable proportion of the variance in the original data set.

Interpretation of factors is ultimately subjective (Hair et al., 1995) with a trade-off between number and variance explained. In the event we settled on 7 (Table 1, Figure 2), explaining 69% of the variance. Two distinct groups can be recognised, the tangibles and the intangibles, corresponding closely to the McDougall and Hinks' (2000) distinction of service and socio-spatial conditions. Tangible components, environmental services, office layout and perhaps 'flexible space' relate directly to the individual and physical environment and are similar to those revealed in earlier studies (e.g. Leaman and Bordass, 2000). The components 'disruption' and 'interaction' appear to point to more intangible or psychological factors; indeed they may be an insight into the social construction of individual offices (see below). 'Comfort' verges more to the tangible, as at first glance does the factor 'informal interaction points' though the two items involved are perhaps the commonest sites of informal conversation. Where the factor extraction set is reduced the two items concerned load with other interaction factors.

Factor	**Variables Loading**	**Cronbach -alpha**
Disruption	Interruptions, crowding, noise, privacy, overall atmosphere	0.8478
Environmental services	Ventilation. heating, natural lighting, artificial lighting	0.8037
Office layout	Personal storage, general storage, work area, desk, overall office layout, position of colleagues, circulation space	0.8469
Interaction	Social interaction, work interaction, physical security, creative physical environment	0.7943
Flexible space	informal meeting areas, formal meeting areas, quiet areas	0.8469
Comfort	Décor, cleanliness, overall comfort	0.8690
Informal interaction points	Position of equipment, refreshment areas	0.5726

Table 1 Loading of variables with Principal Component Extraction at seven. Cronbach Alpha reliability scores for each factor are shown. Factor names (first column) were assigned by the authors.

Cronbach Alpha coefficients were calculated for each factor, and as can be seen from Table 1 support the robustness of most. The component 'Informal Interaction

[10] Factor Analysis can of course be criticised on the philosophical ground that it produces results whether or not what is revealed has real meaning.

Points' has a relatively low coefficient which we take as an indication of heterogeneity in the sample and are investigating further.

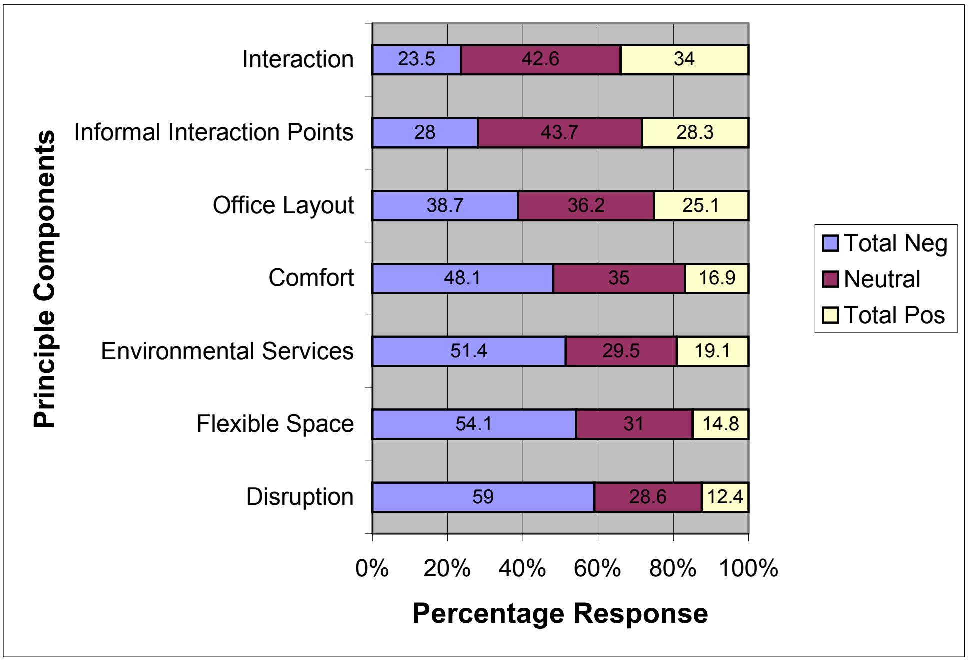

Figure 2. Overall ratings of the perceived impact of different factors on productivity

Figure 2 summarises the overall responses for each factor. Total Negative and Positive scores combine scores for two scale categories each. It is immediately apparent that the interaction factors are seen as scoring more positively whereas disruption scores most negatively. We have not yet been able to examine the 'flexible space' factor in follow up interviews but, given the sector, we suspect that respondents are reacting to the lack of such space and the resulting disruption, or possibly to a 'meetings culture'.

More generally the factors suggest a positive effect, on perceived productivity, of interaction, and a negative effect of disruption. While not surprising, and consistent with the inferences drawn above from the literature, these results do suggest that conventional occupancy analysis, which has historically tended to concentrate on the tangible may often have failed to examine the more important influences of office design on productivity. One important exception (Olson, 2002) likewise identifies the ability to do distraction free work and interactions as the two biggest factors impacting individual performance, team performance and job satisfaction. Olson however draws the conclusion that private offices are superior to 'open plans' but appears to equate open plans with rectilinear cubicle plans, ignoring completely alternative designs.

We by contrast would argue that the interactivity to disruption ratio appears compatible with the edge of chaos model. Too little of the former (order) and productivity, as measured by individual perceptions, suffers. Too much of the latter (chaos) and the negative effects of disruption dominate.

The research instrument also sought to classify responders according to their gender, type of work and mode of working. Investigations continue to examine the validity of the above factors according to different categorisations, particularly the mode of working. Here the best known, in the UK at least, is Duffy's / DEGW's characterisation of four groups (e.g. Laing et al.,1998) according to the variables interaction and autonomy, defined as:

> ***Interaction*** *is the personal face-face contact that is necessary to carry out office tasks. As the amount of interaction increases, there is more pressure to accommodate and support such encounters.*
>
> ***Autonomy*** *is a degree of control, responsibility, and a discretion each office worker has over the content, method, location, and tools of the work processes (Duffy, 1998 p. 60).*

and producing the categories of individual process, team process, concentrated study and transactional knowledge work. In order to recreate the four different subsets of this matrix, the questionnaire asked:

- What percentage of time do you spend with Colleagues?
- How much flexibility do you have to work where, when and how you wish?

The first question aimed to establish the amount of interaction the individual has with their work colleagues when they are in the office and offered a choice of percentage ranges.. The second aimed to establish how much autonomy the individual has with regards to how they work with possible answers on a five point scale from very low to very high. The total dataset was then split into the corresponding subsets using the criteria shown in Table 2.

Way of Working	Flexibility (Autonomy)	Time with Colleagues (Interaction)	Sample Size
Individual Process	Very Low-Average	< 60 %	418
Group Process	Very Low-Average	> 60 %	302
Concentrated Study	High-Very High	< 60 %	184
Transactional Knowledge	High-Very High	> 60 %	93

Table 2 Ways of Working criteria adopted for this study

Column 2, in Table 2, allows the data to be split using the variable flexibility, i.e. autonomy. Therefore people working in individual process or Group Process work have very low-average amount of flexibility as to how, when and where they work. However people working in the concentrated study and transactional knowledge modes, have a high-very high amount of flexibility as to how they work in the office. Column 3 splits the data by establishing the amount of interaction an office worker has with their colleagues. People working in the individual process and concentrated study modes spend less than 60 per cent of their time working with colleagues. Alternatively the people that have the work methods Group Process and transactional knowledge spend more than 60 percent of their time working with colleagues. The final column, in Table 2, represents the sample size that corresponds to the appropriate way of working.

Having created the four comparable subsets; a factor analysis was undertaken for each subset to establish if unique factors are created for each subset, or if the factors created in the total subset are reproduced in the subsets, thus supporting the validity and the generalisability of the original factors. Since this part of the research process is more confirmatory, then each of the new ways of working subsets was analysed with the factor analysis convergence model set at seven factors (Table 3).

	Ways of Working			
Component	**Individual Process**	**Group Process**	**Concentrated Study**	**Transactional Knowledge**
Disruption	0.8115	0.8880	0.7590	0.8345
Comfort	0.7111	0.8927	0.8664	0.8721
Flexible Space	0.8073	0.8443	0.8579	0.8789
Interaction	0.8115	0.8442	0.8547	0.9071
Informal Interaction Points	0.4913	0.6703	0.7916	0.691
Environmental Services	0.7989	0.8552	0.7764	0.7784
Office Layout	0.8535	0.8534	0.8095	No Component

Table 3 Component loading and reliability (Cronbach alpha scores) for staff reporting engagement in different modes of working

The same components load in each category, with the exception of the office layout factor for those who report high levels of autonomy in where they work: i.e. are likely to be mobile. Note however the strong correlation for this group in the interaction factor. The test reported examines reliability: i.e. the correlation between responses of randomly split portions of the sample. It does not measure importance – further examination is planned – but does indicate a high uniformity of view. In general the reliabilities are high for all factors and work types though the impact of Informal interaction points appears to vary more in perceived significance, especially for individual processors. At this stage we take the results as encouraging support for the validity of the constructs identified.

Future Work

Having validated the responses work continues to investigate difference in importance between different groups of workers. Spider plots (e.g. Figure 3) provide a potential tool to calibrate individual offices on the interaction / disruption ratio. We have noticed, comparing scores returned in individual offices, apparently significant differences in both factors but calibration studies continue. The opportunity to conduct statistical tests of the differences and compare with designs and any cultural factors has unfortunately not yet arisen. The importance of such studies is obvious. We are also seeking opportunities to test the results suggested here in other office based sectors, and to integrate such testing with other forms of spatial and sociocultural analysis. Meanwhile the results seem to provide evidence supporting both the informal view that what counts in offices is casual interaction, and the potential for modelling same using tools from complexity science.

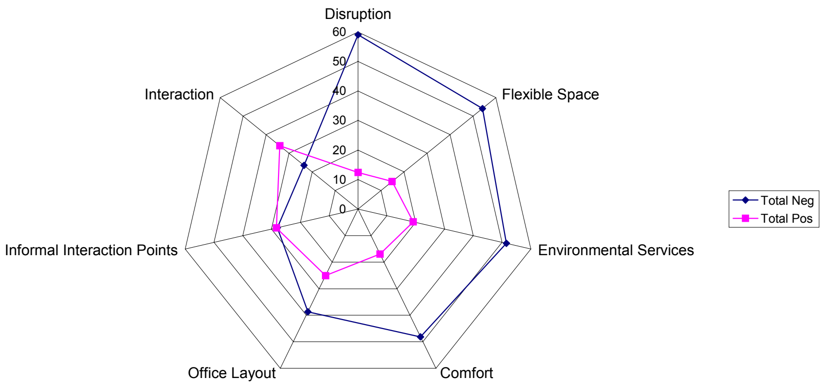

Figure 3. Spider plots of average scores on the 7 components for all offices in the survey

Acknowledgements

Thanks are due Liz Clarke, Shaun Lunn, Cletus Moobela, Victoria Ward, Clive Holtham, James Pinder, Bill Thompson, John Storr and Rob Harris for stimulating discussions. The work was partially supported by FMGC's Local Government Forum and Occupier.org.

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A consideration of the validity of post-occupancy evaluation of complex multi-user environments

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Abstract
The process of post-occupancy evaluation has been applied to a variety of building types with varying levels of success. The majority of documented cases relate to commercial and educational buildings although there are also many examples in the fields of housing and municipal buildings. In general these cases have tended to draw conclusions relating to building-user interaction or building performance based on the assumption that there is a single recognisable 'user'. Whilst in many cases this is an appropriate assumption, the validity of conclusions drawn on the basis of a 'mean' or 'median' user is not necessarily sound in building environments several identifiable user groups.

This paper explores the issues surrounding complex multi-user building environments with reference to case studies relating to two Learning Resource Centres at Liverpool John Moores University (UK). A multiple case study is currently being effected which attempts to apply the accepted process of POE in the environment of LRCs which have distinct user profiles. It is posited that within these environments a series of user 'types' can be defined on the basis of the nature of the individual's perceptions of their environment the their individual functional needs and behavioural traits. Having defined these discreet user types the process of POE is effected and the outcomes related to the various 'types'. This process liberates a series of conflicting conclusions relating to the building and its performance; thus it is difficult to provide any valid conclusions that can be used to inform the design process.

Having established that these different user types may have differing, conflicting demands on the building and hence different needs in terms of design evolution we must attempt to make positive interpretation of the findings. The work currently being undertaken in the Liverpool Case study attempts to identify a hierarchy of needs that allows the results relating to each user type to be mapped against the drivers and inhibitors of the design and evolution of buildings. In addition, the 'proximity' to design decisions is analysed. In this manner the potential for making the most positive design decisions based on a series of ranked conclusions arising from a stratified or type specific POE is examined.

The work involves aspects of qualitative and quantitative analysis and the various research methods adopted are discussed in the context of establishing and maintaining the integrity of the research process.

Keywords: POE, Building Performance Evaluation, User Assessment, Learning Resource Centres

Background and Context

The process of post-occupancy evaluation has been applied to a variety of building types with varying levels of success (Preiser W. 1995). The majority of documented cases relate to commercial and educational buildings although there are also many examples in the fields of housing and municipal buildings. In general these cases have tended to draw conclusions relating to building-user interaction or building performance based on the assumption that there is a single recognisable 'user'. Whilst in many cases this is an appropriate assumption, the validity of conclusions drawn on the basis of a 'mean' or 'median' user is not necessarily sound in building environments with several identifiable user groups.

This paper explores the issues surrounding complex multi-user building environments with reference to case studies relating to two Learning Resource Centres at Liverpool John Moores University (UK). A multiple case study is currently being undertaken which attempts to apply the accepted process of POE (James D. 1995) in the environment of LRCs which have readily definable and distinct user profiles. It is posited that within these environments a series of user 'types' can be identified on the basis of the nature of the individual's perceptions of their environment, their individual functional needs and behavioural traits. Having defined these discreet user types the process of POE will effected and the outcomes related to the various 'types'. This process is likely to liberate a series of conflicting conclusions relating to the building and its performance; thus it is suggested that in drawing generic conclusions it would be difficult to provide any valid outcome that can be used to inform the design process.

It is anticipated that having established that these different user types may have differing, conflicting demands on the building and, hence, different needs in terms of design evolution we must attempt to make positive interpretation of the findings. The work currently being undertaken in the Liverpool Case study attempts to identify a spectrum of needs that allows the results relating to each user type to be mapped against the drivers and inhibitors of the design and evolution of buildings. In addition, the 'proximity' to design decisions is analysed. In this manner the potential for making the most positive design decisions based on a series of ranked conclusions arising from a stratified or type specific POE is examined.

It is generally accepted that the nature of building performance is associated with three broad aspects; the physical nature of the building/space, the functional requirements of its occupants and the behavioural aspects of the occupants.[Preiser W. , 1988] Traditionally the outcome of the POE process has been an attempt to moderate the physical environment to match the perceived user needs. In this way it is anticipated that user 'satisfaction' will be achieved. However, the broader organisational aspects are often neglected.

This paper also sets out to consider POE from the perspective of the commissioning organisation and with reference to the cultural implications of effecting the process. The nature of the organisations that have commissioned POE is examined, together with a consideration of the underlying reasons for their decision to undertake the process. In addition the effects of the process upon the organisation and the groups and individuals within are explored in relation to the concept of user 'satisfaction'

In recent years POE has evolved into a tool for tailoring building performance around changing user needs (Riley M. Wordsworth P. et al 1995). One of the primary drivers in this is the pace of advance in the development of Information Technology.(Graham T. 1995) Many of the large organisations that have commissioned POEs are strongly associated with IT.(White T. 1992) However, as IT has developed they have largely rejected the option of repetitive POE. This paper also sets out to consider why this is the case.

The benefits of post-occupancy evaluation (POE) to certain types of organisation are well documented and have gained general acceptance in the property professions.(Riley M. 1996) The majority of users of formal POE processes have been public sector bodies of various types and large corporate organisations. The reason for this may be linked to the origins of POE as a developmental tool for bodies involved in repetitive building programmes or occupancy profile changes. The concept of a 'learning organisation' using POE data as the basis for ongoing, iterative improvements in facilities and enhancement of quality must rely on the application of a repetitive POE model as indicated in Figure 1. However the repetitive use of POE as a management tool following initial building occupation is still quite rare. The possible reasons for this are explored along with the organisational issues associated with the undertaking of POE within organisations.

Whilst the benefits are quite clear to many, the questions associated with the validity and the value of the process outweigh them. The identification of drivers and resistors of the process is important in attempting to draw conclusions regarding POE as a useful management tool, but also the recognition of the wider organisational strategy and agenda for quality improvement is essential. The basis of the research is to attempt to consider whether a range of discrete user groups using similar facilities (the two case study LRCs), with the same user groups identifiable in each setting will produce similar outcomes from a process of POE.

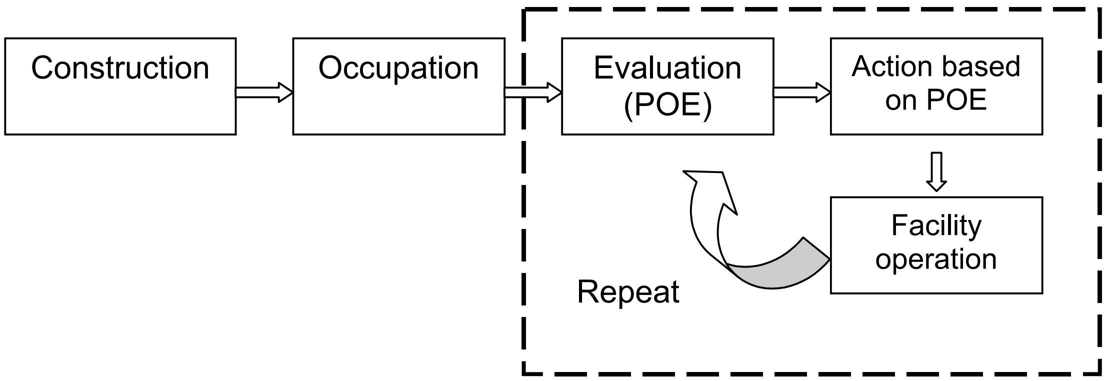

Figure 1: Iterative improvement through repetitive POE

Research Setting

Empirical work is to be undertaken within the setting of two similar Learning Resource Centres located at Liverpool John Moores University. The setting allows comparison of the two buildings which are designed to cater for essentially similar populations with similar needs. Discrete groups are identifiable within the user populations, which will include inter alia: Undergraduate students (full-time and part-time), Postgraduate students (taught and research: full-time and part-time), Academic staff and LRC staff. These groups are replicated in both Learning Resource Centres and both centres were constructed for the same client, in close geographical proximity and were designed by the same Architect using the same client brief. Hence, it is considered that the setting is a close as possible to the duplication of the same environment.

The selection of this research setting, whilst essentially a pragmatic choice, is highly appropriate as an exemplar of the principles involved. It is also highly relevant to the development of informed building design since LRC buildings in higher education establishment are currently subject to review and many projects have been undertaken recent years. The Higher Education funding Council for England (HEFCE) have initiated a programme of funding for such projects and are developing a strategic approach to post-project review which includes POE as a required part of the process. Some of the projects recently undertaken within England are set out in table 1.

Bath	Brighton	Central Lancashire
Lancaster	London – Wye College	London Guildhall
Manchester Metropolitan	Roehampton Institute	Sheffield Hallam
Thames Valley	Univ. College London	Surrey Institute
Westminster	Brunel	Durham

Table 1: Higher Education LRC/Library projects

Research Questions

A series of research questions are posed ; these are directed to the identification of user groups and the examination of their needs, distinctive characteristics and perceptions of the LRC environments. The intention is to show (or otherwise) that the POE effected in two similar environments will result in the identification of the same or similar groupings and that the outcomes for each of these will be similar. The aim is to show replication of the results, such that we can identify the same basis of group definition in each environment and that the perceptions of those groups will be similarly segregated or distributed in each case. Specifically the following propositions are posed:

- Users within a complex organisation can be categorised within a series of discrete user ‘types.’
- These user ‘types’ can be identified by a series of behavioural traits and functional needs or job/user function.
- The link between user type and job/user function may not be obvious.
- Individual behavioural traits as well as functional requirements will affect the way in which these individuals perceive the built environment
- Since POE recognises that building performance is a function of technical, functional and behavioural aspects, the differences manifested between these ‘types’ will necessarily liberate differing results within a POE.
- Interpretation of the results of POE in environments with identifiably discrete user groups should, therefore, take into account these differences rather than drawing ‘mean’ or ‘median’ conclusions.

- Some conclusions can be posited regarding the interpretation of POE results within such environments.

Research Design & Methodology

The methodology for the study is based primarily on the use of case study analysis applied in part using a longitudinal study and in part a multiple case study. Initially a pilot study was undertaken which applied the POE model to the Aldham Robarts Learning Resource Centre. This was used to fine-tune the POE model and to attempt to draw preliminary conclusions relating to the nature of users interaction with the building and its environment. This process was in part attempting to build theory regarding the individuality of perceptions of an environment and the requirements of defined user sets. This theory is then tested within the context of the case study. The use of a case study approach is considered appropriate since the research is based on the observation of contemporary events, with attempts to draw conclusions about what is happening within the POE process. In addition, the author has no control over the events being observed or the behaviour of the case study participants. Although a survey is used within the case study, this simply allows gathering of data about the population.

The empirical research forming the basis of this project has been effected using a case study methodology. An initial pilot study was undertaken in 1995 when a post-occupancy evaluation of the newly constructed Aldham Robarts learning resource centre was carried out. The POE was carried out when the building was approximately one year old. The study liberated a number of preliminary findings relating to the perceptions of users and the user/environment interaction. As a result several areas of mismatch or concern were identified and a series of remedial measures were put into place to rectify perceived failings of the original building environment. Since that time the building has been used in its original form by the student and staff population of the university and there have been no significant changes in the layout or environment of the LRC. The POE that was undertaken in 1995 is now treated as an exploratory pilot study in the context of the research design for this project. As a consequence of the pilot study there has been an identification of broad areas of issue in the examination of the user/environment interaction in the context of LRCs in higher education establishments. The research strategy has now developed and will utilise the approach of a dual case study examining the performance of the Aldham Robarts Centre along with the more recently constructed Avril Robarts Centre. The Avril Robarts centre is a second LRC constructed by Liverpool John Moores University in 1997. The design of the second LRC was informed by the results of the POE that had been undertaken on the Aldham Robarts Centre. For reasons of clarity the two LRCs will be referred to simply as LRC1 (Aldham Robarts Centre constructed in 1994) and LRC2 (Avril Robarts Centre constructed in 1997). The two centres provide a sound basis for the undertaking of a dual case study for the following reasons:

- They are purpose built facilities aimed at satisfying the same design brief
- They service populations that are similar in size, stratification and type
- They operate within the context of a single organisation

- The design of LRC1 was amended as the result of a POE, the outcomes of which also informed the design of LRC2
- They are of similar age and are designed around the same IT infrastructure

A case study approach

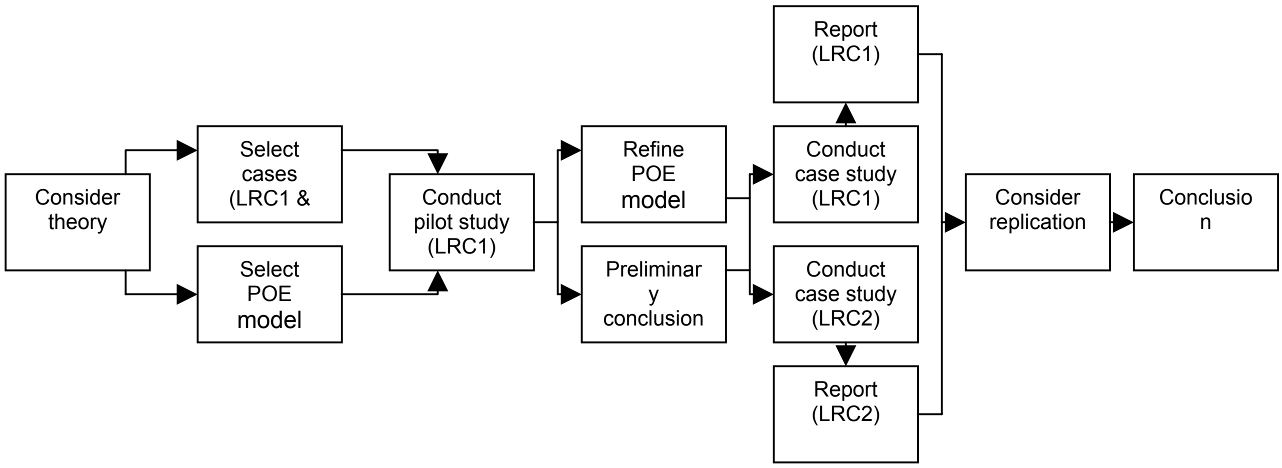

Figure 2: The application of the case study model (Based on Yin 1994)

It is generally accepted that what we understand as building performance lies at the overlap of building technology, user behaviour and functional need.(Riley M. Wordsworth P. et al 1995) Several writers have commented on the specific aspects of this interaction, but it is generally considered as a generic model of interaction. Figure 3 illustrates the principle as it is widely reproduced.

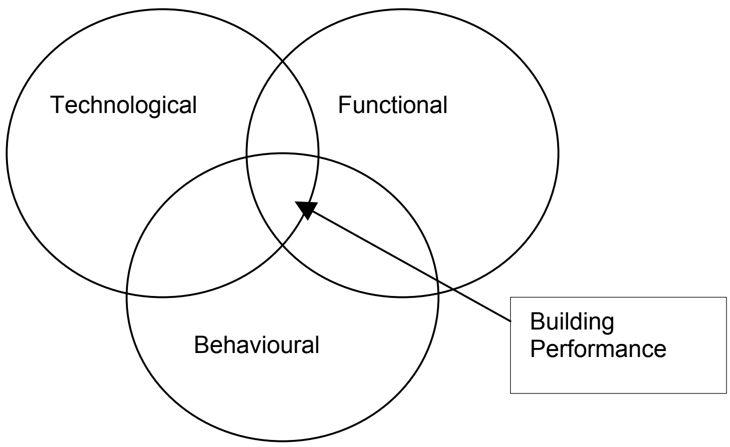

Figure 3: Building performance at the overlap of behaviour, function and technology (White E. 1986)

The interpretation of the outcomes from a process of POE which accepts this model is applied as a series of generic conclusions. However, in complex environments with multiple user groups it is posited that this model is inappropriate since the relevance of these three areas is likely to differ between user groups. Within the case study it is the intention to undertake a simple POE using a range of questions relating to aspects of building performance. This will be used to assess user satisfaction relative to the various components that make up building performance. In addition, however, an assessment of the relative importance of each of these aspects will be undertaken such that a matrix can be developed indicating the importance and satisfaction ranking for each user. (Figure 4)

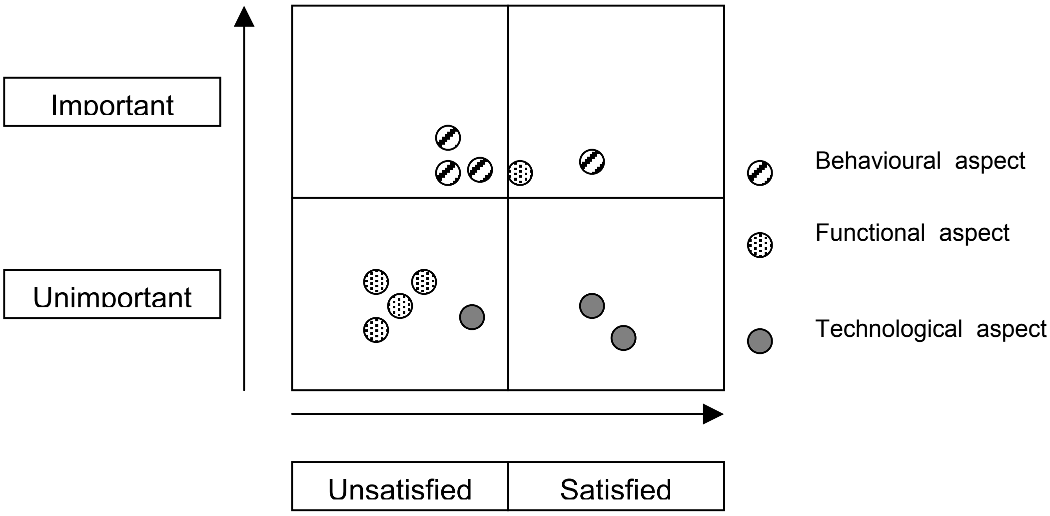

Figure 4: Identifying user groups based on satisfaction and importance

Using this approach a simple multi-scalar analysis will be used to cluster responses as the basis of a definition of user 'type'. The expectation is that there will an identifiable series of response clusters that allow the grouping of users into categories. Statistical appraisal of the responses will then be undertaken to attempt to identify correlations and links between the responses of individuals and types. It is anticipated that the outcome will be a series of differing clustered responses that allow the drawing of conclusions relating to type rather than a generic set of outcomes fro the POE. The balance of the Technological, Functional, Behavioural overlap is likely to be manifested in different ways by differing user types and this will be examined as part of the evaluation of the case study data.

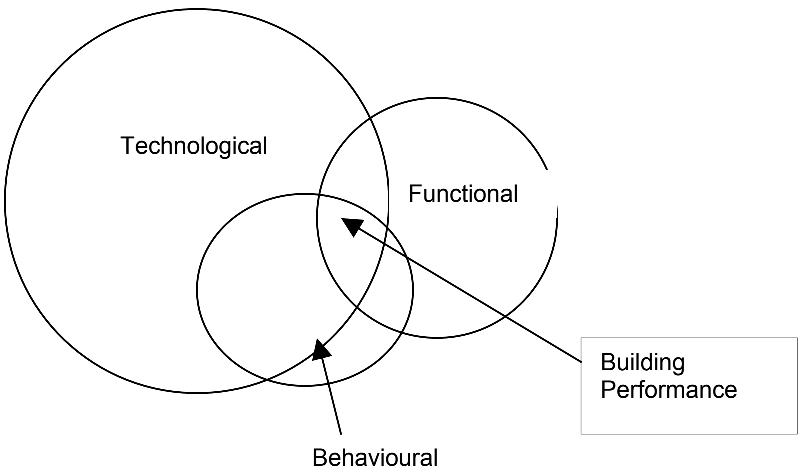

Figure 5: Building performance: A possible range of user types

The varying significance of these areas of building performance will be compared and contrasted based on the identified user groups and conclusions will be drawn in an attempt to assess the implications of this range in using POE as a valid building performance assessment model.

History of POE and organisations

When considering the types of organisation that have commissioned POEs in the recent past there is clearly a focus towards public sector organisations and large corporates. Table 2 illustrates a range of international organisations with POE experience. The inclusion of post-occupancy review as part of the CAPRICODE system utilised by the National Health Service (NHS) for major capital projects may have led to an increase in the level of POE related to NHS facilities. However, the authors' research suggests that where these reviews have been effected they have often been focused towards post project financial audit rather than attempting to truly evaluate the performance of the facility from a user/functionality perspective.

Government of the USA	**Government of Australia**	**State of Ohio**
Military Services	All agencies	Hospital & University facilities
US Customs Service	**Government of New Zealand**	**Kaiser Permanente**
National Bureau of Standards	Military facilities	Healthcare facilities
General Services Administration	**Gvt. California/Massachusetts**	**Duke University Med. Centre**
US Postal Service	Correction facilities	Hospital
Department of Veterans Affairs	**State of New Mexico**	**Takenaka & Shimizu Corps.**
Public Works-Canada	Senior Centres	Spec. Office Buildings
Healthcare facilities	Police facilities	(Japan)

Table 2: Organisations with POE experience. (Preiser W. 1995)

The reasons for these bodies choosing to effect POE must be examined in the context of the organisational perspective. The underlying justification for undertaking a detailed evaluation of facility performance may indeed be related more closely to the organisational agenda than to the absolute performance requirements of the building. It has been suggested that POE is a tool to allow managers to continually improve the quality and performance of facilities (White T. 1992). The term ‘continually’ used in this context suggests an ongoing process. The experience of POE in the main, however, has been very much on the basis of ‘one off’ evaluations. From the perspective of the organisation commissioning the process this may often be sufficient to illustrate an agenda intending to promote user satisfaction and to consider the needs of all within the organisation. This is more than simply paying lip service to the idea of user participation in the ongoing drive for improvement in facilities. In many cases the undertaking of the process is in itself sufficient to promote the idea of improvement, not in the facility itself, but rather in the users’ perception of it. This concept will be revisited later, the more obvious reasons for the commissioning of the process must first be considered.

Drivers for the POE process

The driver for POE within any organisation could be considered generically under the label of quality enhancement. The definition of quality enhancement will almost certainly differ greatly from one organisation to another , hence this label is less than definitive. In the commercially ‘orientated’ private sector as in the commercially ‘aware’ public sector, quality is linked with efficiency, effectiveness and value for money. These are inexorably linked to the level of user satisfaction in the workplace or the location of service delivery for the client body of the organisation. Particularly in the case of public sector facilities such as hospitals, schools and universities the end user is not necessarily employed within the organisation, but rather receives a service from it. Thus there is the added complexity of attempting to satisfy a number of disparate user groups, each with their own specific needs, in one facility. The definition of quality as ‘fitness for purpose’ has been posited on several occasions and has become generally accepted. (Hodgkinson R. 1998) The issue at hand here, however, is related to the problem of identifying whose ‘purpose’ fitness is to be measured against. In multi-user buildings this becomes a very complex problem.

Organisations that have commissioned POEs have been driven by a variety of elements to effect the evaluation process the following sets out some of the more generally accepted:

Commercial or operational benefit: the link between the performance of the built environment, user satisfaction with that environment and productivity or service quality is undeniable. However relatively few commercial organisations attempt to engineer a user-environment match. [Preiser W. , 1988]

Measuring value: the term value is defined in many different contexts, whether taken to mean cost, worth or significance there may be an intention to undertake a comparative evaluation of various alternative facilities or to benchmark a single facility against sector norms.

Public image: the process of evaluating the performance of facilities with an intention to enhance service quality is a positive aspect for organisations wishing to appear sensitive to the needs of those involved in delivering and receiving the service provided.

Private image: the intention to appear to be a caring organisation with empowerment of those within it to effect change in their own environment can have definite positive effects upon those whose opinion is sought as part of an evaluation process.

Developments in Information Technology: advances in IT have changed the nature of the way in which we utilise buildings significantly. It is undoubtedly the case that this change will continue and teat its pace will increase.

Change in organisational strategy: changes in the nature of business or service provision have effects on the nature of building environments need to support them. The evolution of work and attendance profiles result in the need to reconsider the nature of building performance and the interaction of form, function and users.

Resistors to the POE process

Having introduced some of the broad aspects that drive organisations to effect POEs it is necessary to consider the elements that act to resist within organisations.

Lack of awareness or understanding: although the cost of buildings is normally the second largest cost to an organisation after its staff, there is still a lack of appreciation in some areas of the importance of efficient and effective building performance as an aspect of organisational strategy. This is compounded by the lack of detailed knowledge on the part of many facility managers of the potential benefits of POE as a management tool.

Cost: with the cost of a detailed POE being in the region of £ 18-25 per square metre of evaluated space, the total cost to an organisation will be significant.

Organisational inertia: the process of POE is essentially about change or evolution in an organisation. The commissioning of the process, therefore, relies on an acceptance within the organisation of a need to change and the demonstration of a willingness to do so.

Fear of the result: from the perspective of the organisation, there may be a reluctance to expose aspects of facility performance and user satisfaction that require potentially costly changes to building environments or work practices.

Short termism: despite the longevity of many large organisations and the long term occupancy of certain facilities there is still a trend to consider building environments in the short term rather than the long term Learning organisations are comfortable with the idea of evolving organisational strategies, however, linking this to the evolution of the buildings that support them may be a step too far.

Cause and effect: the nature of human-environment interaction is complex and the factors that influence change for better or worse are often idiosyncratic. Thus there is the perennial problem of linking action to reaction or establishing cause and effect.

Timescale: the time lag involved in the enhancement of building performance through POE and in turn the recognition of a positive benefit to the operation of the organisation can be great, often months or even years after the initial POE.

Validity issues in POE

The validity of the POE process has often been called into question, in part as a result of the resistors noted previously. In addition, however, there are some more generic questions regarding the process of user satisfaction appraisal and building functionality.(Churchman A. 1999)

The effect of undertaking user perception analysis as part of a POE is interesting. Through variety of case studies the positive benefit of soliciting user opinion has been illustrated. (Horgen T. 1996) The experience of the author in undertaking a detailed POE based on a new Learning Resource Centre (LRC) at Liverpool John Moores University suggests that there is a clear positive impact in simply undertaking the process.(Revill D. 1995) The Liverpool study followed a well established model (Daish J. 1992) comprising four key stages; definition of performance criteria, measurement of criteria, evaluation and feedback. The generation of a feedback loop allowed for the iterative enhancement of building-user match. A key element in the POE was the analysis of user perception. As was expected there was a tendency during the evaluation for the users to focus on the negative aspects rather than the positive [Boyd M. D. , 1885 #3]. Thirty-five performance indicators were identified relative to the quantitative analysis of building performance. When measured against defined benchmarks such as CIBSE guidance, British Standards etc, there were some deviances but the building generally performed as intended. The user perception analysis relating to some of these same criteria, however, showed dissatisfaction with most of the physical aspects of the building's performance. Of thirty qualitative indicators used to assess user perceptions, there was a negative response to twenty-six aspects of building performance. The main dissatisfaction relating to background noise levels and temperature control.

Faced with the prospect of attempting to address all of the areas of dissatisfaction a decision was taken to attend only to the noise and temperature issues. These were addressed by insulating the fan coil units in the ceiling plenum to reduce noise levels and by re-mapping the buildings' heating system profile. At this stage the users' views were again monitored. The details of the amendments to the building environment were not disclosed, although users were made aware that moderation had taken place following the previous user survey. The results of this second round of user perception analysis indicated dissatisfaction with only thirteen of the performance indicators. Clearly the perceptions of the users had been affected by one of two things. It is possible that the moderation of the heating and noise levels resulted in other minor environmental indicators seeming rather less important; the individual elements taking on less importance when considered outside the context of a building that is noisy and hot. Alternatively the very fact that their opinion had been sought and, apparently, acted upon raised the perception of overall building performance and environmental comfort i.e. a placebo effect.

If the latter of these is accepted then it is possible that the building performance and user perception will converge as a consequence without the need to fully address all aspects of building performance initially seen as unsatisfactory. Effectively the perception and the performance become convergent as a result of the process of evaluation rather that the actions taken as a result.

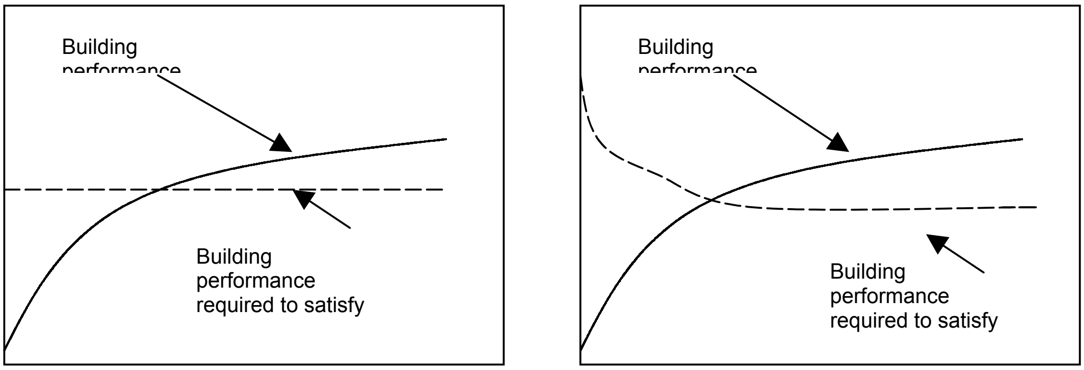

Figure 7: Traditional viewpoint and convergent performance and perception

Epistemology: The known & the knower

The evaluation of building performance and observation of building/user interaction relies on a totally objective viewpoint being taken by the observer. In reality however, even the most objective observer comes to the process with an accumulated knowledge in the field. Whilst this may not go so far as to result in obvious prejudgement it has been posited that one cannot separate the researcher form that which they research.(Churchman A. 1999) They interact with each other and it is suggested as a result they affect on another. The very act of research and observation alters the study environment or its parameters and consequently this affects the outcome of the study. It is also maintained that different researchers with differing viewpoints and different characteristics will interpret the same occurrence or data differently. Thus the observer must be considered as part of the event rather than an external element to it. This is similar to the well accepted Hawthorne effect, the concept that the act of observation itself affects the actions of those being observed. The combination of these two elements, the observer being fashioned by their own experience and the observed being affected by the act of observation calls into question the validity of any observations made. In some instance this may not be a negative thing. If the agenda driving the process is one of corporate PR or the generation of a ‘feel good’ factor within the organisation it is perhaps the process itself that is important rather than the outcomes of it.

Figure 8 indicates some of the factors that may affect the outcome of the process of evaluation in relation to the three variables that are significant ; the individual, the functional environment and the observer or evaluator.

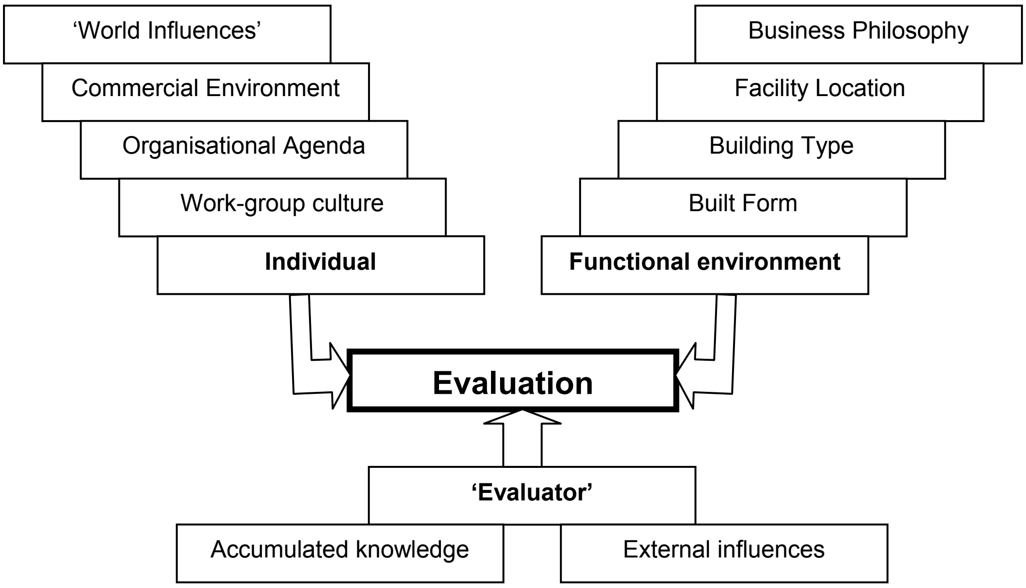

Figure 8: Influences on the evaluation process

Conclusions

This paper set out to consider the background and prior relevant work in the field of POE and the design of learning resource centres. Many sources were considered in the fields of building design, library operation, environmental psychology and the pure area of POE. Further work will be undertaken in this area, although it seems clear that there are significant hurdles to be overcome in establishing POE as a credible tool in the main stream. Uncertainty about the validity of the process along with ignorance of its benefits or even its existence contribute to the problem. It would appear that if the process is to be accepted in the wider commercial world, particularly outside the public sector mechanisms must be found to overcome the perceived resistors. In particular it is desirable to reduce the cost of the process, to improve the validity of the data gathering and analysis and to reduce the time lag inherent in the process. In addition the models for disseminating the acquired knowledge on a wider basis must be developed to allow the benefits of repetition across a commercial sector rather than within a single organisation. Once these aspects have been addressed the process of POE stands a chance of becoming a widely accepted and applied tool for the effecting of measured evolution within organisations wishing to maximise the facility-user compatibility and thus achieving operational benefits.

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Virtual Universities: An Assessment of the Effectiveness of Remote-Learning on University Space Planning and Design

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Abstract: *It is apparent that the world of education has changed. The latest developments in superhighway and the internet together with new forms of information storage are allowing students to be more flexible as to the time and place of learning in ways that were unimaginable ten years ago. The emergence of newly adopted metaphors such as "virtual university", "networked campus" and e-university have greater impact on university modus operandi.*

Proponents of the traditional methods have argued that learning should take place in fixed location within the universities and to be timetabled; they further argued that this will enhance quality and maturity of knowledge and taught experience in students' minds. On the other hand opponents argued that learning does not need to be wholly performed in lecture theatres or classrooms. As information becomes more computer and internet based, the issue of location is no longer necessary. This is synonymous to the ideas of telecottage and working from home. One of the main questions this paper is seeking to address is the wider implications of these changes on a university space planning and design? Will the university be radically transformed into a virtual world? Will the new technology offer an enhancement to the current system, or will it destroy it as the automobile did to horse and buggy industry? Will the university as we know it be able to exist at all? What alternative usages of the existing buildings might be.

An attempt will be made to examine and speculate some of the design implications of these changes on university and the use of the campus buildings and the facilities. This will provide a focal point on which facilities management professionals can identify more clearly issues for best practice and enable assumptions about the idea of tele-learning to be tested rigorously and the likely problems to be identified.

Keywords: Virtual university, Tele-learning, Remote-learning Space planning, Design, IT

1. Background:

Without us noticing, the world of education has changed immeasurably over the last ten years. Technology is allowing students to be more flexible as to the time and place of learning in ways that were unimaginable ten years ago. The dynamic nature of IT intertwined with financial imperatives has made a profound difference to the way teaching and learning is conducted. It has also broken down the barrier of rigid organisational structure into a more loosely-fit and adaptable ones and changed the culture within which students and tutors operate. Over the last ten years a great deal has been written about the notion of home working. Different terminologies have been used interchangeably, in literature, to describe this notion in terms of mode of operations, such as teleworking, telecottage, remote working, hotdesking, and so on and so forth. (Lovejoy,1993; Telecottage, 1995, The Guardian 1996). Most of these modes merge into each other; some of which have been adopted by many organisation but to varying degree facilitated by ease of accessibility to the internet, affordability and connectivity. It was anticipated that this will become the mode of the future. Between 1992 and 1995 the proportion of staff who have worked from home increased by just under 50% (The Miliken Report, 1996)

These new modes of operation have dramatically and irrevocably altered the flow of knowledge and patterns of learning in our society. For the university, the centre for creation and dissemination of knowledge this may have wider repercussions. But what are these repercussions?

1. Greater uncertainty about the new role and objectives of future university not knowing what is the best way of incorporating the emerging technology.
2. Overprovision of existing campus buildings and inadequacy of their units of accommodation to cater for technological change as these have to operate in much more stringent financial constraints and a complex organisational/ timetabling framework.

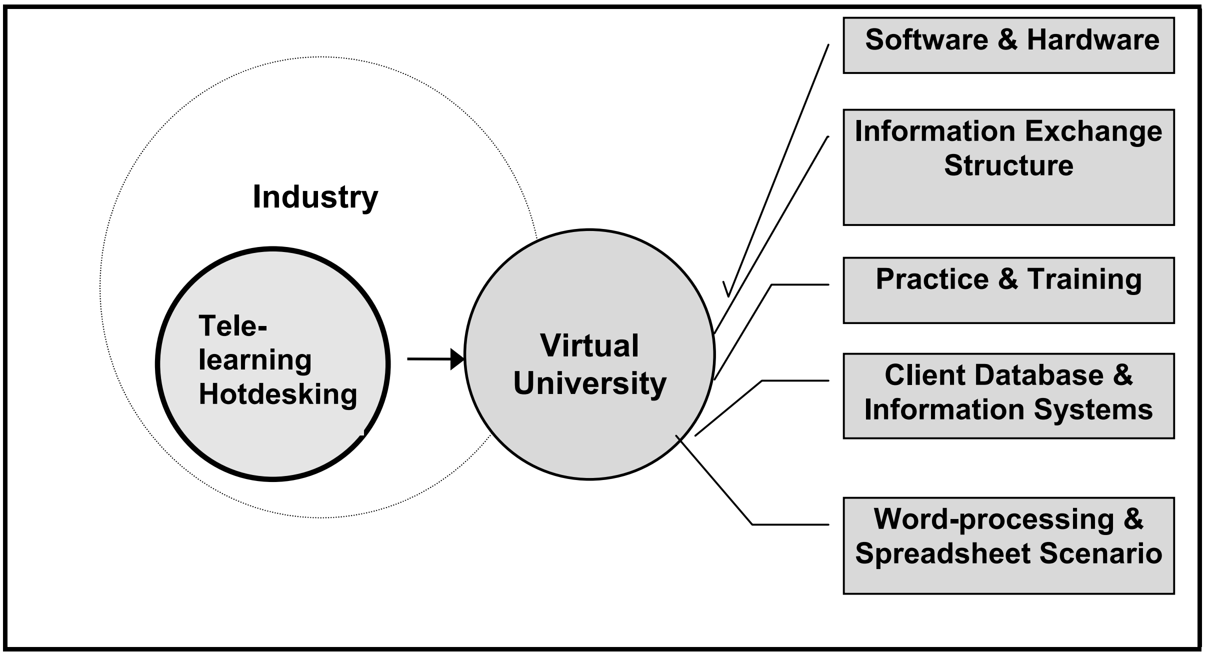

Figure 1: IT Applications and the Virtual university

3. Increasing diversity of type of learning requirements and learners attributed to the multitude of teaching courses/programmes provided by universities. These are intertwined with flexibility of teaching methods and the diversity of learning groups associated with each particular course.

From literature there seems to be two conflicting school of thoughts about the best approach to follow; traditional versus modern. Advocates of the traditional approach argue that learning should take place in fixed locations using a fairly rigid timetable; they further argue that this will enhance quality and the maturity of knowledge and taught experience in students' minds whereas those at the opposite end of the spectrum vociferously argue that technological changes will profoundly change the university of the future- learning and acquisition of knowledge no longer need to be performed wholly in lecture theatres or enclosed classrooms. As information become more computer and internet based, the issue of location is become irrelevant. During the 90's academics across the spectrum began to realise that they have to be more flexible in their approach and keep abreast with the evolving technology which is made available today.

It was estimated that the rate of growth in the use of the internet world-wide has risen from 201 million in 1999 to 407 million by the end of 2000 at 102% new in last fifteen months and we are in the western world becoming much more heavily reliant on this technology as compared with other nations as shown in figure 2.

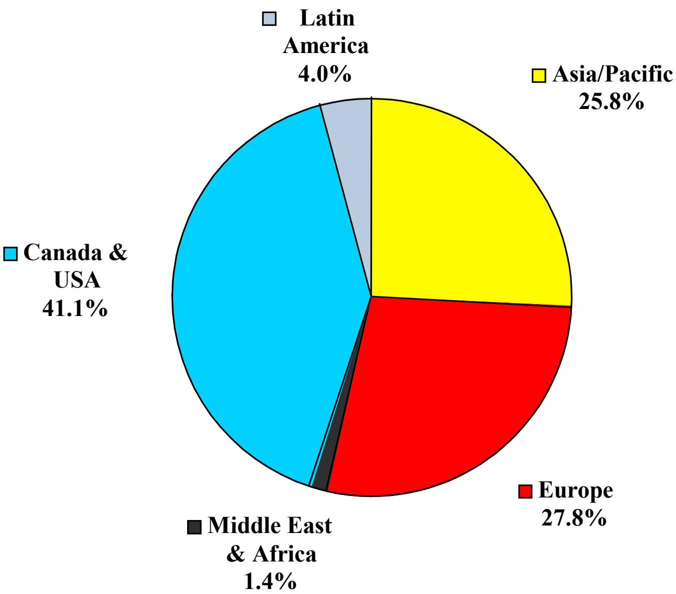

Figure 2: Internet Access by Region as at November 2000

Further discussion of these claim will be undertaken during the course of this paper to assess the pros and cons of technological changes and their impacts on buildings design and space planning.

2. The Problem of Change:

A university is a complex organisation which accommodates a whole range of activities and functions which are invariably in influx of change and in that it is more likely to be affected by whole range of managerial, organisational, financial and logistical problems which might impinge on building design at both strategic and tactical level of operation. These are almost entirely triggered by increasing number of young adults entering higher education. On the strategic level the dichotomy of "physical" versus "virtual" entity of future universities remains to be the sticking point. A number of questions can be raised. Will the university be radically transformed in a virtual world? and if so how would that impinge on the quality of virtual environment? Will the university in its current organisational framework be able to exist at all?

On the tactical level we need to address how these changes can be effectively accommodated to match varying organisational and users' requirements and what can be done to optimise flexibility of buildings in use towards improve their overall operational efficiency .

Early indications are that universities, instead of raising their levels of entrance, could absorb the greater intake by enlarging their premises and increasing their teaching capacity in order to maintain cost and keeping their teaching staff. This raises further question about the extent of overprovision of under-utilised spaces which can cater for such increase; this needs to be established prior to any expansion programme; it becomes imperative to critically assess the level of occupancy and utilisation of existing accommodations. Hypothetically, If such an increase has not materialised will the campus buildings become surplus to present requirements due to an increase of home learning using the internet? If so what alternative usages of the existing buildings might be?

2.1 The Quality of Remote-learners Environment:

If the quality of home learning environment is not wholly appropriate for a variety of reasons then what are the likely effects. Of course there has to be some form of equilibrium between home and university learning resources.

Compare this with the scenario of a student learning from home in front of the computer. There is an immediate appreciation of the learning situation by both the student and the other members of the family. There is an element of distraction and hence the student has to make a compromise, for example, half an hour in the sitting room with the family, then back to finish off the work at the computer. The learning processes is often disrupted as the surroundings are not conducive to this. This raises further question about the adequacy and appropriateness of home environment which needs to be redesign and adapted to meet individual needs. Equally, alternative learning spaces and facilities in wider urban areas or within local community might also need to be adapted to cater for learners needs. These could be found almost anywhere at the library, old factories and warehouses, local industry, office buildings, etc. It can be argued that by regenerating and utilising redundant buildings and/or existing community infrastructure, education can be incorporated as an integral part of any future strategy-a key factor in the economic and social life of a community and a driving force for sustainability.

2.2 Space Occupancy and Utilisation:

Many argues that a university buildings are becoming under-utilised asset; based on the analysis of actual number of hours campus buildings can be used, with the academic year of being as an average of 30 weeks, full-time student would be expected to spend 40 hours per week some of which will be formal class contact via lectures and seminars in campus buildings, others will private study and self-centred studies which could be anywhere (campus, home, local industry, site visit). Assuming that around 75% will be spent on campus as the best estimation i.e. a total of 900 hours per year. Individual working hours are around 16 hours a day, 7 days a week, 52 weeks a year- a total of 5824. It is not unreasonable to suggest that the use of existing campus buildings could be quadrupled or even increased fivefolds.

Utilisation[1] = Desk-hours used/Desk hours available
Room Frequency = Room-hours used/Room-hours available

Desk Occupancy = Utilisation/Room Frequency
Utilisation=Occupancy (when you have one desk per room, e. g. a single office space)

Room frequency breaks this down into the proportion of time that rooms are in use and the proportion of places occupied when the rooms are in use.

E.g.
Desk hours available= 45 hours per week
Desk hours used = 18 hours per week
Room-hours available=No of desks x 45 hours per week

As far as class room/lecture theatre occupancy rates are concerned and based on the assumption that these spaces are available as an average of 9 hours a day, five days a week i.e. 45 hours a week but they are only occupied at an average of 18 hours. Again these figures demonstrate that teaching space is unused and under-utilised asset.

In comparison with office buildings it was estimated that average desk space occupancy is around 40%. This is based on time it is left unoccupied and/or empty due to meetings customers, illness, lateness and lunch hours. Extra running and operational cost brought about by PCs, cabling and telecommunication system, makes it very expensive indeed.

Whilst the shift toward homework and teleworking has been justified on the purely financial basis that is of providing extra income to cater for private pension and healthcare[2]; By shifting some of their workforce to home working many benefits can be achieved in terms of more efficient space utilisation and time and cost saving (Duffy, etal, 1993). Will the same principles applied to remote-learning given lower level of occupancy characterising a teaching space[3].

[1] Utilisation compares 'activity' with space 'capability'
[2] This comes at a time where many organisations start transforming their modes of operation into more networking, flattening their management structure, outsourcing their skills and searching for more alternative officing strategies (Fenwick, 1996)
[3] "An office desk is normally unused at nights, weekends and during its users' holidays, so it is normally used for only 21% of the year" This is equally the case in classroom desk but with few variations in terms of the formula used for calculation.

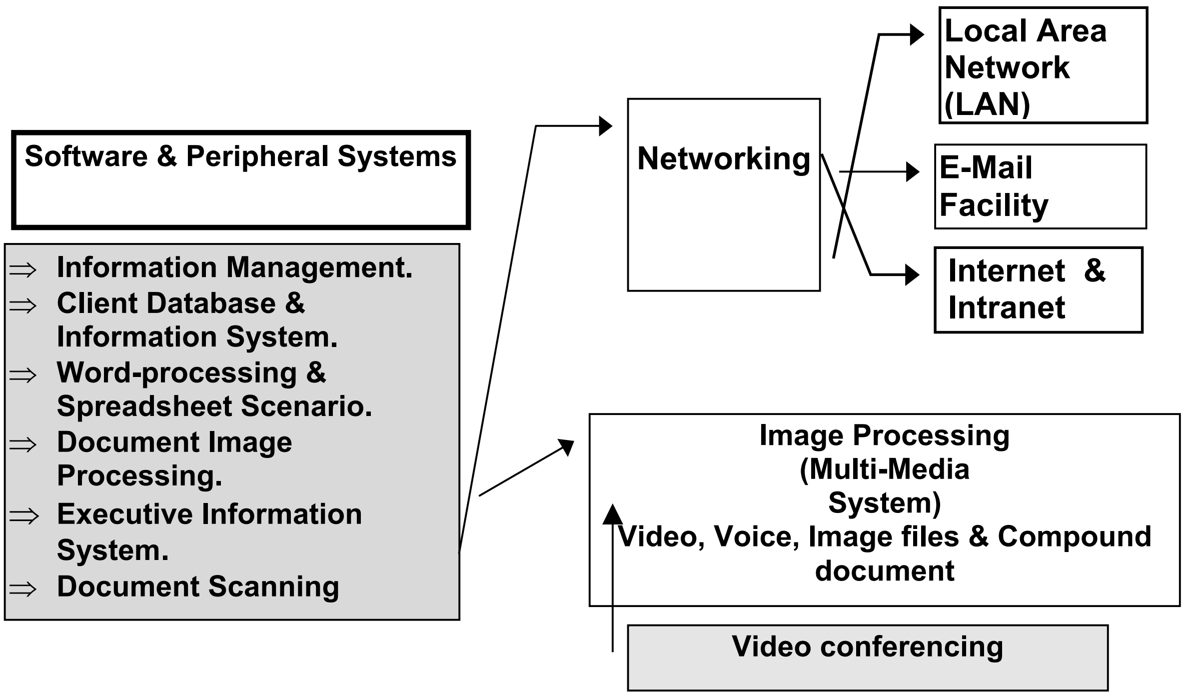

Figure 3: The Globe of Remote Working

To extrapolate on teaching space many similarities can be found. The main driving force is the deregulation of universities earlier this decade and the significant increase in students numbers. It has been estimated that the number of students have actually been tripled over the last five years whilst the number of teaching staff has remained static (The Deering Report, 1996).

The dwindling resources have put more pressure on the universities to maximise their efficiency in terms of organisation, timetabling, space utilisation and occupancy to achieve better value for money. The method of teaching and the size of learning groups are continually changing; there is also a growing shift in the method of delivery towards more evolutionary self-managed, self-centred and project-centred learning facilitated by utilising more flexible modes including teleworking and multi-media centre; these in essence resemble hot-desking.

By the same token, considerable similarities on the management level between teleworking and tele-learning can be found on the detailed level; both are synonymous to each other. In the case of university work, the tutor/lecturer can be substituted for the office manager/team leader and students substituted for workers. Both will require the same ingredients such as motivation, supervision, time management and training in the art of the internet. However, where education is concerned, a homeworking agreement will not exist, only a quality agreement as to the standards of tuition that will be received and the commitments required of the students.

But what is the likely scenario if the university campus has to be transformed in a virtual campus? What type of activities and functions can be incorporated within it?

If the students of the future are surfing the net from their bedrooms, receiving and transmitting information relevant to achieving a degree or other qualification, what will happen to the university buildings themselves? One can envisage that it is more likely that the buildings will be used to house multimedia centres, conference centres, lecturers, tutorials and project rooms facilities. During the Early 90's many universities in the UK have introduced multimedia learning resources centers by either upgrading the existing facilities or by building new centers. Universities will become "touchdown" points. They will also act as a half way house for students who require extra support. The existing university might be transformed into articulated centres. Each will be adapted to faculty requirements, each with a dedicated server and technical support. Access will also be provided to the database of books located at the university library or on the internet.

New forms and new location will have to be found for educational space adaptable to these changes. New avenues have to be found in urban areas aimed at breaking down the barriers that isolate living from learning. As an alternative planning approach, a "university without walls" can be suggested. For instant by transforming and reducing different UCE campuses across the city into a specialised and concentrated multi-networked "nucleus" supported by "orbits" that could be broken down and dispersed throughout the city of Birmingham to meet diverse teaching needs (e.g. learning requirements of different ethnic background and age-groups. This idea is relevant to a whole range of teaching courses and disciplines (e.g. built environment, business, social and health science, etc.). Whilst the idea of regenerating these "nucleus" into more versatile yet changeable entities which might be used for leisure activities, commercial enterprises and social interaction; they remain to be the backbone of the virtual university- the "command and control centers" of higher education (Newing, 1998).

In comparison "orbits" will become the battlefields whereby linking learning to real life situations- concepts can be learned firsthand through direct contact and involvement; Working in a supermarket or a DIY shop, local industry, property firm, local shops, banks, school or social- service activities may become part of this new university. This will enhance a two-way experimentation with sophisticated models of the real world and electronically enable interaction with peers and professionals in the field. Participation of those involved will be invaluable to make an effective and imaginative input in shaping future university.

The facilities offered by universities will be available to organisations that require short-term bases in which to house project teams around the country. The University halls of residence will house managers, staff and possibly sales representative who require temporary accommodation while they use the university facilities.

Use of tutorials as a means to maintain motivation and receive any feedback concerning the learning process and any obstacles met by the student.
One can also speculate that universities will combine both academics and businessmen under one roof. Both can learn from each other via two-way interaction.

3 Accommodation of Change:

The key answer seems to be flexibility. As the relationship between a building and an organization is becoming more changeable, and thus necessitating more flexible design layouts to cope with different patterns of change of the functional, organisational, managerial and IT requirements most characterising feature of many building types.

The controversy in describing flexibility in buildings could be envisaged through a diversity of terminologies, such as flexibility, adaptability, variability, expansion, versatility, convertibility and so on (Aylward, et al, 1974, 1979).

Most of these definitions have described flexibility as the potential to accommodate change, indicating why flexibility is needed, and how it was advocated in design.

In the light of the above, and given the uncertainty and changeability of the relationship between activities, space and the building in order to reduce the probability that campus building will not become obsolete, an informed state of knowledge about the activities which might occur in the building will be important if any strategy is to be drawn.

For any particular building, Sufficient data about flexibility need to be gathered to enable a more reliable prediction to be mad with regard to Interchangeability in the balance of activities (e.g. number of students engaged for each activity, overprovision or access of workplaces).

- Change in the sequence and interrelation of activities.
- Change in time-tabling.
- Change in learning methods and mode of delivery.

During the last twenty years several design notions were proposed, embodying the shift from identifying and designing for specific users' requirements, towards more general and indeterminate users' requirements (Maclure, 1984; Owen, 1990, 1993). This might be one most predominate feature of future university- the spatial organisation of building can be altered to suit any unique requirements of its users at any particular point in time. That is to say to maximize the potential for accommodating change in the organisation and activities housed in a building, without recourse to adaptation.

The first implies that a considerable degree of looseness of fit between activities and the building has to be maintained during use to cope with any demand for change. In other word, spaces should not fit closely the requirements of certain types of activities, but they should be loosely fitted to the majority of activities performed in which might change on daily, weekly and monthly basis. This may be facilitated by over-provision of spaces or by maximizing the independence of building elements, that is permitting some parts of the buildings to be redesigned after initial construction.

By maximising the potential of building which permits change and variations in the requirements of the organisation housed in the building which includes activities, time-tabling and group size without the need for adaptation, these will be better suited to organisational/users' needs in the foreseeable future without incurring extra cost.

Built-in flexibility will be a safeguard for accommodating change in the activities within a building which is facilitated by a continuum of space and a well-designed system of portable and adaptable furniture, cabling; equipment and hardware, allowing users to rearrange their accommodation whenever needed.

3.1 Connectivity:

By adopting the US model as a benchmark or a yardstick, what will eventually happen in the UK and the rest of Europe? There is a general recognition that what is occurring in the US now, will have an effect in the United Kingdom in about 3 - 5 years time[4].

It is anticipated that within a very short period of time, the infrastructure will be in place to provide unlimited connectivity. One site will be able to "dial up" another site and achieve two-way video, audio, and data connections. It is very important to understand what dial-up connectivity means. A student or lecturer will be able to be virtually present with any other student or lecturer in the UK.

Given greater connectivity, one of the main implication is that any university will be able to reach more students in more sites; such expansion beyond geographical area will be unimaginable in terms of competition which might lead to chronic uncertainty.

While the technology certainly allows us to serve more and more students who are further away, the concept that will dramatically alter higher education is connectivity. It is the ability to make connections interdependently among and between a wide variety of parties and share resources how we operate.

Telecommunications and information technologies make the virtual corporation possible. Could this same concept be used for universities. Could Universities around the UK pool their resources, with private sector help, to provide graduates that meet industry's requirements. A possible scenario is that students can stay at home but receive information and tuition from numerous universities, via the internet, to achieve their qualification. For each student the human and technical resources are assembled anew, but this might create considerable uncertainty which might lead to disruption of learning.

Perhaps we are pushing the speculation further ahead. Co-operation and integration of FE Colleges and universities has already taken place on more regional level and there are only few attempt on the national and European level but these are still under assessment. It seems that connectivity may facilitate such integration and makes it possible. Suffice to say that universities are considered to mirror our social and cultural values; places to provide services of passing our cultural heritage from

[4]This is based on the following:

1. There has been a 700 % increase in video conferencing systems sold.
2. Fibre optic cable is being laid down at the rate of roughly 600 mph, 24 hours per day.
3. The entrance of Intel into the video compression market.

one generation to another. In so doing, they are authorised to certify the qualified students for society's needs.

3.2 Interactivity:

Apart from that successful learning requires high quality interaction which can be envisaged in terms of student vs tutor; student vs pc, student vs knowledge base and models of the real world and student vs peer group. Indeed this interaction, and the network of professional contacts built up, is an increasingly valued ingredient of higher education provision. Email, the WWW, groupware, video conferencing (and advances as yet unknown) will continue to transform interaction between students and staff and within peer groups, more effectively. This will be independent of time and place of teaching. Knowledge management will provide an organisational framework for such developments which could be used to support ongoing and lifelong learning (Manchester, 1999). Face-to-face interaction among students is important.

Chodorow (1996) argued that “the electronic environment may enhance, but it cannot replace the intellectual society of the University. “We humans cannot thrive in bottomless, faceless environments”. He implies that as society is healthy enough to need new knowledge and educated individuals, there will be a role for the university to play. But what will this role be?

4 Ways Forward:

Remote-learning is multi-faceted and a complex notion which embodies a whole range of logistical, organisational and technological changes. It is too early to draw tangible conclusions about the design implications of such changes on the emergence and development of the virtual university as no real empirical assessment has been conducted so far to gauge the full impacts. However, a few pointers which reiterate and reinforce those themes can be drawn as far as teaching/learning/ networking are concerned as follows:

1. Portability and connectivity of IT and networking can now be used to provide high quality, interactive learning modes for students and adults alike across the spectrum. These have the potential radically to alter the relationship between teacher and learner. current teacher-oriented paradigm can give way to a learner-centric paradigm characterised by: asynchronous tuition; distance learning; the tutor as guide and mentor rather than information and data provider. Acquisition and dissemination of information into knowledge will be shifted to students.

2. Networking will increase student’s flexibility and mobility. Learning pattern is no longer a linear process; on the contrary it becomes more cyclical and metamorphous; Individualisation, long-life and loose-fit pattern will be predominant; thus allowing students of different age group and interests to play different roles at their own pace and pick different modules to meet qualification criteria. The idea of assembly-line classrooms where 30 to 40 students are taught identical course will be disappearing giving way to new types virtual learning space(s) for individual and small learning groups, as much emphasis will be given to address individuals rather than groups needs.

3. Changing university attendance boundaries and inducing greater community/industry integration might require further reorganisation of campus buildings through disintegration and decentralisation of facilities. In such a changeable environment users participation and advocacy techniques will be vital in determining the brief, the programming and the design of the facilities. New role will be evolved for users in initiating change.

However, the concept of an education system mediated *entirely* by computers is incommensurable nor would it be fully supported by the universities; it would only be a second-best experience. Remote learning is not suited to some school leavers as the face-to-face elements of peer support, tutorial support and socialisation are important for this maturing age group. Further empirical research is needed to examine the aforementioned issues particularly the role of the key players-diminishing versus expanding roles. Is there a need for a new teaching paradigm. One would only aspire to see a significant change but not at any cost-more computers and more networking is not the answer but it is the culture of all those involve in IT which really need to be changed. How can we possibly move forward?

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The effect of information and communication technologies on workplaces in South Africa

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Abstract: *Much attention has been devoted in the literature of the past five years or so to the growth of the Internet and information and communication technologies (ICTs) and the impact thereof on business practices and the demand for office space. In pursuance of the question of what the impact of the ICTs has been on commercial office space in South Africa, a working hypothesis was adopted that argues that the growth of the ICTs has resulted in a decrease in the demand for office space. A particular focus was the impact the ICTs have had on the structure of firms that have adopted new working practices – and the consequent impact on how they use space.*

Six office developments currently under construction or recently completed were studied in a qualitative enquiry. Semi-structured interviews were held, some telephonically, with a set of discussion questions / issues having been sent to interviewees before the interview.

The main findings of the research were that there is little correlation between the nature of working practices as caused by the ICTs and the demand for space – and that where this correlation exists it is mainly in certain types of businesses. Outsourcing, contracting and office intensification have similarly had little impact on the demand for space. The research highlighted barriers to the impact of ICTs such as human resistance to change in working practices; high costs of technological infrastructure; and high levels of functional obsolescence in existing buildings. The overall finding of the research is that the impact on office space of the growth of the ICTs in South Africa has been relatively small compared with the major developed economies.

Keywords: *Workplaces; Information and Communication Technologies; Foresight.*

Introduction

This research addresses a specific issue in a broader research project being undertaken. The main project concerns the investigation of how the growth of the Internet is affecting the property industry. The growth of the Internet, and the potential for the growth of e-commerce that it implies, is clearly a matter of great importance to industry and commerce – and therefore to the providers and managers of the physical spaces that accommodate it. The growth of the Internet and information and communication technologies (ICTs) has been flagged by several national foresight studies as a global change driver requiring research in order that the longer term impact thereof can be anticipated and planned for (Cattell, 2000). However, because foresight studies essentially consider the long term, firms in affected industries tend to be less interested in them than they are in short-term issues that directly affect profitability – that is if they are aware of them in the first place (Flanagan, *et. al.,* 1999)

The ICTs have had a profound impact on the way we work. It is inconceivable to consider working without computer software, e-mail, the World Wide Web, a mobile phone, or a fax machine, yet most of these have only been available to us for a decade or less. As this relates to foresight, the question is whether the property industry would have been better prepared to provide facilities suitable for the world of modern work, had it know twenty years ago that the ICTs would emerge and have the effect that they have had. The answer is undoubtedly that it would have, and this makes a compelling case for why it is necessary to consider what the further development of these technologies might mean for work and facilities in twenty years time. This is not to say that the research reported in this paper will predict anything, but rather that, through the study of current responses to the impact of the ICTs, it aims to sensitise those involved in property investment, development and management to the possibilities of the future in order that they might consider appropriate responses.

Literature review

The literature review below describes trends in the UK and the USA. No published sources of similar information exist for South Africa. This research seeks to shed light on how the ICTs are affecting workplaces in South Africa, but because of the lack of local published material on the subject, the empirical enquiry was essentially informed by the issues discussed below, which are probably less relevant to developing countries than they are to their original context.

The impact of the ICTs on firms – firm structure, working practices and space requirements

Information technology (IT) has had the effect of increasing the general productivity of office personnel. The number of clerical staff required to service middle and upper management staff has decreased due to office automation and the capacity of clerical staff has increased, which in turn has meant that fewer middle managers are required. IT has also given upper managers greater analytical capacity, which has further reduced the need for middle managers. IT has thus enabled the development of flatter organizational structures (Newey, 1996).

The development and convergence of the information and communication technologies (ICTs), along with globalisation, have affected business activities. Because of these trends, the need to secure competitive advantage is greater than ever, and this has led to business restructuring and new working practices (NWPs), which in turn have led to changes in the nature of and the demand for commercial office space (Lizieri, 1997). In attempting to meet market demands, firms have become more flexible and responsive, and hierarchical management structures have tended to give way to vertically integrated companies and flat horizontal operational networks (Becker and Joroff, 1995).

Modern organizations (mainly client-focused services like accounting, management consultancies and IT firms) are increasingly focusing on core business activities, downsizing and outsourcing many products and services to others (Lizieri, 1997; Duffy, 1997). In the process, they require fewer direct employees and space to accommodate them. The new workforce is leaner and more orientated towards teamwork, and the space it requires is radically different, in terms of *what* it is, *where* it is and *when* it must be available. The new workforce requires a new workplace, which has profound implications for office design (Newey, 1996; Jaunzens, 1997).

In summary, the development of the ICTs and the process of globalisation have both enabled and required firms to become more competitive. This has led to downsizing and business process re-engineering, resulting in smaller, less hierarchically structured, teamwork-orientated firms that require different workspaces to traditional hierarchically structured firms.

The impact of new working practices on space – types of space, lease structures and ICT infrastructure

Office design must now accommodate a different workforce, only some of which is based at the workplace (Turner, 1999). The following outlines the relationship between NWPs and the types of workspace required:

(i) Interactive workspaces (work areas designed to be flexible and to support teams as they expand and contract). Examples of these are: *"caves" and "commons"* – a dedicated or open group space surrounded by individual offices or workstations; *activity centers* – spaces designed to support specific group activities; *team suites* – spaces that temporarily accommodate project teams.

(ii) Autonomous workspaces (alternative workspaces geographically remote from the main workspace). These spaces accommodate teleworkers who work from home and need to be technologically connected to the main workspace. Similarly, satellite offices – fully supported facilities provided to workers close to their homes – need to be technologically linked.

(iii) Non-dedicated workspaces (temporary space allocated on an as-needed basis). These spaces accommodate "hotelling" (reserving space for a specific length of time), "free addressing", or first-come, first-serve; "group addressing" and "shared workspaces" – dedicated to teams, groups or shifts for specific durations

NWPs aim to make firms flexible, and as they change, so do their space requirements, as outlined above. The move towards such flexibility has been hampered in the UK by the traditional 20-25 year leases (Lizieri, 1997). However, the situation in South Africa, where office leases are typically 3-5 years (Cattell, 2000; Lockett 2001), is far more conducive to the adoption of NWPs.

A prerequisite for the adoption of NWPs is the investment in new technology to achieve Internet connectivity (Lizieri, 1997), particularly if autonomous and non-dedicated workspaces are to be incorporated. There is a trend away from local area networks towards intranets, which makes it essential that landlords facilitate the connection to the Internet of their tenants (Thompson and Hills, 1998). A possible outcome is that a landlord could offer a connected building, providing 24-hour Internet access and data transmission services - available as a service at a lower cost than would otherwise have been incurred by the tenant – capable of providing an income stream and improving the marketability of the building (Thompson and Hills, 1998). Lawson (2000) indicates that tenants in the USA consider Internet connectivity essential, but surveys indicate that they consider it a service like electricity or water and are reluctant to pay extra for it's availability.

To summarise, NWPs use space differently from traditional practices, a particular requirement being that they must be technologically connected. Further, they require a high degree of flexibility, which is only possible if leases are of relatively short duration.

Survey findings in the UK indicate that, although business structures have changed and NWPs have been widely implemented in firms, relatively few types of firms have been affected (e.g. accounting, management consultancy, IT) and a relatively small number of staff have been affected. It was also found that, while there has been an obvious response at the level of office design, there has been little effect on the geographical location of space or form/duration of tenure. These findings combine to suggest the conclusion that change is occurring gradually, rather than suddenly. A combination of internal factors have slowed the pace of change, for example, under-investment in, and under-utilisation of, IT; and resistance to the adoption of NWPs by staff and middle management. Similarly, the external factor of inflexible long-term leases, has hampered change.

Research problem and methodology

Against this background, the research sought to investigate whether NWPs are being adopted in South Africa, and if so, how they influence the demand for space.

The research proposition was that NWPs are being employed, albeit on a limited scale, and that the effect of this is a reduced demand for space.

The research method adopted for this study was selected after consultation with property developers and brokers, and involved targeting specific respondents based on the assumption that they could provide good insights into the subject because they were, or had recently been, involved in the development of a new office building. The research instrument was a structured set of questions, which was sent to the 12 interviewees prior to the interview. The instrument was intended as a discussion agenda and interviewees were encouraged to engage in the discussion to the extent that their experience permitted (as opposed to answering each question precisely).

The responses of seven of the twelve are presented below (those omitted did not raise any issues not covered below). The seven respondents were: company directors (1); space planner/ facilities manager (3); general property manager (2); and project architect (1).

The presentation of the findings below must be read with the above in mind – the method was qualitative and no attempt was made to measure the extent to which NWPs are being adopted. The case studies produced a rich set of responses, which formed the basis of the reporting below.

Scope and Limitations

The scope of the enquiry was limited to individuals who were, or had recently been, involved in the procurement of a new office building, in Cape Town or Johannesburg.

Presentation of the findings

The following are the questions/discussion items put to the interviewees, and a summary of the main issues and opinions raised in their responses.

Q1. How widespread are new working practices in business?

Respondent 1, a company director, reported that his organization employs hotelling through out their new Johannesburg building for all staff including middle and upper management, except secretaries. Employees shuffle around in order to be close to specific resources required for specific projects.

Respondent 2, involved in space planning and facilities management on a new building for a national cellular phone network provider, believes that NWPs are not as widespread as they ought to be in South Africa. They are mostly adopted in companies with strong financial backing and young leadership. Respondent 3, the general property manager for this company echoed these comments and reported that hot-desking and hotelling were not at all widely employed in his organization. There has been talk of moving towards NWPs, but no action yet. Respondent 3 raised an important issue in noting that the cost of land in South Africa is considerably cheaper relative to the UK and USA. In this context, there is less of a need to consider adopting NWPs.

Respondent 4 reported that NWPs were “fairly widespread” in the service based industries. Respondent 5 echoed this, but indicated that the adoption of NWPs had occurred in large organizations only, and mainly in the administrative work of the business.

Respondent 7, the managing director of a facilities management firm, reported that NWPs are not widespread in South Africa (“they hardly exist”). His organisation spends a considerable amount of time marketing the concepts to executives and CEOs, but with little effect. His belief is that there is no incentive for companies to change, because managers are very comfortably off and there is no pressure from competitors to do so.

The diverse responses above suggest that NWPs are emerging, rather than established and could not be described as widespread. Considering the responses to question 2, it appears that NWPs are being adopted in specific divisions of certain types of businesses, rather than generally across all divisions of all types of businesses. The relative cheapness of land in South Africa compared with the UK and USA, appears to be a factor in this, in that there is less incentive to change to more space efficient working methods.

Q2. Are new working practices being adopted in a wide range of business types, or only in particular types?

According to Respondent 1, NWPs (hotelling and hot-desking) only work in businesses where the workforce is generally itinerant, but not where it largely consists of nine to five, office-bound workers as, for example, is the case in most government departments. Organisations with large sales forces and accounting/auditing, consulting, journalism and, to some extent, advertising, were identified as organization types in which NWPs are commonly adopted. Respondent 4 also identified advertising/marketing practices as business types employing NWPs, particularly telecommuting designers.

According to Respondents 2 and 7, organizations specializing in sales, management consulting and accounting have been more inclined to adopt such practices.

Indications are that NWPs are being adopted in the types of organizations where they are best suited and easily implemented – i.e. business with largely itinerant workforces (sales, management consulting and accounting were frequently cited).

Q3. How significant are new working practices in terms of the demand for business space (– i.e. do downsizing, outsourcing, contracting and office intensification affect the demand for office space) and how has the property market responded to this?

Respondents 1, 3 and 5 were of the opinion that downsizing has a significant effect on the demand for space, outsourcing and contracting have a minor impact and office intensification has very little effect. Respondent 5 views office intensification in terms of space required per employee. He argues that office intensification through open planning does reduce the space required per employee, but not by as much as is often believed, because additional space in the form of meeting rooms, pause areas and breakaway rooms is required.

Respondent 1's organization has adopted the hotelling approach and has downsized, and this has resulted in the company requiring a significantly smaller building (600m^2 instead of 800m^2) than would have been the case had it not done so.

Respondent 1 raised the issue of the indirect expenses of adopting NWPs, giving the example of the technology required (e.g. databases, LANs, WANs) and the specialized staff required to support it. Further, where hot-desking and hotelling are the predominant mode of working, additional cleaning staff or services are required to clean workstations between shifts. The costs associated with this must be taken into account when assessing demand for space – there may be savings of up to 30% in direct leasing and operating costs, but approximately half of this saving will be eliminated by additional staffing costs for the reasons described above.

Respondent 4 noted that less space is needed due to the adoption of NWPs. This respondent was unhappy with the response from property developers, many of whom, reportedly, continue to build unsuitable speculative buildings. This claim was supported by Respondent 6's comment that developers of speculative office buildings are still constructing buildings with wing widths of 10 to 12 metres, which are unsuitable for open plan office designs.

Respondent 5 reported that the adoption of new working practices had affected the demand for space by making older buildings less attractive to tenants, in terms of both their location and physical characteristic aspects.

Downsizing has clearly had the biggest and most significant impact on the demand for space. There are indications, however, that initial space savings are offset to a significant extent by other costs associated with the adoption of NWPs.

Q4. Do new working practices affect the location of space?

Respondent 3 indicated that his company had conducted demographic studies of employees' residential areas before deciding upon the building's location. This is a direct result of the fact that virtually all of its core business is conducted using ICTs, making the actual location of the building irrelevant.

Respondent 5 noted that the importance of location was diminishing with the increased automation of the office and use of telecommunications. This respondent also noted that telecommuting had not grown as much as he had expected. His (service) organisation's approach to telecommuting had been to place employees at their client's premises to enable them to respond to problems immediately. However, the strategy did not work, because getting the necessary communications infrastructure in place had been problematic, his organisation's flexi-time model was not always mirrored in the client organization, and it was easier to provide the employee with the necessary facilities and support when located at the main office.

Respondent 7 believes that in future, location will be of paramount importance and the major cause of obsolescence. Distance between home and work will become a major issue, according to this respondent, who believes that telecommuting will increase. He cited a British Telecom pilot project involving 10 000 people working from home as indicative of the trend.

The responses above suggest what was expected – that NWPs do affect the location of space in several ways as described above. The overriding theme is that they free businesses from the traditional CBD-based model. Consequently, businesses may choose where to locate according to social values (e.g. close to employees residential areas), nature of business (e.g. operate out of a warehouse in an industrial area), or any other criteria.

Q5. Has there been a rapid move towards the adoption of new working practices?

Respondent 1 did not believe that there was a rapid move towards the adoption of NWPs, partly because developers of speculative office space do not create suitable space.

Respondents 2, 4 and 6 believe that the transition to NWPs is gradual, and occurs mainly in new and relatively young businesses. Existing stable corporations tend to be well entrenched in their (older) buildings which are typically less capable of accommodating such practices, or of accommodating the necessary technological infrastructure requirements.

Respondent 5 indicated that the move to NWPs had been gradual up until a few years ago, but had increased rapidly since then, particularly in larger organizations.

The consensus in the above responses is that the move towards NWPs has been gradual.

Q6. What are the barriers to change in terms of the adoption of new working practices?

Respondent 1 noted that the main internal barrier to change is the human factor. Individuals associate loss of personal control over territory with loss of status. This problem was preempted in his organization by personal counseling prior to such changes, although it was not perceived as a general problem, given that the average age of employee was 27 years, and the majority of this age group was in favour of the NWPs. The main external barrier to change was reported as inadequate bandwidth because of the high cost thereof. Much of the organisation's Cape Town work would be done from Johannesburg if this were not the case.

Respondents 2 and 3 cited resistance to change by top management, coupled with the costs of change, as a major barrier to change. Respondent 3 added that his company's workforce was also resistant to change.

Respondents 3 and 6 noted that managers fear losing control if telecommuting were to be introduced.

Respondent 4 identified the cost of instituting NWPs as a major barrier to change. He argued that human resistance was not a barrier because in his view open plan environments better suit employees' needs. He also raised important points regarding telecommuting, as did Respondent 7, arguing that it will never become widespread as long as the Telkom service remained high cost and poor quality. Bandwidth costs four times as much in South Africa as in the United States according to Respondent 7 and a large corporate's monthly costs per square metre in this regard can be double that of the rental it pays per square metre for A Grade office space.

Respondent 4 argued further that traffic congestion in South African cities is not serious compared with other major cities worldwide. In summary, he noted that the cost of putting high-speed connections in employees' homes would currently exceed that of housing them at the workplace.

Respondent 5 believes that cost is a major barrier to change. The issue here is that tenants in buildings inadequately configured to accommodate NWPs would face prohibitively high rental increases if buildings were altered to suit NWPs. South African office space is relatively cheap, compared with rentals abroad, thus the percentage increase on current rentals would be far higher in the case of South African buildings if such improvements were made.

Respondent 7 believes that the greatest barrier to change is that developers and architects do not understand the needs of the market. They build what they know, not what is needed. They have no idea that potential new income streams can flow from the proper consideration of ICTs (e.g. bandwidth delivery, management of value added services on networks, facility management, energy management).

Several barriers to change were identified. The main issues can be classified as follows: *human factors* (territorial issues; general resistance to change; fears of loss of control); *bandwidth issues* (one national provider with high cost, poor quality service); *non-response of property development industry* (potential market for firms wishing to adopt NWPs in ICT friendly buildings has not be recognized by office developers).

Q7. To what extent is "ICT friendly" office space viewed as an asset and considered essential to the realization of strategic goals?

Respondent 2's organization believes that its adoption of NWPs and the way it uses space, are an advertisement to its markets of its culture and values. Flat organizational structure, large open plan office, interactive streets, chill areas, breakaway rooms, etc., are all concepts intended to illustrate that the company believes in equal rights, transparency, business focus, dynamics and happy employees.

Respondent 3 cited the inadequacy of the present stock of office buildings in South Africa, which are largely not ICT friendly, as a big motivator of change. Most of these buildings were built on speculation by developers, and funded by the large financial institutions. They were not designed with NWPs in mind, nor can they easily accommodate them. Respondents 3, 5 and 6 stressed how the general floor to ceiling heights in these older buildings makes them "ICT-unfriendly" because they cannot accommodate access flooring. Respondent 6 identified the downstand beams typically found in older structures as being the cause of the problem, and noted that modern structures typically opt for flat slab construction.

Respondent 4 argued strongly that the provision of an appropriate high bandwidth connection to a building, particularly if it is A Grade space, is paramount.

As noted above, "ICT friendly" buildings are regarded as very important. There is also clearly a problem in this regard in South Africa, with the majority of the existing stock of office buildings being unsuitable and little can be done about it.

Q8. Do firms require greater flexibility in office design, technology and lease structures because of the adoption of new working practices?

Respondent 1 indicated that his organization selects space according to the following criteria: flexibility of design (so that it can be adapted to suit their working practices); proximity to employees' residences; and proximity to client base. Flexibility is very important to the organization – space usage follows a modular design using standardised workstations for the 150 strong administrative staff section, which can be moved around to create space for board meetings, teaching rooms, project rooms, etc. Regarding lease structures, it was noted that as a tenant, his organization would always want the flexibility to get out - the shorter the lease term the better - but the pressure from developers is obviously in the opposite direction.

Respondents 3, 5 and 6 argued that flexibility is enormously important if the major costs associated with frequent churn are to be avoided. Respondent 3 noted that churn within the buildings occupied by his organization had sometimes cost R30 per square metre (approximately 50% of the market rate for leasing A Grade office space in Cape Town's CBD). Over the past six years, the churn factor in these older buildings has been 150%, i.e. everyone has moved one-and-a-half times per year on average. Respondent 3 further noted that, since South Africa's re-entry into the world economy, the large financial institutions have virtually stopped financing speculative office buildings. As a result, many new office developments are now being built for specific tenants, whose flexibility requirements are being met.

The above responses clearly indicate that churn is expensive and inevitable. For this reason, and because many NWPs require it, flexibility is considered vital.

Q9. Are interactive, autonomous and non-dedicated workspaces generally designed into new office layouts?

Respondent 1 indicated that because hotelling and hot-desking are normal modes of work in his organization, such spaces are provided. He noted that in South Africa, if they are to be found, it will be in consulting and insurance firms, but the availability of such spaces is not widespread. Respondent 1 noted that in his organisation's India operation, satellite offices in Bombay were essential to avoid employees from the opposite side of town spending four hours per day commuting to and from work. The organization is considering doing the same in Johannesburg.

Respondent 6 indicated that this is not the case in speculative office buildings.

The low number of responses to this question suggests that the respondents had not been exposed to many buildings with such spaces.

Q10. Are existing office buildings becoming functionally obsolete in terms of the potential or otherwise of re-designing their layouts to suit new working practices?

Respondents 3, 4, 6 and 7 raised the issue of building wing widths and lighting requirements. Older buildings typically have wing widths of less than the 14 to 17 metres deemed necessary for modern offices. This is a direct consequence of the increased use of computers, the issue being that daylight and standard fluorescent lamp glare off computer screens should be avoided and the only way of doing this is to increase the wing width. A negative consequence of this, though, is that capital and operating costs associated with the necessary additional artificial lighting and requisite HVAC systems, are incurred.

Respondents 3, 4 and 5 stressed the importance of having an uninterrupted power supply (UPS), which is seldom available in older buildings and cannot be installed in some.

Respondent 5 cited the level of crime in the inner city, coupled with the availability of ample decentralized land suitable for office buildings, as the major cause of obsolescence of CBD buildings. This can clearly be seen in the rapid expansion over the past five years of Sandton, the new location of many Johannesburg businesses previously located in the CBD. The trend is also evident in Cape Town, which currently has 180 000 square metres of vacant office space in the CBD.

Respondent 7 expressed a view that IT companies who own the WANs, access to the Internet, and have the capability top manage the ICT infrastructures of buildings will be the future leaders in property development, not the financial institutions which have historically dominated the scene.

These responses clearly indicate that a problem exists in South African CBDs. They suggest that most buildings are obsolete and that little is being/will be done about restoring them to functionality because of factors such as crime levels and the cheapness of decentralized land.

Q11. How have the ICTs and resultant new working practices affected the life-cycles of commercial office buildings?

Respondent 1 noted that the effect of the ICTs has clearly been to reduce the functional life span of buildings. Looking towards the future, he believes that wireless technology will be a major influence. Currently, the need is for better and faster connectivity in terms of bandwidth.

Respondent 7 is of the opinion that in future office buildings will have to provide workstations and related spaces on a monthly rental basis. Leases, long or short-term, he argues will go. This will place more risk onto developers of office facilities and fundamentally shorten life cycles, because to attract tenants, buildings will have to constantly provide state-of-the-art infrastructure and facilities.

Although there were only two responses to this question, they spell out what is implied and stated in the answers to the previous 10 questions – i.e. that what the ICTs make possible in terms of working practices physically cannot occur in the buildings of yesteryear. If they are not yet obsolete, they are fast becoming so. Their life spans will, on average, be shorter than was anticipated when they were designed, and this is likely to continue to be the case for existing and new buildings.

Conclusion

The situation is clearly more complex than is implied in the proposition for this research. At one level, the proposition can be confirmed – NWPs are being employed in South Africa on a limited scale and they are effectively reducing the demand for space. At another level, though, we have seen that, because many South African businesses appear to be relatively comfortable with their existing working practices, because they fear change, and because property developers and designers are not preempting the need for NWP/ICT friendly *speculative* buildings, the reduction in the demand for space might have been and could remain relatively insignificant compared with what is happening in developed economies. It will be particularly interesting to monitor Respondent 7’s predictions that the property developers of the future will be the IT organizations.

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Indoor Air Quality for Facilities Managers: Understanding the Salient Issues Concerning Airconditioned Environments

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Abstract: *Investment in commercial property in Australia continues to be compromised by poor environmental systems management.*

This paper begins by explaining how building related illness, sick building syndrome and physical discomfort may negatively impact those associated with airconditioned environments and how questions of legal liability may arise.

The latest data from what has now extended to a 12 year study of 1067 airconditioned commercial buildings in Australia is presented; findings confirm the effects of widespread ignorance and poor system performance arising at all stages of the development process. While this unsatisfactory position applies to the survey sample generally, speculative low cost developments are clearly identified in the worst light.

As an aid to facilities managers not expert in matters concerning airconditioning plant and airhandling systems an explanation of proactive and remedial measures designed to ensure the successful management of commercial environments is presented with the case study data. A series of useful checklists and proformas developed by practitioners in Australia for the successful management of indoor air quality are provided as appendices.

Keywords: Australia; best practice; environmental systems.

INTRODUCTION

Although efficient, productive work output is seen as the essential purpose of commercial accommodation, situations of poor indoor air quality will inevitably affect building occupants by bringing about some degree of physical discomfort and/or illness. While personal well-being and quality of life will suffer, reduced work output and absenteeism must also be a matter of serious concern, not just to directly affected staff and their employers but all those associated with the provision of workplace accommodation. In recent years however, complaints of less than adequate conditions have become increasingly prevalent. Both naturally ventilated and mechanically ventilated/airconditioned buildings have been implicated although comparative studies have more often than not concluded that the latter are at greater risk (Sykes, 1989).

In spite of a plethora of published work dealing with issues of occupant illness and discomfort associated with building environments, there remains an appalling lack of understanding of the most basic issues even among those who ought to be responsible within the construction and property professions. Also, there would appear to be considerable confusion and bewilderment in the minds of those building occupants who are themselves the victims of unsatisfactory conditions. This paper sets out to highlight a range of commonly occurring inadequacies, improvements to which are likely to significantly reduce the incidence of illness and discomfort arising in air-conditioned buildings. A disturbing picture of the state of existing airconditioned buildings provided by a decade-long evaluation of predominantly office stock is presented.

BUILDING RELATED ILLNESS AND SICK BUILDING SYNDROME

Illnesses arising in indoor environments may broadly be classified as falling into the category of *Building Related Illness* (including legionnaires disease, pontiac fever, humidifier fever, hypersensitivity pneumonitis, occupational asthma and allergic rhinitis) or *Sick Building Syndrome*. While cause may clearly be established for the former, Sick Building Syndrome is relatively ill-defined, covering a range of symptoms which tend to be short-term, including eye, nose, throat and skin irritation, dry mucous membranes, fatigue, headaches, seeming airway infections, coughing, hoarseness, wheezing, hypersensitivity, nausea and dizziness. It is also important to appreciate that while Building Related Illnesses may at one extreme be fatal, as in the case of legionnaires disease, and Sick Building Syndrome is in contrast characterised by low-level malaise, the latter is considered to be a much more widespread problem, possibly effecting individuals in up to 30% of new and remodelled buildings.

Building Related Illnesses arise through airborne contamination of one form or another as is mostly thought to be the case with Sick Building Syndrome. Healthy buildings must therefore account for the control of problematic airborne particles and micro-organisms, as well as gas and vapour contamination (Williams, 1993). It is also worth noting that

(i) A range of important other influences may exacerbate or speed up the onset of illnesses. Such include a run-down state of health, poor comfort, lighting and acoustics and the psychological effects resulting from lack of freedom, insufficient intellectual challenge and an inability to personally control environmental conditions while at work.
(ii) Building Related Illnesses will typically be accompanied by Sick Building Syndrome although Sick Building Syndrome itself will more usually be found in isolation.
(iii) Sick Building Syndrome may be caused by a combination of two or more contaminants the concentrations of which are typically extremely low.

AIRBORNE CONTAMINATION

(i) Particles and biological contaminants

Of greatest concern will be the many different airborne allergenic and pathogenic (ie allergy and infection causing) contaminants that are so small as to be able to reach into the very smallest airways in the lungs.

The extent of contamination is highly variable, being effected by such factors as the amount of the fresh air being added to systems; the cleanliness of both fresh and return air supplies and air-handling equipment itself; the state of dehumidification equipment; the type of ductwork and associated lining (if any) in use; the class and state of filter employed; the quality of housekeeping within the building itself and the extent of cooling tower maintenance. Efficient control of respirable suspended particles (RSP's) is best achieved through effective ventilation for dilution and good quality filtration together with responsible source control. And where for one reason or another systems have been allowed to run down with contamination over time, a rigorous decontamination regime should be put in place.

The position regarding biological contaminants is complicated by the fact that parts of airconditioning systems are able to function as sites for the proliferation of harmful microorganisms. Dirty and moist or wet components may provide ideal environments for fungal and bacterial growth because nutrients exist in the presence of moisture and conducive temperatures. Such a combination may well arise for instance in condensate drain pans where microbial slimes may develop in stagnant water, and on duct surfaces immediately downstream of cooling coils where relative humidity may approach 100% and dust and fibres tend to adhere to moist, rarely (if ever) cleaned surfaces. Insulation fixed as acoustic lining to ducts and air handling units may also become moist and dirty and act as a nutrient niche for microbial growth.

Unless consciously planned for, regular cleaning of airconditioning system components is an awkward procedure which will all too often be set aside. By way of example, in a large building, numerous air handling units may be installed, each requiring time to expose the condensate pans and cooling coils; all too often such an installation will have taken place without the expectation of regular maintenance. Air handling units are frequently not provided with access doors or are otherwise inaccessible, such as above ceiling tiles, and maintenance consequently is difficult to perform. But rigorous maintenance is essential since it is particularly easy for fungal spores, for instance, to be airborne from proliferation sites thereby provoking allergic reactions.

Legionella pneumophila is the most undesirable bacteria that may be distributed by air handling systems; such may easily infest cooling tower plant since it naturally exists widely outdoors, particularly in soils, and thrives in the ideal conditions of temperature, nutrient and moisture offered by condenser water. Pathogenic aerosols will arise when the water itself has been contaminated, with potentially disastrous results for the condition of air in the vicinity of the cooling tower. Legionella bacteria may be transmitted in concentrated dose for instance, via fresh air intakes serving either the subject or adjacent buildings. Responsibility for rigorous maintenance of cooling tower plant together with appropriate juxtapositioning of cooling tower and fresh air intakes should be clearly understood by all those concerned with the design and maintenance of systems.

That the building interior irrevocably forms an integral part of any air handling system is a key factor often lost on those who occupy buildings. But in fact interior spaces may well give rise to airborne particle and biological contamination; for instance carpets and fabrics which are capable of harbouring considerable nutrient are known to represent fertile sites for microorganic growth, once exposed to dampness. Chemical dusts may also arise where carpets have been shampooed. A rigorous cleaning regime is required in such circumstances.

(ii) Gas and vapour contaminants

This category includes human biofluents as well as tobacco smoke and it is essential that ventilation to AS 1668 Part 2 be put in place.

Volatile organic compounds (VOC's) which are typically associated with materials derived from petroleum products, arise in off-gassing from a variety of building products, furnishings, cleaning products and a number of other indoor and outdoor sources. Formaldehyde is one of the most commonly encountered being sourced from certain glues and resins used in wood-based products such as particle board and plywood and a variety of other widely used products including urea formaldehyde foam insulation. It is known to irritate the eyes and respiratory tract and is a suspected carcinogen. But over 5,000 VOC's have been identified in building air, including toluene, benzene, trychorethane styrene and zylene. The off-gassing is normally greatest when products are new and may continue for months or years. Even at peak output concentrations are however extremely low relative to occupational health standards applying to industrial workers.

The effects of exposure to organic compounds vary greatly and range from unpleasant odours, mucous membrane, respiratory and eye irritation to fatigue, nausea and, as mentioned, suspected cancer. It is important to note that building occupants may be exposed to many pollutants, simultaneously, and that although exposure to individual contaminants may well be extremely low, the combined effects over time may be much more significant. It is recommended that this potential hazard be approached responsibly by means of source control (including selective materials specification) and fresh air ventilation. A table entitled Major Australian Indoor Air Pollutants : Sources, Health Effects and Measurement and companion checklist of Major Australian Sources drawn from Brown, 1997 are provided in Appendix Bi and Bii.

LEGAL LIABILITY

All those involved in the provision or maintenance of indoor air systems or those employing people to work in buildings serviced by those systems should be aware that they may be at risk of prosecution or claims for damages for systems inadequacies. The risk should be intelligently managed; relevant duties and obligations and compliance methods need to be clearly understood in the first instance.

Legal regulation impacting on indoor air quality is extensive with causes of action potentially stemming from a variety of provisions including:

- Occupiers liability which imposes a reasonable duty of care to see that any person on the premises will not be injured or damaged by the state of the premises (such relating directly to indoor air quality). It is important to appreciated that an owner will normally be considered an occupier.

- Common law. The duty is something of a “catch all” extending from building owners and managers to those involved in the design, construction and occupancy phases including architects, engineers, builders, equipment manufacturers and maintenance contractors.

- Health (Infectious Diseases) Regulations. Such deal in part with legionnaires disease and impose a duty on the owner or other in managment control of plant such as cooling towers, evaporative condensers, warm water systems, etc. to undertake regular maintenance and testing.

- Occupational Health and Safety Act. A person managing or controlling the workplace – which could include not only the employer but an owner or managing agent – owes duties to anyone at the workplace, not only employees.
  The employer also owes duties to see that employees and contractors are not put at risk e.g. by an unsafe working environment. Those engaged in business must also ensure that persons other than their employees are not put at risk from the operation of their business. An owner or managing agent would thereby owe duties to see that tenants and others entering the building are not at risk. Contractors maintaining plant also owe duties to those who use the premises; systems designers may also have obligations. Plant Safety Regulations impose duties on designers, manufacturers and suppliers of equipment and employers using such equipment (e.g. airconditioning systems, boilers etc) to control associated risks.

Several standards and codes of practice dealing with the design, operation and maintenance of airhandling and water systems are provided in the list of references. It should be remembered that while these documents do not provide legal force of themselves , where they are called up, for instance, in the Health (Infectious Diseases) Regulations, non compliance will represent an offence. Even where such publications are provided for guidance only, they may be used in prosecutions or claims for damages as evidence of available information and a reasonable level of compliance.

While Australian experience is often to the contrary, it is essential that all parties, from the time of project inception, thoroughly understand the duties and obligations described in this paper and that methods of compliance be clearly identified. On-going monitoring of system performance is critical and detailed records must carefully be kept as evidence of compliance since technical data confirming the integrity of the system is essential.

A deliberate IAQ Management Plan as partly provided by the Meerman (1997) and Hona (1997) checklists and Ruskenas (1997) audit proformas is recommend as a key component of this process (refer Appendix Ai to Aiv). It is essential that any management plan proposed possess integrity and that quality communication ensure that all of the numerous parties enjoy confidence in the system ultimately adopted.

THE CASE STUDIES

It will be apparent from the above discussion that a range of weaknesses to do with buildings themselves have the potential, solely or in some combination, to give rise to indoor air quality problems and discomfort. In a comprehensive evaluation Grimsud et al (1988) report that such will often concern air conditioning plant and air handling systems although other diverse aspects of the physical building and its use may be responsible. But the problems may commonly be overcome without a lot of effort or cost; not much more than an intelligent understanding and appreciation of the profit to be gained through improved occupant well-being is needed. Detailed explanations of regimes for improvement are provided by Hona (1997), Meerman (1997) NRCC (1992), BOMA (1991) USEPA (1991), and Ruksenas (1997).

In response to an apparently widespread lack of awareness of indoor air quality issues arising at all stages of the building procurement and post occupancy phases, a 12 year study of 1067 airconditioned buildings in Melbourne was undertaken by the author between 1989 and 2000. During the years 1989 to 1995 relatively small and low cost speculative office buildings were chosen as the focus of the study because of the rapid increase in this class of accommodation in recent years (such category now comprises approximately 50% of the available office space in Melbourne), the significant proportion of all office workers now accommodated and the relatively low standard of performance to be expected from investment buildings of this kind. From 1996 however no such restriction was applied and while a range of different building types were examined, there was also a tendency for evaluations to be performed on buildings of generally improved quality where first cost had not necessarily been so critical a driving force in the development. Important components of the study together with pertinent comment on these and related issues follows:

When digesting the data provided, it is important to note -

(i) that figures are generally first provided for case study evaluations conducted over an eleven year period 1990 to 2000 inclusive i.e. a stock of 1002 buildings.
(ii) Supplementary figures in brackets are given for evaluations of 228 small speculative office buildings conducted during the three years 1990 to 1992 inclusive. These figures are provided since they clearly emphasise the poorer performance arising in this category.
(iii) At times it is appropriate to provide figures drawn from Part 1 (1989) of the study since this early part of the study varied in some ways from that which followed.

INADEQUACIES IN AIR SUPPLY AND DISTRIBUTION

Responsible building design should ensure that fresh air intakes are juxtaposed so that they themselves are not contaminated. The following should be borne in mind:

- contamination may be due to emissions from the building in question itself, as well as other buildings/sites in the vicinity.
- while re entrainment of exhausts is common at roof level where sanitary vents, kitchen, toilet, air conditioning system, boiler stack and cooling tower discharges are typically located, this does not rule out problems arising elsewhere.
- unpredictable and variable wind currents may transfer outdoor contaminants to unexpected situations.
- It is difficult to set general rules for the separation of intakes and exhausts. AS1668 Part 2 does at least state however that intakes are not to be situated anywhere that will reduce intake air to a quality lower than that found in the general locality or where adjacent structures or wind effects are likely to reduce outdoor air intakes below recommended levels although it is clear that these provisions are poorly, if ever, policed.
- Air intakes should be located as far as possible from sources of motor vehicle exhaust including street traffic, car parks and loading docks.
- Airborne contamination from industry, streets, construction sites, etc. should be taken into early consideration as part of the site selection process.

- Not only is occupant health potentially effected by airborne contaminants, but undesirable odours may invade the building.
- Apart from effecting air intakes, outdoor contamination may present other problems of local or general infiltration of the building .

Results of the main survey of 1002 (228) buildings showed that in 45% (63%) of cases the intakes were considered to be compromised by contamination emanating from or arising in the immediate vicinity of the subject building. Examples of sources of contamination were toilet exhaust, carpark, kitchen exhaust, cooling tower, plant exhaust, spill air, truck exhaust, chemicals, fume cupboard and boiler stack, and it should be noted that more than one source may have been present in the vicinity of any particular intake. Of the main sample of 1002 (228) buildings 37% (54%) of fresh air intakes were considered to be compromised by outdoor air contamination arising from other close to hand sources such as exhausts from adjacent buildings; examples of some of the external sources arising were building site, traffic, factory discharge, carpark, toilet exhaust, petrol station, kitchen exhaust, incinerator, hospital exhaust, cooling tower, boiler stack.

Contaminated air generated by motor vehicles is a potential problem where there is a possible connection between carparks and occupied spaces. Such may arise by way of lift shafts or stairwells where, for instance, negative pressure in the occupied spaces developed by the air handling system together with natural thermosyphon "stack" effect or the pump action of lifts may promote infiltration of carbon monoxide (which is insidious, since it is colourless and odourless as well as being cumulative in the blood) and other contaminants. Of the 65 buildings studied in Part 1 of the investigation, 32% possessed interconnecting basement parking and interconnecting lift shafts and stairwells providing potential for contamination. It should be noted however that most of the buildings studied were of low rise form, not being equipped with lifts or subject to the sort of stack effects associated with high buildings.

The need to consider the building interior as an integral part of any air handling system has already been explained since it is here that significant problems of airborne contamination may often be sourced. Photocopiers may often arise as one such source capable of emitting a variety of particulate and gaseous contaminants as well as adding unwanted heat to the environment; chemicals used for cleaning and other purposes may often contain undesirable VOC's and odours. The investigation reported specifically on the extent of photocopiers, and whether these were mechanically exhausted, as is desirable. Of the total stock of 1002 (228) buildings, 81% (90%) contained photocopiers that were not exhausted. Significantly, Part 1 (1989) of the study showed that only those buildings containing four or less copiers had exhaust systems fitted, or by contrast, the more photocopiers contained in a building the less likely they were to be exhausted.

Reduced and inadequate fresh air ventilation which arose as a cost-cutting response to the oil crisis of the early 1970's is often cited as the most significant cause of indoor air quality problems afflicting existing airconditioned building stock. But minimum rates have in fact been recommended for many years by Ashrae and the Standards Association of Australia with the aim of avoiding unacceptable levels of human bioeffluents (including CO_2) and tobacco smoke in the first instance. The current standard AS1668-2 (1991) sets 10 l/s/person as the recommended level for office space where moderate smoking is expected. It will be apparent that apart from controlling bioeffluents and tobacco smoke, fresh air is also capable of diluting all airborne contaminants; such a strategy is advanced by those favouring the "building systems" as opposed to "source control" approach to contaminant control.

Many of the buildings investigated were in fact built at a time when the minimum Australian requirement for fresh air was set at only 3.5 l/s/p (AS 1668-1978). This aspect was examined in the 65 buildings investigated in Part 1 of the study in 1989; while 10% of the sample even failed to meet this requirement, it is of some significance that 82% of the sample failed current criteria.

An "economy cycle" enabling air handling plant to operate entirely on fresh air is a most desirable feature that may be fitted to airconditioning systems. Such an arrangement is certainly of benefit in the Melbourne climate, since energy savings for space cooling may be obtained when outside air is cooler than return air, with refrigeration plant operation being substantially reduced. Systems fitted with air economy cycles provide the added advantage of being able to fully flush occupied spaces with fresh air, thereby promoting dilution of contaminants beyond that possible with minimum recommended rates. Significantly, systems were not fitted with economy cycles (or if they were, such were not operative) in 51% (88%) of the main sample of 1002 (228) buildings.

Once air has been supplied to occupied spaces the adequacy of its distribution will be effected in part by whether or not complimentary supply and return provisions have been provided for each room, whether or not internal room obstructions impeding the ready distribution of air in occupied areas are in place, and whether or not supply air diffusers themselves are properly placed to ensure adequate air distribution in the first place. The investigation reported inadequacies in these three categories at 29% (33%), 35% (32%), and 24% (26%) of the main sample of 1002 (228) buildings.

From a vital comfort perspective it must be remembered that individuals are extremely sensitive to air movement to the extent that draughts and stuffiness may readily be perceived. ISO7730 (1984) recommends maximum velocities of .15m/sec in winter and .25m/sec in summer; a lower limit of .lm/s is also desirable to avoid stuffiness. But widespread cost-cutting at the commissioning/air balancing stage often ignores the need to accommodate these levels of sensitivity, and all too frequently too much air is delivered to parts of the building and not enough to others. VAV systems should be singled out for special attention in this latter regard, to ensure that minimum air flow is in fact adequate. A lack of priority given accurate commissioning together with the inadequate maintenance already discussed, was widely evident in distortions to air distribution in the building stock examined. Sensations of cold draught were reported significantly effecting 56% (63%) of the total stock and unacceptably stuffy, drowsy conditions significantly effecting 56% (62%) of all cases.

SYSTEMS IN OPERATION : POOR ACCESSIBILITY, HYGIENE FILTRATION, MAINTENANCE, COMFORT, etc.

Sykes (1989) accepts, in a thorough evaluation of SBS that the incidence of the illness is far higher among airconditioned rather than naturally ventilated buildings and, in the absence of any other clear direction, emphasises the importance of adequate attention being given to the design, installation, commissioning and maintenance of airconditioning systems.

There is widespread support for this view; Burge et al (1987) conclude that the level of SBS is often best correlated with standards of system operation and maintenance and of general cleanliness of air conditioning systems and interior building spaces. Such attitudes are reinforced by studies of problem buildings (NIOSH 1984, HBI 1990). The former deals with 529 buildings during 1988, the latter with 412 buildings during the period 1981 to 1988. Ventilation problems were found by NIOSH in 53% and HBI in 62% of their respective samples, 33% of the HBI buildings being without any source of fresh air at all; air in 34% of the NIOSH sample was classified as contaminated; of the HBI sample 61% suffered from unsatisfactory air filter installations, 58% from demonstrably unclean air handling equipment, only 25% being regarded as well ventilated, efficiently filtered, clean and well maintained.

One recent Australian study similarly confirms lax attitudes towards maintenance of cooling towers and the control of legionnaires disease (Battisti 1999). Of 164 towers in 57 buildings investigated for compliance under the Health (Infectious Diseases) Regulations 1990, 80% were found to have no effective risk management plan in place for legionnaires disease, 18% failed to provide monthly bacteria counts and did not clean and disinfect towers six monthly while 21% failed to maintain any documentation on tower maintenance.

The need to keep air handling systems clean and dry so as to control the amplification and airborne distribution of particles and microorganisms will already be evident. It follows that plant and plant rooms should be designed so as to facilitate rather than impede cleaning and maintenance. But alarmingly, in 37% (47%) of the main stock of 1002(228) buildings significant problems of either inadequate access or unclean components were found. Often even the most basic needs of access had been overlooked, unsatisfactory provision to key components being found in the following percentages of cases: filters 19% (25%) cooling coils 22% (25%); fans 20% (24%), cooling towers/evaporative condensers 8% (13%). Filters were "locked in" with inadequate space for physical withdrawal in 10% (11%) of the stock.

The problems of inaccessibility undoubtedly gave rise in part to a significant lack of cleanliness or fouling which was reported at the following rates for individual system components over the total building stock: ducts 12% (18%); and cooling coils 12% (17%); cooling towers/evaporative condensers 8% (14%); fans 9% (12%).

And while the type of air filter employed is acknowledged as a key factor in the endeavour of keeping systems clean the survey showed that, by and large, lip service only had been paid to this function, 59% (88%) of the total building stock examined being equipped with poor performance dry or impregnated flat media panels, and only 34% (12%) being fitted with improved quality arrestance such as that provided by V form/pleated or bag type filters. The above figures clearly reflected attitudes of low priority widely afflicting the airconditioning industry.

The need to regard occupied spaces as an integral part of air handling systems and of necessity maintain good standards of interior housekeeping was addressed by the investigation. 48% (53%) of total cases were reported with questionable fouled return air grilles, indicative of inadequate attention being given the housekeeping function.

It must be emphasised that where for one reason or another either fresh or return air streams have been contaminated over time that deposition of problematic particles will inevitably arise in key airhandling components and the ductwork system; various causes including inadequate filtration and poor housekeeping of occupied spaces may be responsible. It is likely for instance that coils will have become partially blocked with design air quantities upon which comfort levels are heavily dependant thereby put at risk. And while much of the system contamination may in fact be classified as inert, at the least discomfort and irritation will typically result and the life expectancy of expensive interior furnishings and finishes reduced. But as previously discussed, particulate water may be much less desirable and capable of causing allergenic and pathogenic reactions, fine respirable particles including biologically active contaminants being of greatest concern. It follows that a thorough cleaning/sanitation regime for all parts of the airhandling system including occupied spaces must form an essential component of any reasonable indoor air quality management plan.

In recent years clever robotic and other intelligent duct vacuuming devices such as augers (for rectangular ducts) and rotary sweepers (for circular ducts) have been developed by an increasingly sophisticated cleaning industry. Various treatments designed to retard microbial growth at susceptible sites, seal niche and remote dust accumulations, sanitise and deodorise airhandling and ductwork components as well as deal with problematic acoustic ductwork lining are also available. In order to facilitate appropriate decontamination as well as prior manual and/or remotely controlled video inspection of ducts, access panels at 10 m intervals and at bends throughout ductwork systems are strongly recommended particularly since experience suggests (Hona, 1997) that such may be achieved in the initial installation at little extra overall cost.

Because of the critical influence of thermal comfort on occupant well-being in general, temperature levels were examined, general dissatisfaction being recorded at a rate of 40% (54%). Unsatisfactory temperature differentials affecting adjacent spaces were also reported in 47% (64%) of cases.

Impacting on the ability to control temperature will be thermostats that are inadequately located, adjusted or otherwise out of order. Poor location in a situation which is not properly representative of the zone being controlled is an all too common problem; the investigation variously found thermostats adversely effected by the heat output of electronic equipment, situated in sunlight or an incorrect zone. In fact weaknesses in thermostat locations were reported potentially capable of effecting 39% (47%) of the total building stock with unsatisfactorily regulated temperatures confirmed in 30% (40%) of all cases.

The lack of control afforded individuals whereby thermostats typically cannot be adjusted/accessed has, incidentally, been suggested as an unnatural feature of airconditioned environments; a positive cost-benefit case may in fact be made for the use of small zones whereby individuals or small groups may more effectively control their own destinies. But it must be generally accepted that from a maintenance perspective that unnecessarily complex systems will complicate work. For instance elements of plant may be dispersed in numerous different locations with functions fragmented and repeated. In 54% (71%) of the total stock such was in fact the case, i.e. in only 46% (29%) was the maintenance process consciously facilitated by a centralised plant approach.

Systems should, of course, be maintained regularly by appropriately qualified individuals although it became clear during the course of the study that inadequately trained staff were often employed by contractors and that, worse still, the work of maintenance organisations themselves was rarely effectively supervised by owners, tenants or their agents. Insufficient time and resources were often devoted to contracts in a situation of little understanding of the system as installed. While 97% (92%) of the total building stock was reported to be under some sort of maintenance contract or other arrangement, this was no guarantee that work would be satisfactorily carried out; in fact regular maintenance was found not to be followed in 16% (20%) of cases, procedures were comprehensive in only 80% (76%) of cases, and maintenance did not appear to be of a good standard in 16% (23%) of cases. As an indication of maintenance standards generally, filters were found not properly fitted thereby permitting unfiltered air bypass in 10% (18%) of the total stock, filter maintenance was excessively infrequent, i.e. at intervals of 12 months or greater, in 17% (18%) and performed only on demand in 8% (6%) of all cases.

The lack of any formal post-occupancy inspection procedures by either public authority or, as is thought much more preferable, accredited mechancical or IAQ consultant, to ensure adequate system performance over time, is a matter of concern. Apart from the issues already discussed, ventilation systems may be improperly adjusted, for instance, so as not to provide sufficient fresh air or, in the extreme, no fresh air at all (e.g. to conserve running costs). Ventilation controls may also be faulty; VAV boxes may be improperly adjusted/controlled so as to provide insufficient, if any air, at low load. Although continued system performance to standards such as those provided by BOMA (1991) are desirable, 72% (95%) of the total building stock investigated had not been the subject of any such post-occupancy evaluation.

CONCLUSIONS

Numerous weaknesses in the performance of airconditioning systems and the potential effect of these weaknesses on ill health, discomfort and legal liability have been identified in this study of 1067 buildings conducted over a 12 year period up to and including the year 2000. These concern simple physical faults in air conditioning systems and their management that should usually be possible to remedy without much difficulty or cost. A clear picture of the incidence of such faults arising in commercial buildings confirms the extent of remedial action required in Australia.

Low priority and ignorance in matters concerning the design, installation, commissioning and on-going operation of airconditioning systems is widely and negatively effecting the performance of commercial buildings. While this position applies to all building types generally, data presented in this paper clearly identifies speculative developers' stock in the worst light. It is apparent that where low first cost is an overriding consideration and subsequent owners and managers remain either incapable or unconvinced of the benefits to be gained that performance in indoor air quality matters is likely to be particularly poor. Apart from addressing questions of legal risk there is an urgent need to raise industry performance by better informing its members about the impact of simple airconditioning system inadequacies on indoor air quality. Effective communication about these fundamentals will be essential if any IAQ Management Plan proposed is to be embraced by the various responsible parties.

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ACKNOWLEDGEMENTS

The study underlying this paper was initially supported by a generous grant from the Sunshine Foundation.

Contributions by several prominent Australian airconditioning, IAQ and legal consultants, in particular Melbourne based Andrew Meerman and John Ruskenas of Noel Arnold and Associates, Tom Hona of Kinhills, Alan Coleman (former head of Bassett Consulting Engineers), Peter Mathieson of Lincolne Scott and Barry Sherrif of Freehills as well as Joe Robertson of Healthy Buildings International in Sydney have been invaluable.

Appendix A1

IAQ Management Plan Checklist

Building Name: ____ Date:__________________________

Address:____

Completed by:____

Use this checklist to ensure that you have considered all elements in relation to the development of the IAQ Management Plan.

Item	Date begun or completed	Person responsible	Status
Select IAQ Manager			
Complete IAQ Profile			
Assign responsibilities			
Facility personnel			
Tenants			
Contractors			
Training			
Facility personnel			
Tenants			
Contractors			
Facility Operation & Maintenance			
Confirm equipment operating schedules are appropriate			
Confirm appropriate pressure relationships between building usage areas			
Compare ventilation quantities to design, codes (AS 1668.2)			
Schedule equipment inspections as per preventative maintenance plan or maintenance schedule			
Use HVAC checklists, update as required			
Schedule maintenance activities to avoid creating IAQ problems			
Prepare MSDS register for building			
Consider using alarms or other devices to signal need for HVAC maintenance (eg overloaded filters)			
Occupant Communication			
Establish health and safety committee or joint tenant/management IAQ task force			
Review procedures for responding to complaints; modify if necessary			
Review lease provisions; modify if necessary			
Renovation, Redecorating, Remodeling			
Identify IAQ issues with architects, engineers, contractors, and other professionals			

Establish appropriate control plan for IAQ issues/concerns			
Obtain MSDSs; use materials and procedures that minimise IAQ problems (ie low odour, volatile materials)			
Schedule work to minimise IAQ problems (weekends, nights)			
Arrange ventilation to isolate work areas (blank ducts, return air)			
Install exhaust ventilation			
Use installation procedures that minimise emissions from new furnishings			
Inform occupants/tenants of IAQ management strategies			
Housekeeping			
Evaluate cleaning schedules and procedures; modify if necessary			
Review MSDSs for products in use; buy different products if necessary			
Confirm proper use and storage of materials			
Review waste disposal procedures; modify if necessary			
Review loading dock procedures. If air intake is located nearby, take precautions to prevent intake of exhaust fumes.			
Check pressure relationships around loading dock areas			
Hazardous Materials			
Establish register of hazardous materials in building			
Assess risk from hazardous materials			
Implement control measures for hazardous materials (remove, contain, manage in-situ)			
Establish inspection & monitoring program			
Pest Control			
Consider adopting Integrated Pest Control			
Obtain and review MSDS's; review handling and storage procedures			
Review pest control schedules and procedures			
Review ventilation used during pesticide application			
Smoking			
Eliminate smoking in the building			
Work with occupants to develop appropriate non-smoking policies, including implementation of smoking cessation programs			

From Meerman, 1997

Appendix A2

Airconditioning Design Checklist

	Completed ✓
1. Design Brief	
• Prepare a design brief for the project - do this even if the client does not ask for it	
• Discuss and explain the importance of IAQ issues	
• List the proposed design criteria, eg. Indoor temperatures, ambient conditions etc	
• List the proposed filtration efficiencies and types of filters proposed	
• List the proposed minimum air change rates	
• List the proposed dedicated exhaust systems	
• List any dedicated fresh air systems	
• List all the applicable standards, eg. BCA, AS 1668, AS 3666	
2. Design	
Ventilation Requirements • Determine the applicable ventilation (outside air) rates from AS 1668.2.	
• Design the outside air system to maintain the required ventilation rates at all times - be aware of variable air volume systems which turn down to a minimum position	
• Locate cooling towers as far away from outside air intakes as possible	
• Carefully select the air intake locations - discuss with the architect	
• Check possible contamination of outside air intakes from other (existing) sources	
• Record ventilation rates calculations on drawings if possible for future reference and tenancy changes	
Air Distribution • Zone the system properly - limit zone sizes to allow temperature control and future air redistribution with changing occupants usage	
• Design the air distribution system to maintain the minimum air change rates	
• Design the air distribution system and return air system to provide thorough mixing	
• Not all air diffusers perform well - do some research and specify air diffusion equipment which is known to perform and have been tested by certified laboratories	
• Air boots and light air luminaires should be tested as a combined unit by a certified testing laboratory at the commencement of a project. Once approved, manufacture can commence	
Filtration • Select the appropriate air filtration system - refer AIRAH Application Manual DA 15	
• Select filters below their rated maximum capacity	
• Take care in specifying/detailing a filter frame assembly which will eliminate bypass	
• Allow adequate space and access for filter maintenance	

	Completed ✓
• Install "Magnahelic" gauges across filter banks to monitor pressure drop and note pressure set point when filters need replacements	
• On larger installations monitor pressure drop across filters via the BMS and raise alarm when dirty filter pressure drop has been reached	
Ductwork • Provide ductwork access panels for inspections/cleaning	
• Provide dedicated exhaust systems - need to be easily extendable	
• Provide dedicated fresh air systems - need to be easily extendable and accessible	
• Do not use exposed fibrous internal lining - use perforated sisalation as a minimum	
• Ensure ductwork is well covered and protected from dust on site	
Controls • Use indoor air quality sensors where appropriate, eg. cinemas, canteens, theatres etc	
• Use an outside air economy cycle where possible	
• Use a purging system - particularly on new buildings	
• Check that fresh air dampers open after the warm up cycle	
Other Components • Air handling units - ensure there are no porous surfaces, seal the floors	
• Condensate trays - design to ensure proper grade and with appropriate trap	
• Motorised dampers - specify quality dampers which seal well and allow minimal leakage	
• Humidifiers - steam humidifiers are least likely to create moisture problems in the ducts. Avoid internally lined duct downstream of humidifier - use "Mylar" or "Melinex" lining on internal insulation to avoid moisture ingress.	
• Central vacuum systems - install them where possible	
• Air locks should be provided to car parking lobbies to reduce contamination of HVAC system	
Maintenance • Review your specification and ensure that a proper maintenance regime exists during the defects liability period	
• Design all HVAC components to allow for proper maintenance, particularly filtration systems	
• Write a detailed and separate maintenance specification at the end of the project so competitive maintenance contracts can be entered into with the scope of work clearly specified	
• Where possible engage a certified air quality consultant to be involved during the design of the project and to carry out IAQ audits during the defects liability period with at least quarterly inspections	
• Ongoing maintenance should include independent air quality monitoring by a certified air quality consultant to ensure an acdeptable IAQ is maintained	

From Hona, 1997

Appendix A3

IAQ Walkthrough Inspection Checklist

Item/Issue	Need Attention (Yes/No)	Comments
Office Areas		
• Are there dust marks on the supply register		
• Are floors dirty		
• Is there visible dust on surfaces		
• Is there condensation on windows		
• Is there staining on walls or adjacent windows		
• Are there noticeable odours		
• Does the space seem stuffy		
• Are there noticeable drafts		
• Have registers been altered or blocked by tenants deliberately		
• Is their anything obstructing ventilation grills		
• Have partitions been moved or altered since the commissioning of the building		
• Are there photocopiers or printers in the area		
• Is office too cold or hot in areas		
• Are the location of thermostats blocked or in direct sunlight		
• Does the air seem dry		
• Are chemicals or solvents used or stored in the area		
• Is lighting adequate for the tasks in area		
• In noise an issue ie plant noise		
• Are there other tenants who may contribute to pollutant sources into the investigation area		
Air Intakes		
• Are cooling towers within 10 metres		
• Are they located near a loading dock, parking area or trafficable area		
• Are they blocked with leaves or dirt		
• Is there vegetation nearby		
• Are there pollution sources ie. Chimneys, stacks, dry cleaners, toilet or kitchen exhausts		
• Are there signs of water staining		
• Is there indication that dampers are not working properly		
• What is the damper setting in relation to the outdoor weather		
Local Exhaust		
• Are they being used		

• Are exhaust stacks high enough to prevent re-entrainment		
• Do exhaust outlets go through exterior walls - during high winds may reduce exhaust efficiency		
Entrances and Loading Docks		
• Are major vehicle traffic or loading dock areas adjacent entrances		
• Does air flow into entrances bringing in pollutants		
Exhaust Outlets		
• Do they face air intakes		
• Are they near cooling towers		
Plantrooms		
• Are floors clean to prevent matter entering air plenums		
• Is there stagnant water on floor area		
• Is there evidence of water damage in the plantroom ie. Mould, peeling paint		
• Are there chemicals or other items which may enter air intake		
Filters		
• Are filters overloaded or require cleaning - refer pressure differential		
• Is there filter by-pass, is there debris in the chamber		
• Is there moisture accumulation in the filter plenum		
Coils		
• Are they clean		
• Does condensate drain to trays		
Trays and Sumps		
• Are they graded to prevent pondage		
• Is there corrosion		
• Are they accessible for cleaning		
Condensate Drainage		
• Is it graded to drain condensate		
• Has the air break dried out		
Fan Assembly		
• Is the fan guarded		
• Is the belt in good condition or slipping		
Plenum Chamber		
• Is the plenum clean from debris		
• Is lighting in chamber burned out - indicates haven't been checked for a while		

from Meerman, 1997

Sources: USEPA Building Air Quality
National Research Council Canada, Managing Indoor Air Quality

Appendix A4

from Ruskenas, 1997

AIR HANDLING UNIT INSPECTION REPORT

Building Location	Street, Melbourne	
AHU Description	AHU 15	
AHU Location	Level 37	
Date	1 March, 1997	
Item	**Parameter**	**Comments**
Air Intake	Weather/Vermin Proof	Evidence of water incursion
	Damper condition	Corrosion
	Debris Accumulation	Minor debris
	Damper Setting	Max. outside air - fully open
Air Filters	Filter Type	Email, Four Peak
	Filter Dust Load	Dirty
	Pressure Differential	140 Pascals
	Maintenance Access	Satisfactory
	Filter By-pass	Yes, debris in chamber
	Moisture Accumulation	None
Coils	Condition	Requires cleaning
	Condensate Drainage	Satisfactory
Trays and Sumps	Graded to prevent pondage	Poor grading, water pooling
	Condition	Debris in tray
	Accessibility for cleaning	Difficult
	Corrosion	Significant in pooled areas
Condensate Drainage	Trapped	Satisfactory
	Graded	Satisfactory
	Air Break	Dried out, reverse flow evident
Fan Assembly	Condition	Unguarded and fan belt
Plenum Chamber	Condition	Debris and dust deposits evident
Plant Room	General Housekeeping	Satisfactory

Comments: Prevent water from entering the air intake and repair damper.
Clean out debris from air intake area and prevent re~ccurrence.
Replace filters. Correct filter by-pass. Clean coils.
Improve grading to condensate drain to prevent pooling.
Replace fanbelt and improve guarding. Clean plenun chamber and remove dust and debris.

Indoor Air Quality Complaint Form

Occupant Name: ____ Date:______________________

Tenancy/Location in Building: Phone:

____ __________________________

Completed by:_________________________________ Title __________________________ Phone: __________________________

This form should be used if your complaint may be related to indoor air quality. Indoor air quality problems include concerns with temperature control, ventilation, and air pollutants. Your observations can help to resolve the problem as quickly as possible. Please use the space below to describe the nature of the complaint and any potential causes.

____

____

____

____

____

____

____

____

____

____

____

____

We may need to contact you to discuss your complaint. What is the best time to reach you? _____________

So that we can respond promptly, please return this form to:____

IAQ Manager or Contact Person

Room, Building

OFFICIAL USE ONLY

File Number: _________________ Received By: _________________ Date Received: _______________

Occupant Diary Form

Completed by:________________________________ Title: ______________________ Phone: _________________________

Tenancy/Location:_____________________________________ File Number:_______________
_

On the form below, please record each occasion when you experience a symptom of ill-health or discomfort that you think may be linked to an environmental condition in this building.

It is important that you record the time and date and your location within the building as accurately as possible, because that will help to identify conditions (e.g. equipment operation) that may be associated with your problem. Also, please try to describe the severity of your symptoms (e.g. mild, severe) and their duration (the length of time that they persist). Any other observations that you think may help in identifying the cause of the problem should be noted in the "Comments" column. Feel free to attach additional pages or use more than one line for each event if you need more room to record your observations.

Time/Date	Location	Symptom	Severity/Duration	Comments

Log of Activities and System Operation

Building Name:______________________________ Address: ________________________ File Number: ___________________________

Completed by:_______________________________________ File Number:___________________ Phone: ___________________

On the form below, please record your observations of the HVAC system operation, maintenance activities, and any other information that you think might be helpful in identifying the cause of IAQ complaints in this building. Please report any other observations (e.g. weather, other associated events) that you think may be important as well.

Feel free to attach additional pages or use more than one line for each event.

Equipment and activities of particular interest:

AirHandler(s): ____

Exhaust Fan(s): ____

Other Equipment or Activities:____

Time/Date	Day of Week	Equipment Item/Activity	Observations/Comments

Occupant Interview Form

Building Name:_________________ _ ____________________ File Number: _______________

Address: ____

Occupant Name: ____ Work Location: ____________________

Completed by: ____________________________ Title: _____________________ Date: ______________

SYMPTOM PATTERNS

What kind of symptoms or discomfort are you experiencing?

____

____

Are you aware of other people with similar symptoms or concerns? Yes:___________ No: ____________

If so, what are their names and locations?

____

____

Do you have any health conditions that may make you particularly susceptible to environmental problems?

- ❒ contact lenses
- ❒ chronic cardiovascular disease
- ❒ undergoing chemotherapy or radiation therapy
- ❒ allergies
- ❒ chronic respiratory disease
- ❒ immune system suppressed by disease or other causes
- ❒ other
- ❒ chronic neurological problems

TIMING PATTERNS

When did your symptoms start?

____

When are they generally worst?

____

Do they go away? If so, when?

____

Have you noticed any other events (such as weather events, temperature or humidity changes, or activities in the building) that tend to occur around the same time as your symptoms?

____

SPATIAL PATTERNS

Where are you when you experience symptoms or discomfort?

____

____

Where do you spend most of your time in the building

____

ADDITIONAL INFORMATION

Do you have any observations about building conditions that might need attention or might help explain your symptoms (e.g. temperature, humidity, drafts, stagnant air, odours)?

____

____

Have you sought medical attention for your symptoms? _____________________________________

Do you have any other comments? ____

Appendix B1

MAJOR AUSTRALIAN INDOOR AIR POLLUTANTS
Sources, Health Effects and Measurement
Brown (1997)

Pollutant	Major Source(s)	Health Effects	Indoor Exposure Goal ([,pb)	Pollutant Measurement
Nitrogen dioxide	gas combustion	chronic respiratory disease	120 (one-hour)	col. tubes, passive badge
Carbon monoxide	gas combustion, enclosed carpark, cig. smoke	foetal devel., aggrav. of carciiov a~.dis ease	9000 (8-hour)	col. tubes, instrument
Formaldehyde	pressed wood products, consumer products	eye, nose, and throat irritation, lung func., asthma, nasal cancer	100 (max)	'spot check' kits, bubbler, passive badge
VOCs	new building products, cleaning products, office equipt., consumer products	eye, nose and throat irritation, headache, lethargy, and compd specific effects	100 (one-hour)	specialised analytical laboratory
Environmental tobacco smoke	tobacco smoke	eye, nose and throat fm~tstion, aggrav. asthma, Chronic respiratory disease, lung cancer	none (smoking prohibition)	specialised analytical laboratory
Legionella spp.	cooling towers	pneumonia with 10-15% mortality rate, Pontiac fever	none (control at towers)	specialised pathology laboratory
House dust mites	carpets, furniture, bedding	asthma, nasal inflammation, eczema	<2ug/g allergen in dust	specialised immunol. laboratory
Lead in indoor dust	pre-1970s paint	childhood mental development	1.5 ug/m^3 (3 months)	lead check test kit for paint

Appendix Bii

INDOOR AIR POLLUTANTS - CHECKLIST OF MAJOR AUSTRALIAN SOURCES BROWN (1997)

Nitrogen Dioxide
• Unflued Gas Heaters • Kerosene Heaters • Gas Stoves without Rangehood • Urban Pollution • Tobacco Smoke • Photocopiers/Laser Printers
Carbon Monoxide
• Unflued Gas Heaters • Garages • Kerosene Heaters • Tobacco Smoke • Urban Pollution
Formaldehyde
• Particleboard, Medium Density Fibreboard (MDF) and Plywood Interior Products (Panels, Furniture) • Particleboard Flooring • Low-Emission Particleboard, MDF etc • Some Printed Materials • Some Cleaning Products • Some (Wet) Paints
Volatile Organic Compounds
• "Wet" or Dried Building Products - Paints, Adhesives, Sealants • Floor coverings -Carpet, Vinyl, Rubber • Furniture - eg. Particleboard, MDF • Photocopiers/Laser Printers • Overcrowding with Occupants • "Zero" - VOC Products (eg Paints)
Environmental Tobacco Smoke
• Dispersed Tobacco Smoke (from Other areas of Building)
Legionella SPP
• Cooling towers • SPA baths • Reticulated Hot Water System
House Dust Mites
• Bedding (all including Mattress)
Lead In Indoor Dust
• Pre-1970s Paint • Flakes from Pre-1970s Paint • Walked-In dust from Outside
Microbial Pollutants (Fungi & Bacteria)
• Water-Damaged Materials • Pooled Water (Stagnant) • Visible Mold/Mildew • Surface Condensation
Pesticides
• Sub-Floor Termaticides (esp. Leaky Floors)
Respirable Particles
• Tobacco Smoke • Inadequate Vacuum Cleaners • Urban Pollution

Surveying 'Asbestos Containing Materials' in Public Buildings in Scotland - a Year 2002 Facilities Management Priority

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Abstract
There are approximately 3000 asbestos related deaths per year in the United Kingdom and of these 600 are attributed to construction workers who carry out routine maintenance work in public buildings (electricians, plumbers, carpenters). These figures have prompted the United Kingdom's Health and Safety Executive (HSE) to propose amendments to current asbestos regulations (Control of Asbestos at Work Regulations 1987) to identify the location of ACMs (Asbestos Containing Materials) in public buildings. How these amendments will alter the current practice of surveying asbestos is the main aim of this paper.

Essentially, the proposed amendments to the UK asbestos regulations will tighten the regulations to improve the current requirements on asbestos training, surveying methods, risk assessments, and registers. There are three types of asbestos surveying methods outlined in the proposed amendments: a). non-destructive (Type1); b). intrusive (Type 2); c) destructive (Type 3). A Type 1 Presumptive survey uses only visual methods of assessing a property and raises a presumption that a material is an ACM unless there is robust evidence to rule this out, for example, a materiel specification from the original building plans. Using intrusive and/or destructive methods will not be used, at least initially, as this method would be too expensive to carry out full-scale on all public properties.

INTRODUCTION

Forthcoming changes to the Control of Asbestos at Work Regulations 1987 will place specific duties on persons in control of premises to **manage** Asbestos Containing Materials (ACMs) in their buildings. A comprehensive and accurate building survey is the foundation of any successful asbestos management strategy. Therefore, it is necessary under the proposed Asbestos Regulations 2002 to assess how the following may be successfully implemented:

- Identify the location of ACMs - Survey.
- Keep a record of its location - Register.
- Assess how hazardous it is - Risk assessment.
- Instigate an inspection programme - Monitoring procedures.
- Adopt structured documentation practices – Asbestos Management system.
- Implement procedures in case of a fibre release - Emergency plan.

HSE have proposed a draft document, MDHS 100, which contains advice on surveying techniques. However, this documents advice will not be directly enforceable as the only surveying technique available to surveyors. Therefore, this creates a 'grey-area' in terms of standardising asbestos surveying techniques throughout the UK. This in turn may create difficulty in establishing a UK-wide register for accessing the necessary information concerning the location of ACMs in UK Public Buildings.

CURRENT AND PROPOSED REGULATIONS (HSE)

The UK currently has a three stage legislative strategy for the Control of Asbestos as shown below:

- **The Control of Asbestos at Work (CAW) Regs. 2002 (Proposed Asbestos Regulation)** – it is proposed that this regulation will be consolidated with the Control of Asbestos at Work Regulation 1987 (which largely deals with safe removal techniques), coupled with the present proposed amendments for identification and surveying. It is thought the new Regulations will become law by June 2002.
- **The Asbestos (Prohibitions) Regulations 1985 and 98** – this prohibits the use of asbestos in a variety of applications including **all** construction projects these days.
- **The Asbestos (Licensing) Regulations 1983** – this aims to ensure that only competent employers will undertake the more hazardous work involving asbestos (e.g. lagging, sprayed coating, and boards).

The draft Asbestos 2002 Regulations mirror existing duties in the UK's Management of Health and Safety at Work Regulations 1999, but they also extend these regulations by an explicit duty on the controller of the premise to identify and manage ACMs.

OVERVIEW OF HSE's OBJECTIVES

HSE propose to publish an Approved Code of Practice (ACoP) within the proposed Asbestos 2002 Regulations. The document will give employers guidance on the preferred means of compliance with their duties to manage the risk from asbestos. The guidance covers the following:

- Identifying asbestos.
- Maintaining a register of asbestos.
- Assessing the risk of fibre release.
- Preparing an action plan to monitor the state of asbestos in building.
- Setting up an administrative systems to control any future disturbance of suspected ACMs.

A publication from the Method for Determining Hazardous Substances series (MDHS 100) supports the previously described changes. HSE have issued this *"Method for Determining Hazardous Substances for Surveying, Sampling and Assessment of Asbestos Containing Materials in Premises for Management Plans".* The guidance seeks to establish and standardise current good practice, so that asbestos containing materials (ACMs) in premises are accurately surveyed, recorded and assessed, in order that an effective management plan is produced. The main objective is to **manage** ACMs in premises to prevent or reduce airborne fibre exposure to maintenance workers who may unknowingly disturb ACMs.

An appropriate log to record the survey information is an area that is still open to discussion. A register is at present is the most likely solution, however, annotated drawings are also a possible choice. The potential for these plans being displayed over the Internet is a real possibility. HSE are keen to ensure that competent surveyors with suitable qualifications are the only persons who carry out asbestos survey work. An HSE asbestos working group has agreed that the minimum qualification for asbestos survey work should be the British Institute of Occupational Hygienists (BIOH) P402 proficiency course: 'Building surveys and bulk sampling for asbestos'. The BIOH higher qualification S301 is preferable (Asbestos Competency Certificate). A pilot accreditation scheme (the 'UKAS' scheme) for asbestos surveying practices or companies is also proposed to be in place during the summer of 2002.

RESEARCH OBJECTIVES

1. Assess asbestos surveying training standards in Scotland.
2. Assess the effectiveness of quantitative asbestos risk assessments.
3. Investigate possible provisions for asbestos survey information.
4. Assess asbestos surveying standards in Scotland

RESEARCH METHODOLOGY

Three Local Government Authority case studies were carried out to evaluate how they intend to implement the requirements for asbestos surveys, risk assessments, and asbestos registers. A day of observations and informal interviews was conducted for each case study. The cases were chosen because of their different geographic locations within Scotland / United Kingdom and data were collected by interviews, observation, and document review.

- Glasgow City Council (GCC) – Many buildings (population 800 000).
- Highland Town Council (HTC) – Inverness (population 80 000).
- Comhairle Nan Eilean Siar (CNES) – Western Isle (population 5000).

FINDINGS FROM THE THREE CASE STUDIES

Training Standards

Both Glasgow City Council (GCC) and Highland Town Council (HTC) are striving in the right direction in terms of gaining a good standard of qualification through completing the BIOH Modules (British Institute of Occupational Hygiene). Unfortunately, Comhairle Nan Eilean Siar (CNES) are lagging behind in terms of qualifications gained, their surveyors have only an appreciation of the dangers of asbestos due to the fact that they have only undertaken brief awareness seminars. These only aid the surveyors in taking their level of competency to the next level (=BIOH Modules).

A new training scheme is being run by the Royal Institute of Chartered Surveyors (RICS). However, this is of little help in setting standards throughout Local Authorities. It merely focuses on Building Surveyors who are *'chartered' (MRICS)* - this would result in very few surveyors of the Local Authorities interviewed gaining accreditation qualification.

[1] The Royal Institute of Chartered Surveyors (RICS) and the Surveyors And Valuers Accreditation (SAVA) scheme have collaborated in implementing an accreditation scheme for certifying individuals as competent to conduct asbestos surveys. This is known as 'SAVA' accreditation.

Surveying Standards

The actual methodology of surveying proved to be a grey area to investigate. CNES had no set method; HTC did not carry out their own surveys; and GCC were in the process of implementing a new system. CNES have an advantage over the other Councils because the vast majority of their properties are small. Although, HTC are not carrying out their own surveys, they do have a very efficient computer system planned for the future by using hand-held software to note down the information. But, GCC, due to the implementation of a new register, have new survey sheets drawn up in line with the asbestos register guidelines which will create a system that will give out accurate survey information for the end user.

Risk Assessments

Risk Assessments appeared to be an area of an asbestos project management that was largely controlled by financial constraints and internal politics. In an ideal world, each property would be given equal attention. However, in the real world, property prioritisation occurs, and this has meant focusing on 'schools' because of the sensitive and political importance of this kind of property.

A worrying area to emerge from the research is about the risk assessment methods employed. The 'risk rating' factors that Councils use in determining what is a *priority* seems inconsistent. None of the case studies could clearly define the levels to which the risk assessment scores were rated.

CNES used a similar method to that proposed by the MDHS100 document. The information laid out in the assessment did not clearly define a risk level and it did not appear that they had any method of coming to a conclusion apart from pure experience as a surveyor. HTC carried out initial visual risk assessments in order to produce a brief for tendering to consultants. To their credit they drew up a framework that provided each area of an asbestos project a *zone* that dictated **who** was to be made aware, **how** they were to be alerted and **when**, **who** would carry out the risk assessment, and an action zone that dictated the **asbestos contractor's duties**.

GCC have implemented an integrated risk assessment and survey sheet. The structure of the assessment is clear and concise and gives an accurate 'risk rating' score. However, the risk ratings provided by the software designers, have been altered by GCC to suit their own version of the risk ratings. This shows that financial implications are going to affect the actual level of risk scored !.

Asbestos Register

Across all three case studies, an asbestos register was probably seen to be the most important part of implementing a successful asbestos surveying strategy. The reason being that in trying to protect the public and construction operatives, it is necessary to produce the asbestos survey information in a clear form for all Local Council staff; especially construction operatives carrying out the work.

The standard of information provided by both HTC and GCC was of a good standard. GCC's information being very detailed. However, it is apparent that government inspectors would not be satisfied with CNES's asbestos register. The main worrying factor being that all the survey information was not provided. It is possible that they rely more on the paper copies of the information, however, this information would not be easily accessible for all other Council staff.

Interestingly, all the case studies mentioned that they had either implemented, or were in the process of implementing, an 'Intranet system'. This is a necessity within any Local Authority as it provides freedom of information for all staff at the time they require the information.

Auditing

None of the three case studies mentioned auditing in any degree of detail. It is probably an area that has been largely overlooked. This area now requires serious attention. Many of the asbestos registers installed are fairly new and require the training of staff to use them, therefore, it is necessary to have a process of internal and independent external audits. This will ensure that everything is being used in the correct manner. There is also the added pressure that government (HSE) may, at any time, cross-examine the information and decision making process in relation to the Asbestos Register.

CONCLUSIONS

1. The MDHS 100 document does not clearly state the training standards required for asbestos surveying. This is surprising considering that they have agreed (with UKAS) on a qualification that would set a standard.

2. The advice given for surveying standards is vague. Although information is given on asbestos materials and location, it is unclear as to the exact methodology to adopt. A single method is needed.

3. The required structure of an asbestos survey is clearly defined by HSE, however, a suitable format has not been drawn up. For example, the Internet is not being exploited.

4. The MDHS 100 risk assessment algorithm is very cumbersome to use due to its two-part structure. The first section is accurate in assessing the **material risk.** The second section on **building usage** seems very subjective. Conclusions

drawn do not seem to be valid. An adequate one-step risk assessment will provide the necessary information for a ‘risk rating’ and this is needed urgently.

5. The implementation of an asbestos register is seen to be one of the weakest areas of the document. They do not dictate strongly enough the standard of register required, they simply state: *‘a computer database of suitable form is extremely useful’*. This comes across in a very unassertive way. A stronger case should be put forward for a computer database systems.

6. The standard of Local Authorities databases vary from simple spreadsheets to hi-tech computer databases. In general, a simple spreadsheet will not cover the required information because it is limited in scope. HSE need to devise a prescriptive format that all organisations should adopt (or enhance), to avoid sub-standard asbestos registers.

7. All Local Authorities see the implementation of an intranet system as being paramount in ensuring that all Council employees have access to the asbestos register.

8. The cost implications of training surveyors and operatives through BIOH Modules are reasonable and affordable for Local Authorities and should therefore be compulsory.

9. In larger Councils such as GCC and HTC, the financial impact of wide scale asbestos surveying of their building stock will prove to be very onerous.

RECOMMENDATIONS

1. The three important areas of the proposed changes to the Asbestos Regulations appear to require further tightening. The guidance relating to training, survey methodologies, risk assessments and asbestos registers are not specific enough for Local Authorities to effectively implement.

2. The UK government (HSE) need to align themselves more strongly with UKAS (an accreditation body) to enforce acceptable methods of surveying.

3. It is essential that HSE devise an accepted assessment criterion for asbestos risk assessments. There is too much variation available. A simple set method is desirable and this should include contingency plans for when things go wrong.

4. HSE should put out to tender the ‘design of an appropriate asbestos method with a set survey format, risk assessment procedure, and asbestos register’. This could take the form of an HSE Contract Research Report.

5. The budget allocated to asbestos works for Local Authorities needs to be increased. This should come from central government. The asbestos problem that will not diminish without extra funding.

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Workplace flexibility: Value for money*

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Abstract
Companies large and small, in every industry, face a common challenge: Do more, better, with less. The organizational problems to be solved, while meeting this kind of corporate mandate, are also widely shared: attract and retain high quality employees; strengthen brand identity; increase flexibility in the face of highly uncertain market conditions and new technologies; assimilate mergers and acquisitions; and accommodate frequent changes in group and team size and structure. This article describes findings from research that examined the workplace strategies of independent small startup initiatives, as well as those initiated inside large corporations. The findings suggest that it is possible to identify aspects of overall workplace planning and design that reduce costs and increase flexibility while maintaining or enhancing organizational effectiveness.

Key Words: Workplace, flexibility, strategy, office, value proposition.

Companies large and small, in every industry, face a common challenge: Do more, better, with less. The organizational problems to be solved, while meeting this kind of corporate mandate, are also widely shared: attract and retain high quality employees; strengthen brand identity; increase flexibility in the face of highly uncertain market conditions and new technologies; assimilate mergers and acquisitions; accommodate frequent changes in group and team size and structure;. Over the past several years the Cornell University International Workplace Studies Program (IWSP) has explored some of the ways workplace strategies—how space is designed, procured, built, and managed—can help organizations better cope with these kinds of challenges. An earlier report *Managing Uncertainty: Integrated Portfolio Strategies for Dynamic Organizations* described "zero-time" space solutions such as tensile and pre-fabricated modular structures and fully-serviced offices that simultaneously meet employee expectations about a quality workplace while enhancing flexibility and reducing costs.[1] This article describes findings related to flexibility from a recently released report that examined the workplace strategies of independent small startup initiatives, as well as those inside large corporations.[2,3]

- This paper was originally published in Journal of Facilities Management, Volume 1, Issue 2, August 2002: 154-162

Smaller, startup firms are worth examining because their limited resources create strong pressures to make decisions about facility planning, design and management that directly help the firm meet business challenges like the ones identified above. Small firms do not have the luxury of spending money where the payoff to the organization's ability to survive and prosper may be minimal. As large firms struggle in today's economy to do more with less, smaller, startup firms offer fertile ground, we think, for gaining insight into how firms of all sizes might, to use a British expression, get more "value for money" from their workplace strategies.

Value for Money

- Minimal renovation
- Iconic branding
- Targeted spending
- Open plan designs
- Aesthetics of flexibility
- Diversify the workplace portfolio

Minimal renovation

Buzzsaw, a spin-off of Autodesk, the leading supplier of software for the architecture and design community, was like a lot of other dot.com companies around the country in 1998. They had more ideas than time or money. They were growing fast, and they needed offices quickly. Like many other firms in the same situation, they leased space wherever they could find it. In their case, it was the offices of an old-line San Francisco law firm in a venerable building in the heart of the financial district. They needed space for web designers and software engineers, marketing and sales, and the standard complement of executive and corporate support functions.

Where an established firm with a well-developed corporate identity and the associated space and design standards might have extensively renovated the space before moving in, Buzzsaw by and large "made do." The large conference rooms became a shared executive office. Two to four people shared individual closed offices. The "open" area was filled with the folding tables used in hotels for banquets and meetings, and occupied by a dense pack of computer engineers. A storage room became the conference room.

When Buzzsaw outgrew this space, they moved down the street into a similar type of building. Once again, renovations were minimal. The primary expense was beefing up the power and data infrastructure, fundamental to the nature of the business. The only other significant renovation was laying down carpet tiles and painting the walls, and creating a simple but attractive reception area.

What was gained? Time, money. effectiveness. Minimal renovations reduced the time to occupancy, and cost relatively little money. These *targeted* renovations resulted in a space that created a clear corporate image. The decision to put executives and other staff together in a shared office, rather than renovate space to create individual offices, used substantially less space than would have private offices or even workstation cubicles. As important, the team-oriented shared offices facilitated communication and interaction and speeded the flow of information that the firm depended on to be able to develop new products and services as fast as possible.[3]

Iconic branding

Large corporations spend significant amounts of money developing and implementing design standards in order to establish and convey a consistent corporate image to both their employees and to the marketplace. Such corporate design standards can be all encompassing, from business cards and stationary to furniture, materials and finishes and the architectural design of the building itself. EHPC, the product of a recent European merger of industry stalwarts Ericksson and Hewlett Packard, designed all of its buildings to be visually indistinguishable inside and out, so that they are a recognizable brand from the street or the interior. The image is consistent, but so is the cost and effort, both of which are considerable. The small startup companies we visited shaped their corporate image in much simpler, faster, and less expensive ways, primarily using the building's interior as the corporate image's canvas.

Google, the highly regarded Internet search engine, captures perfectly the use of very simple iconic design features to create a strong brand at minimal cost. Walk into their non-descript headquarters building in the heart of California's Silicon Valley and you immediately feel like you are in a "hip" firm. Why? A row of lava lamps, one of the icons of the digital world, stands near a window. There are two bright red curved sofas in the tiny reception area, along with a continuously scrolling live digital screen that displays key search words people are entering at that moment in time around the world. In the work areas, the Google "brand" is achieved with brightly colored physio balls lying around to kick or sit on. Nameplates made from clear plastic CD cases with computer printed inserts cost fifty cents, rather than the ones originally specified by designers that cost seventy-five dollars each. With very little expense, and the ability to create the brand almost instantly, Google conveys that they are a fun and imaginative firm that invests its scarce resources where they have the most payoff. Workstations are of good quality, technology is superb, and the meals at the company cafeteria (which employees value hugely) are first-rate. Smart decisions mean allocating scarce resources where they do the most good. Young employees care more about good (and free!) food than high quality carpeting or expensive workstation panels.

Visit Google's new, small office in New York City, and you immediately know you are in a Google facility, with its lava lamps in the reception area and colored spheres mimicking physio balls embedded in the carpet tiles. With very little money, time, or effort to implement, Google has created an extremely fast and easy to replicate corporate image that can be rolled out on as wide a scale as wanted, in any type of facility or building, anywhere in the world.

Targeted spending

Common to what we found Buzzsaw, Google and other small startup companies doing is *targeted spending.* It starts by rethinking what level of "quality" one actually needs.

Years ago Kodak realized that their commitment to quality sometimes made little sense. Why buy carpet manufactured to last twenty-five years if you only plan on occupying the space for five years? Kodak shifted the definition of quality from buying the "best" to buying what fit the situation. At one of the software development firms we studied, this took the form of buying freestanding screens from a retail home furnishings store for about $70 each, rather than buying screens that served the same purpose for about $800 from one of the large contract furniture companies. Without doubt, the $800 screens are more durable and made of better materials. But functionally, there was little difference. From a design perspective, the non-corporate look and feel of the less expensive screens was a good fit with the young, informal culture of the firm. If the screen broke, you could replace it several times over and still not have paid the price of the more expensive screen. Implementation speed benefited as well, since the time from purchase to installation could be counted in days, not weeks or months, as it often is with contract office furniture.

Our visits to small firms found many examples of this approach. Buy something that works well for a specific time and purpose, accepting that it may not last as long as a better engineered product or that you may not be able to find the same product in five years time. At Google, the cafeteria chairs cost $7 each. A rolling T-screen purchased from a local job shop for about a quarter of the cost as the same unit from a contract furniture company served as a white board and moveable divider between workstations, or as a sliding "door" to a workstation. Again, it worked just as well functionally as its more expensive version.

Firms engaged in targeted spending are not buying everything as cheap, in price or quality, as they can. They are doing exactly what Kodak was doing with carpet. They are targeting where they spend their scarce resources. The same startup firms that bought inexpensive cafeteria chairs purchased good quality ergonomic chairs from the large contract office furniture companies because these are demonstrably better than those one can purchase in retail office furniture stores at much less cost.

Open plan designs

The cheapest, and perhaps the most flexible, office is the non-office. The less office space required, and the longer the same office can be used (and accommodate change) without having to reconfigure it, the more flexible and less expensive it is. This is one of the benefits of non-territorial or "hoteling" offices. As more people come on board, the ratio of employees to offices change, not the physical characteristics of the office itself. This is a perfect example of a "zero-time" space solution, since change is accommodated by a shift in policy (the employee-desk ratio) not a change in the environment.

None of the firms we studied employed hoteling. But several had adopted some form of team-oriented bullpen with freestanding desks that users themselves could easily reconfigure to reflect shifts in the composition and size of work groups and teams. The constraints to this kind of flexibility are power and data connections, which typically dictate the organization of furniture (and thus of work itself) in space. Raised access floors and dense floor power grids address the problem, but at a premium price. Power poles, and even more so flexible overhead cables (like the power supply cables found in automobile repair shops) and open cable trays, provide flexibility at less cost.

Eliminating walls and integrated systems furniture panels does more than reduce the cost of the furniture itself. It also creates a more permeable set of boundaries between individuals and groups that can ebb and flow easily and quickly as groups change and evolve over time. The range of furniture that can be purchased is also wider and less expensive when freestanding desks are chosen instead of work surfaces that are part of an integrated panel-based contract furniture system.

Reducing the cost of churn (the reconfiguration of workstations and offices to accommodate organizational changes) can have a significant corporate impact. In one global financial services firm, the cost of churn is estimated to be about $50 million annually. Each physical change of a workstation costs about $2-4,000. In other firms, even with “box moves” where the only thing that moves when an individual changes location is a box of personal files and belongings, the typical cost is $400-600 per move. Universal plan cubicles or offices, in which most of the individual work places have the same size footprint, make it possible to move people, not walls. But our research suggests that this approach, while reducing costs, also reduces effective communication and interaction when it takes the form of a sea of identical high-paneled cubicles.

Few organizations can afford to maximize benefits along a single dimension (e.g., cost, or flexibility). The team-oriented bullpen’s attraction stems from the fact that such designs typically cost less initially, are easier to reconfigure, and can better accommodate changes in population density over time. They also allow higher densities before becoming uncomfortable and counterproductive. Squeeze a high-paneled cube to the footprint of a desk in a bullpen, and it more closely resembles an isolation cell than an office.

Aesthetics of flexibility

Speed and precision are uncomfortable bedfellows. Yet for a variety of reasons the “modern” office is, in fact, put together extremely precisely. Minimally, corporate offices are very tidy in look and appearance. Like the dining room sets advertised on late night television, everything matches. Corporate image defenders like to keep the evidence of work hidden in drawers, files, and behind closed doors. And like a showroom, furniture is neat and orderly. There is a place for everything and everything has its place. Think of a teenager’s bedroom, and then imagine the opposite.

Buying and maintaining all that order takes time and money. An aesthetic of flexibility costs less and supports organizational change better.

It tends to have the character of "messy vitality." At Igus, a German manufacturer of precision bearings, the exterior building panels, as well as the workstation components are fastened with exposed bolts. They are easy to get to and no special tools are required. Workstation panels overlap, making it fast and economical to achieve the desired size workstation without having to buy special panels or keep extensive stock (requiring time and money); or have available panel sizes dictate the size of the workstation.

Why must all the furniture come from a single manufacturer, or be from the same manufacturer line? Even "quick ship" programs from the major contract office furniture firms can take several weeks if not months. Our experience with small firms needing to quickly accommodate growing populations is that they go to retail office suppliers where they can get products the same or the next day, and at lower cost. But cost is not necessarily the only or primary driver; speed of delivery and installation is, because that directly influences how soon people can begin productive work. All the furniture may not look alike, but the aesthetic and branding conveys the need and desire to be nimble, and a commitment to spending time, energy, and money where it gives the best return. Precision is a luxury and a by-product of time and money that fewer companies can afford today.

Diversifying the workplace portfolio

If you look at the sales pitch of a firm like Regus Business Centres, which is the largest provider of fully-serviced, on-demand office spaces globally, you will find that they argue that about sixty percent of the corporate workspace portfolio is likely to take the form of conventional office buildings. They are interested in the forty percent of demand that might be met by their specialized product and service offering. The aim, as with any financial portfolio, should be spread risk over a highly diversified range of products. For the workplace building portfolio, this might mean a mix of fully-serviced offices and conventional leased and owned property. For interior fit out, it may mean a range of office types from cellular offices and high-paneled cubicles to team-oriented bullpens. No organization needs team-oriented bullpens for every job function, nor should every piece of furniture in a Hewlett Packard or Barclays Bank or any other large firm be from IKEA. Order and standardization have a place. Our argument is that firms truly pursuing—whether from preference or necessity--a workplace strategy that solves the dilemma of creating environments that are simultaneously flexible and support work effectiveness at as low a cost as possible, need to diversify their workplace portfolio. They also need to rethink what constitutes "quality" and conveys being "professional," "contemporary," and "successful."

Workplace principles: Lessons from small firms

We examined small startup initiatives inside and outside large corporations to consider what lessons or insights large firms might gain from the workplace strategies of small firms. We are not suggesting that a Goldman Sachs, IBM, or any other large global enterprise should copy *for every department and group* within their organization the workplace strategies of a fifty or one hundred person startup. Rather, the intent is to stimulate large organizations to think about some of the *principles* of how space is planned, designed, and managed in small firms might be adapted to their own context to increase organizational agility and effectiveness while minimizing costs. The Kodak example noted earlier, of buying less expensive carpet based on historic occupancy patterns reflects a principle of value for money. Union Carbide's headquarters built in Danbury, Connecticut more than twenty years ago embodied the same kind of small firm principle we found at Google: go to a job shop to manufacture portions of the furniture required, while spending more money on a few key contract furniture components. Union Carbide headquarters encompassed a million square foot building with more than 3,000 employees, hardly a small, startup enterprise.

Large firms acceptance of higher densities than they typically considered acceptable reflects another small firm workplace strategy. Whereas 75 usable s.f./person might be an acceptable figure for a technology startup firm, a figure of 100 usable s.f/person might be acceptable for similar functions in a large corporation. The square foot metric would not be identical; the principle is. Higher densities in more open, team-oriented bullpen type offices reduce the total amount of space required and they can be reconfigured more quickly and at less cost than cubicles or cellular offices. Yet they support effective communication and work patterns for many types of jobs. The insight from the smaller firm is to set aside preconceived definitions of what constitutes "high" density, and to consider that the point at which higher density becomes dysfunctional or counterproductive may be higher (fewer square feet per person) than might have been expected.

As with any approach, workplace solutions do not need to be applied universally to every job function in every business unit in every part of the globe. Many firms believe that they have a "one firm" policy about space allocation, despite clear evidence that they do not. Look in almost any global financial services firm, for example, and you will find that the technology people do not sit in the same kind of space, at the same densities, as equity traders. They, in turn, occupy different space than research analysts, who are in different space than the people in human resources. In fact, different solutions are already being applied in most companies. They go officially unrecognized in the name of fairness and equity.

The small firm principle is to look for places where natural differences across job functions and employee profiles make it possible to exploit value for money propositions. At Google, this meant buying more expensive workstations and very inexpensive cafeteria furniture. At Digital Equipment Corporation in Finland (before the acquisition by Compaq), the lounge furniture was inexpensive patio furniture, while the telecommunications equipment was the best money could buy. Freestanding furniture and workstation layouts reduce the cost of churn by making minor reconfigurations fast and easy, while minimizing organizational disruption. These savings provide capital to invest in other parts of the organizational enterprise. Exploiting such savings potential may require spending more money initially on different, and more flexible furniture, but that investment is likely to payoff significantly in lowered costs and greater organizational effectiveness and agility over time. Reducing churn by even relatively small percentages, when per unit moves cost between $1-3,000, generates savings in large organizations that are more than pocket change. At the same time, simpler but more flexible office designs allow the organization to dictate how it wants to organize itself, rather than having the prohibitive cost and disruption of churn dictating who sits where and how teams function.

Flexibility, cost and effectiveness

The starting point for our analysis of workplace strategies was organizational ecology: the concept of an interdependent web of spatial, technological, cultural, demographic, and work process factors. As should be evident by now, our research indicates that some workplace strategies are more likely than others to reduce costs while increasing flexibility and work effectiveness. Some things companies can do, specifically, to constrain costs while increasing the speed with which groups are able to begin work in a new environment, accommodating change in group size and structure, and strengthening corporate image and work effectiveness include:

- Minimizing renovations in space and looking for ways of imaginatively using existing space and design. That may mean using a conference room for an executive team space, or a lobby for a central social hub and meeting area.
- Doing targeted branding. Identify a few key features such as a highly visible reception or break area and fit it out with inexpensive, but distinctive, furniture that establishes the desired image and feel at low cost.
- Zoning activities more carefully, to minimize the need for physical barriers between incompatible job functions (e.g., marketing and software development) that are costly and disruptive to move over time.
- Creating an aesthetic of flexibility; that is, celebrate visible diversity related to productive work. All spaces do not need to look like a furniture showroom. Create more “dens” and fewer “parlors.”
- Think about how to make cable drops and other technology solutions a simple and visually interesting design element, not just a morass of wires. Whimsy does not cost a lot, but in the right setting lowers costs and enhances flexibility.
- Using more freestanding furniture that workers themselves can reposition for a team meeting or to support a newly created work group in a team-oriented bullpen.
- Creating more permeable boundaries between groups that allows them to ebb and flow over time, by using flexible, easily movable, freestanding panels instead of walls or fixed panels.

The underlying principle is eco-diversity: developing a diverse portfolio of real estate and design and furniture options that can be deployed as necessary, without assuming that any one of them is “the answer” for the whole company or for ever after.

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[3] Data was collected at 8 sites that included independent startup firms, corporate spin-off startups, and internal corporate web-related initiatives. Office types included private offices, high-paneled cubicles, low-paneled cubicles, shared enclosed offices, team-oriented workstation pods, and team-oriented bullpens. A total of 3,160 interactions among 329 people were observed over a total of 130 hours. Of the 229 completed surveys (47% response rate), 62% were male and 38% were female. Seventy-seven in-depth interviews were conducted.

The Property Standard Index: How well has it performed?

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This paper reviews and evaluates the use of the Property Standard Index (PSI) developed by CSIRO/QUT in collaboration with Queensland Department of Housing. The motivation behind the model and application development is discussed as is the performance of the application.
Since its development and subsequent release the PSI application has under gone a number of modifications. Areas examined in the paper include technical upgrades such steps taken to improve the performance of the application, expansion of the functionality of the program and improvements in the user interface as well as improvements in the model leading to improved accuracy of the index estimation for small selections. Also discussed are the efforts made in programming the application to enable it to link with other applications utilising spatial mapping technology facilitating development of strategic plans for acquisition and disposal of properties dependent on demand models. The benefit of application testing and user feedback prior to general release with regard to application utility and acceptance is discussed including the emergence of some unexpected uses.

Keywords: Property Standard Index, Condition Index, Portfolio Maintenance, Asset Management

Introduction

A Property Standard Index (PSI) has been developed for Queensland Department of Housing providing the Department with a measure for assessing performance, adequacy and quality of its housing portfolio. The primary purpose of the portfolio is to provide low income and or special needs clients with safe, secure and affordable housing. The portfolio, which consists of over 55,000 properties, is mostly residential properties consisting of detached houses, attached housing, apartments, units, cluster housing, duplexes and seniors units. The properties are constructed with varying building materials including cavity brick, brick veneer, timber and fibrous cement external cladding. These buildings range in size from 35 square metres, one-bedroom units to 5 or 6 bedroom detached houses. This portfolio makes up approximately 5 percent of the total housing stock in Queensland.

The Department of Housing operates within the Queensland Government's "Managing for Outcomes" policy framework which prescribes an integrated approach to planning, budgeting and performance management. This policy along with the increasing pressure on housing funding was the motivation for the development of the PSI. The funding concerns forced the Department to seek a consistent objective methodology for the strategic management of its housing stock. One such method was the derivation of a Hold/Sell index (HSI). This Index balances demand and demographics with the current status of properties in the portfolio, thus assisting the Department to realign their portfolio to better match housing stock with the current demand patterns. The HSI gives a total picture as to the desirability of a dwelling for the purposes of public housing and can provide the basis for strategic decisions on the sale or retention of a property. The PSI facilitates the calculation of a hold/sell index which will become a corner stone of the Portfolio Management System.

The PSI is based on the Housing stock condition index (Tucker *et al*, 1996) and objectively calculates a rating for each building within the portfolio resulting in a score out of ten. This score provides the portfolio managers a standardised measure of the property standard which indicates how the property is performing and enables the property to be directly compared to others. The index is based on a series of factors relating to the physical condition of the dwelling, the property's age and how it relates to the standard of newly constructed departmental residential buildings. Initially the methodology was developed to provide an insight into the current condition of a selection of properties to enable strategic maintenance planning. The methodology however was expanded to include other aspects of the property and use of the application was broadened to include the ability to assess a single property enabling use at operational and tactical levels and providing support for strategic asset management decisions (Tucker *et al*, 2000). Thus the PSI application is now useable by several levels of management as a decision support tool. To date the PSI application has been used by a relatively small group of users (about 30). It is currently undergoing further improvement development to integrate new features and improve the functionality based on user feedback and observed limitations of the initial version prior to being rolled out for general use.

PSI Application

The index model was developed to quantify the condition of selected properties in terms of a standardised index in a consistent and accurate manner, while the application was designed to report the ratings in a user-friendly clear format. The research provided the Housing portfolio department with a tool that affords an insight into the properties they manage enabling maintenance and upgrade planning beyond what was previously possible. Development of the application is detailed in Johnston *et al*, 2000.

The PSI application was developed using a modular approach to enable inclusion of new as yet unknown features. The current version has many output features, which are discussed below, and provides the user with a flexible property selection interface which enables the user to select the whole population or any subset based on specified criteria such as administrative criteria, property profile or component criteria.

The application output provides information to the user in both graphical and textual content based on the selection providing:

- The PSI rating and a chart of its distribution across the selection,
- A chart displaying the contribution of the three sections of the condition assessment; the maintenance, the standards and the age for each property,
- A chart of the spatial distribution of the Property Condition Index,
- Identification of the components that contribute significantly to the downgrading of the condition rating for the property, and

- Identification of the particular element within a component that impacts on the property condition.
- Display of the selection criteria for verification and reference, and
- Printable reports

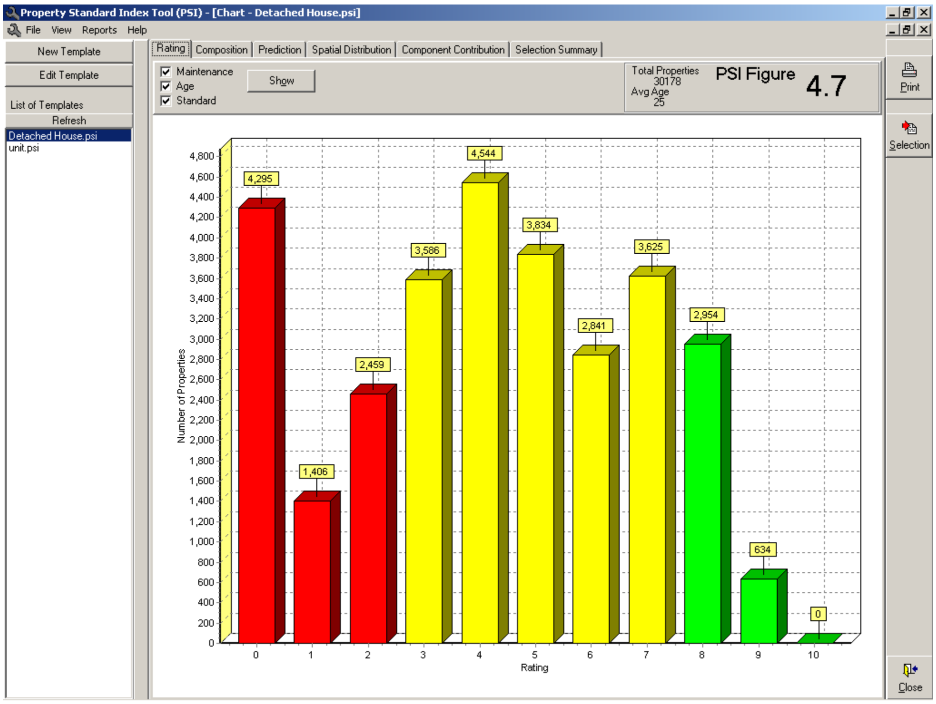

Figure 1 *PSI Detached house rating distribution chart*

Improvements

The initial user testing of the application identified a number of important elements which were incorporated into the full production version. These included:

- Utilisation of a “Dynamic Filtering” process employing a hierarchical selection tree.
- Tab-controlled separation of management and output sheets.
- The rating chart was improved to include the facility to display the rating distribution by any combination of maintenance, age or standard depreciation.
- A “Rating Composition” chart, which showed the rating of each dwelling in the selection together with the amounts of maintenance, age and standard depreciation was incorporated to enable the user to quickly see dwellings that would benefit most from repair or upgrade expenditure when compared to dwellings that achieved a similar rating.
- Navigation buttons were implemented in the rating composition chart enabling the user to easily move to a particular rating score.
- The addition of printing options to all of the charts.
- Provision for the user to edit the current selection immediately. This made it quicker and easier for the user to confirm and change the selection options of selections already displayed in the application.

These improvements illustrated the benefits of user testing and further user testing has been carried out during the development of a refined algorithm to ensure the application meets with the needs of the department.

The inputs for the application include general property information, current property condition information and benchmark information (for standards assessment). The data for the properties is updated quarterly in line with other data updates within the Department and at this point the index rating for each property and other preliminary calculations are carried out. As is evident the application is data intensive using information from a number of databases and, while the use of these data is one of the strengths of the model, the performance of the application was a concern. To overcome the concerns a range of pre-calculations is done at data upload. The pre-calculations enable fast processing of queries thus reinforcing its position as a practical tool. Initially the pre-calculation process took over 100 hours to complete but improvements to the algorithm (mainly by reordering calculation steps) reduced the pre-calculation time greatly.

The PSI application is now undergoing a final upgrade to incorporate improvements including the refined algorithm (McFallan *et al*, 2002a). Other issues addressed during the full development included improved user access control and security issues. Also an application interface to the reference tables was addressed to enable simpler administration of the application.

It was envisaged that the PSI application would be developed as a module of another Queensland Department of Housing application called “InSite”. InSite is a GIS application for querying and displaying dwelling specific information geographically. Although it is not yet a “module” of InSite the PSI application has been developed with the same “look and feel” as the InSite product and with a complementary database structure. Once the revised age function has been implemented the PSI rating could be used in the InSite application as dwelling specific GIS data but until then it is considered that the individual ratings are not suitable for use at a single dwelling level.

The desire of Queensland Department of Housing to review a small selection, possibly even a single property, was the motivation to revise the algorithm. The revision undertaken concentrated specifically on the methodology used to estimate the amount of wear and tear incurred by the property. The initial algorithm used the Gamma distribution to estimate the likelihood of failure for the property. This distribution was established as a suitable estimator of the probability of failure for the property, based on its current age, through analysis of expected component failures and tested through simulation. The assumptions and justification for the use of this distribution is detailed in The Property Standard Index Final Report (Tucker *et al*, 2000).

The major limiting factor of the index was the generalisation of the expected life of a property and how a specific property would perform in relation to this. The expectations, based on a series of simulations, was that for a selection of properties the assumptions made would hold, however the variation expected due to the heterogeneous nature of the portfolio would mean use of the index at the property level would require careful consideration by the users. The goal therefore was to develop a methodology to provide a property specific measure of the probability of survival. The approach taken was to consider the property as a compilation of components, estimate the likelihood of failure for the components then aggregate the estimates to provide an estimate for the property as a whole (McFallan *et al*, 2002b). The number of properties in the portfolio ensured that there was sufficient data to provide a reasonable confidence level in the estimate.

The analysis carried out as part of the validation process highlighted the benefits of the new methodology showing that the failure curve of an specific property was similar to the generic model used but had significant departures which would limit the use of a generalised model on individual properties. The new methodology allowed the possibility of a property to retain a relatively high probability of survival despite its age by carrying out appropriate maintenance thus consisting predominately of 'new' components. The benefits of using this methodology would be at the operational and tactical planning levels. At the strategic level the earlier methodology would have been suitable but the estimates calculated with this new method will ensure more accuracy overall.

The validation process reinforced the belief that the methodology will provide the level of confidence sought and is sufficiently robust to limit the effects of extreme events on the resultant PSI ratings. It has also proven resistant to variability in the expected median survival time implying marginal errors in the expected duration on individual components would not have significant effect on the overall result for a property. The consequence is that the rating achieved for each property is expected to be more reflective of the current state of the property which will strengthen the confidence of the users in the use of the PSI application and acceptance of the PSI rating as a consistent and comparable measure of the property standard.

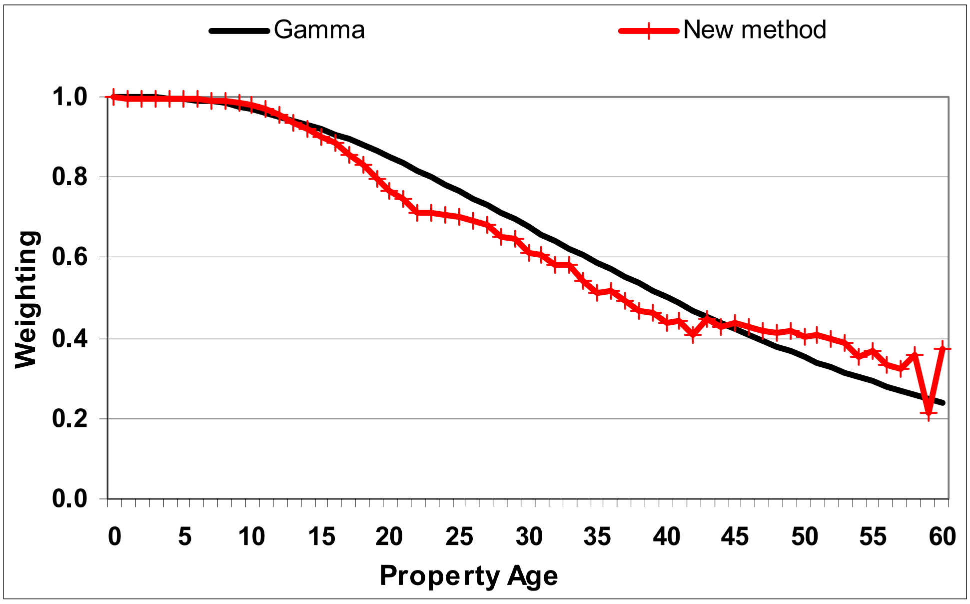

Figure 2 *Comparison of old and new property weighting methods*

Future improvements include improved data collection methodology through the integration of the data collection into an intelligent handheld electronic device. Current research at CSIRO is seeking to develop a tool that will enable property inspectors to collect condition data on the properties using hand held computing with data input using voice recognition. This approach should enable uploaded data on properties to be updated quickly with minimal error by inspectors ultimately leading to higher quality data at lower cost. Also improved functionality of the application through introduction of a budget scenario function for the rating predictions. This move would allow maintenance managers to optimise their maintenance budget. This feature is now possible with the introduction of the newly developed ‘age function’.

The only significant deployment issue has been the training and familiarization of the system administrators with the tool. Due to the PSI application’s significant computing resource requirements they had to be convinced of its importance and stability before giving the application the necessary hardware and computing time resources. Appropriate staff had to be trained and given security access to administer the application and its data. Staff have been enthusiastic about the information now available by way of the PSI and have been coming up with ways to use the information to assist them in their respective roles.

Uses

The PSI, in conjunction with the HSI, provides the Queensland Department of Housing portfolio managers with a decision support tool beyond anything previously available to them. The information obtainable as a result of the development will be used by managers and operational staff in all branches of portfolio management including:

- Strategies
- Standards
- Investment
- Operations
- Review
- Asset Information
- Business Management

Other agencies will also benefit from the development of the PSI including tenancy staff as well as designers, contractors who deliver capital works, and maintenance contractors.

Areas identified as benefiting from the development of the PSI include:

- Investment and funding expenditure
    - Which properties require resources,
    - What is the benefit of providing the resources, and
    - Is there a better alternative?

The PSI will provide support for decisions on whether funding is best used for capital expenditure, maintenance expenditure, or upgrades by allowing users to compare and contrast cases and reviewing implemented strategies to establish how the strategy has influenced the condition rating. It will provide input for measuring and forecasting the effects of investment.

- Maintenance strategy
  - Strategic planning - what components perform best, how can we use this information? Properties/components/materials can be classified into appropriate maintenance strategy category, either preventative time based service maintenance, condition based maintenance, zero based maintenance, statutory maintenance (smoke alarms, emergency lighting, etc).
  - Tactical planning can be addressed - how can the resources best be used, and
  - Operational maintenance planning - which properties need what work?
  - Review of maintenance standards.
  - To assist in identification of deferred maintenance.
  - To quantify the effect of deferred maintenance.
  - Monitoring service provide performance.

Using the PSI tool, the Department will also be able to identify the components that contribute significantly to the downgrading of the condition rating for the property and the particular element within the component that impacts on the rating. The PSI will provide insights to managers of differences in condition profiles for properties with varying characteristics or in different environments.

- Review branch
  - Identification of properties for review.
  - Comparison of properties being reviewed.
  - Monitoring portfolio condition for accountability.

The PSI will assist with provision of timely reports to meet reporting requirements both statutory and those requested for information purposes.

- Standards branch
  - Review of property standards.
  - Quantify the cost of meeting the standards.

The Standards branch can use the application to establish the proportion of the portfolio that meets specific standards and quantify the effect of introducing standards. The PSI provides a means of monitoring the movement in the portfolio towards agreed standards of amenity.

- Client Services
  - Provides a mechanism for assessment of whether a property is tenantable.
  - Enables quick and easy reference for assessing tenant complaints.

The Department communicates regularly with tenants and clients information about housing products and property management, using the PSI staff will be able to reference data instantly providing improved service.

- Financial Services
  - Enables a more refined assessment of the remaining useful life of the asset.
  - Has significant input into the revaluation models for property valuation.
  - Provides input into the assessment of the long term suitability of a property within the portfolio.
  - Provide support for annual review of market rents.

The PSI has provided input into models for estimating the remaining useful life leading to a 15% improvement of the estimation on the previous method and is being used to minimise the variability of the estimate of the property valuation.

- Housing Policy and Research
    - Provides input into the evaluation of strategic priorities.
    - Leads to development of coordinated strategic policy.
    - Contributes to the corporate planning and budget cycle.
    - Contributes to output policy and planning processes.

Housing Policy and Research staff can use the PSI to assess the various property profiles within the portfolio. Intimate knowledge of the condition of the property profiles at the various stages of their lifecycles will lead to improved portfolio management strategies and policies.

Aside from these identified uses the PSI will provide designers with evidence to support the use of particular components or material in specific location or under particular conditions to improve the sustainability of the properties. This information can then be utilised to better estimate the lifecycle costs of the asset through a better estimate of initial capital costs, those incurred later including upgrades and refurbishment and minimising recurrent costs both operational costs and maintenance costs. Improved lifetime data for components could also contribute to a lower disposal cost through a higher residual value for an asset. A study into the housing production carried out by CSIRO recommended designers carry out a cost planning exercise to fully cost the new residential design standards and quantify the cost impact of the schedule of approved products (Allen *et al*, 2001). These activities could be supported with output from the PSI application.

The Queensland Department of Housing has developed a strategy for future building of housing in the form of the Smart Housing concept with focus on five integrated areas of development:

- Affordable – cost efficient over time
- Energy efficient – comfort and energy costs
- Universal design – inclusive – to be used by people with disability
- Safety and security – safe home, well-being
- Sustainable – adaptable over time with changing needs

CSIRO has carried out some preliminary research into developing a Smart House Product Register (Tucker *et al*, 2001). The research considered means of providing an accessible register of 'smart housing' products which could be used by designers, contractors and building owners as a reference for suitable products for their specific requirements. This recommended method involved compilation of product technical data that including component level data. The PSI is a suitable source for supplementing this technical data with in situ performance data.

With the PSI, dwellings can now be assessed on an easily expressed scale, which shows the potential impact of funding injections on the overall condition of a dwelling, and whether the expenditure will improve the dwelling to a point on the scale which would make the upgrade economically viable. The HSI then adds further elements such as demand, and asset management decisions, which can be made in a logical, considered manner (O'Shea *et al*, 2000).

Discussion

The development of the PSI has lead to more effective asset management for Queensland Department of Housing. The PSI provides the measure required for effective accountability assessment of maintenance strategies and provides the systematic review process needed to identify poorly performing assets. The tool provides the means to measure activities in terms of:

- Sustainability
- Accountability
- Maintenance and upgrade planning and delivery;
- Asset performance
- Quality Management

The use of the Property Standard Index tool has reinforced the belief that there is a real need for an operational and fully functional tool and that is integrated into the current business processes of asset managers. The PSI provides support for important principles of asset management helping ensure asset management decisions are integrated with strategic planning. It can facilitate asset planning decisions providing decision support to help evaluation of alternatives which consider the 'life-cycle' costs, benefits and risks of ownership. It can support disposal decisions to achieve the best available net return. As a result of the amount of data supporting the PSI and the index algorithm, it can be used at an operational level, tactical level and a strategic level.

Current research is continuing in the algorithm refinement and application functionality.

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Using the ASTM/ANSI Standards for Whole Building Functionality and Serviceability[1] for major asset and portfolio decisions

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Abstract
This paper reports on the use of the ***ASTM/ANSI standards for Whole Building Functionality and Serviceability*** *to prepare a profile of functional requirements for a major organization and its five main groups, a rating profile of the capability of the building they are currently occupying to meet those requirements, and to assess the match between the profiles. The building is on a long-term lease managed by the US Government Services Administration (GSA). GSA used the results from these profiles and comparison in deciding whether to buy the building or move out.* ***ASTM/ANSI standards for Whole Building Functionality and Serviceability*** *provides the tools to capture actionable, customer defined needs, and match them to indicators of capability expressed as ranges of performance on different topics. The ASTM standards can also be used to compare the capabilities of several facilities, or the functional requirements of several groups. There is a lot to be learned from doing Needs Analyses and Building Evaluations. But to be useful for asset and portfolio management, Building Evaluations need to be linked to Customer Functional Needs on one hand and Customer Satisfaction on the other, as part of a comprehensive system of measurements. The use of these standards in project processes such as those of GSA is diagrammed and described.*

Keywords: functionality; indicators of capability; serviceability; suitability; user requirements; workplaces.

Overview of the Functionality-and-Serviceability Approach

The F&S approach helps facility managers to better meet functional and financial goals, avoid or reduce cost overruns, ease communication, and support value engineering.

The Functionality-and-Serviceability (F&S™) approach should be used by a facility manager to:

- Deliver facilities that more closely meet the functional needs and financial goals of tenants.
- Avoid or reduce cost overruns from project budgets due to late recognition of required features in a project.
- Ease communication with occupants, and encourage collaboration.
- Identify surplus capability that is a safe target for cost cuts, while helping to avoid cuts that reduce functionality, as can happen during a value-engineering review that lacks information about minimum threshold levels for functionality and serviceability.

As diagrammed in Figure 1 on the next page, the F&S approach uses standard, calibrated multiple-choice questionnaires to define the levels of functionality and service life required by stakeholders. A different but matched set of standard, calibrated multiple-choice questionnaires is used to measure the levels of capability to perform, and service life, of a design, a building, or infrastructure. The two sets of levels are compared to determine if the capability is the same, or more or less, than is required.

Cost is low.

Cost is low for using the F&S approach to avoid or reduce later change orders and cost overruns. For a typical 50,000 sq.ft. or 100,000 sq.ft office building, a basic rating profile can be done by a knowledgeable property manager in about three or four hours, or by an outside consultant for a few thousand dollars. For a consultant to apply an organization's requirement profile is about a quarter to half more work than doing a rating.

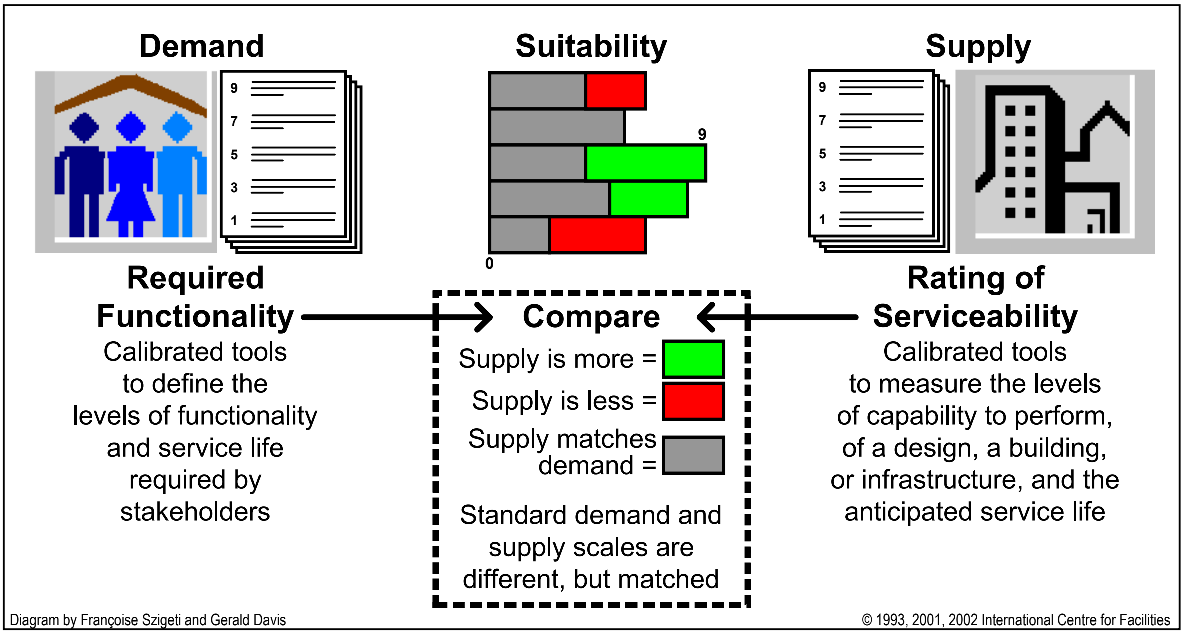

Figure 1. Core elements of the Functionality/Serviceability approach

Use the F&S approach as part of Feasibility Study, and for management of a portfolio of property.

A portfolio management group would use the F&S approach as part of the Feasibility Study phase, when deciding on a course of action about a tenant that requires new or replacement facilities, or a building that requires a comprehensive refit. The F&S approach is also being used for strategic management of a portfolio, by comparing the capability of major buildings in the portfolio against the typical requirement profiles of occupants.

Manage and measure functionality during design.

At several milestones of a capital project, the design should be rated and compared against the required functionality profile. This will provide early warning of shortfalls that might require changes that later would be costly. It can also save cost by identifying instances where the design calls for a higher level of functionality than has been specified.

Select best value among rental proposals.

When comparing rental proposals, ratings of the facilities on offer can show which provides best value to the occupants, in support of their organization's mission. If an offer is for renovation or remodeling of an existing building, or for new construction, the designs can be rated and compared to other such offers, or to existing facilities.

Asset Managers and Project Managers likely lead use of F&S approach.

At the start of a project, and during the Feasibility Study, it is likely that Asset Managers in a Portfolio Management group will be the responsible lead in applying the F&S approach. During the Program Development phase, it is likely that a project manager from will be responsible.

Update requirement and rating profiles at major changes and milestones.

Requirement and rating profiles should be updated when there is a change of occupants or a change of mission of the occupants, or when a lease is about to expire, or otherwise on a regular cycle, e.g. after five years.

The Case Study Example[2]

Overview

Report provided by GSA as aid to the Divisions.

In the 1960's, GSA had rented approximately 121,000 m2 (1,300,000 sq.ft.) in a large building in the National Capital Region. In 2001, the Building housed five operating divisions (Divisions) of a large government department.

In 2001, the functionality requirements for office facilities were ascertained for each of the Divisions, using the American National Standard classifications for whole building functionality and serviceability. Five reports were prepared.

Division can compare functionality requirements to facilities it now occupies.

A report for each Division sets out what level of workplace functionality that Division needs so that its workplaces will support, enhance, and not impede, achievement of the Division's strategy and the functioning of its staff. It gives a numeric level of functionality on each of about 100 topics.

These standard classifications enable managers of each Division, and their staff who work in the Building, to measure the fitness for purpose of their facilities. With the standards, they can numerically link functionality requirements to the business strategy of their Division, can measure the functional capability of facilities provided, and can verify that those facilities match the stated requirements.

Building did not meet Division's functionality requirement.

When the rating of serviceability of the Building was compared to the functionality Requirement of the Divisions, it was clear that the Building was not suitable for them. This study provided information on the physical changes that would be needed, but not the cost, to make the building suitable for them.

GSA used report in deciding about the building.

GSA also used the findings from this study in making decisions about the future use of the building, for which GSA's lease will expire in 2010.

Compare functionality requirements to those of other agencies and of the private sector.

Because these classification tools, and the methods for using them, are American National Standards, the Divisions were also able to compare their requirement levels to those of other government agencies, and to relevant organisations in the private sector.

Functionality requirement levels of Divisions mostly similar to each other.

The overall functionality requirements of all the Divisions were found to be very similar, in this study. For example, compared to the average levels of all the Divisions, the barcharts of one Division show 6 significant differences out of about 100 topics.

Functionality requirements respond to new needs:

- **Support anticipated information technology.**
-

The functionality requirements for this Division, as for the other Divisions, is noticeably more demanding than comparable government offices would have called for a few years ago, in these respects:

- ***Infrastructure to support anticipated information technology:*** The requirement profiles support much greater volumes of data use at the workstation, and much higher expected data transfer rates between workstations, servers, and networks, than in the past.

- **Attract and retain high quality staff to replace retirees.**

- ***Attract and retain high quality staff*** to replace the large proportion of the government workforce becoming eligible for retirement in the next few years:
  The requirement profiles call for a more functional and attractive physical setting of work than has traditionally been offered in government, and support a high-quality image for government work.

In this example, the Division had higher requirement levels than other Divisions for some security, image, and operating topics.

The 6 topics on the list below are there because of needs particularly important:

- Support for informal meetings and interaction.
- Protection around the building.
- Identity outside the building.
- Telecom center/situation room for managing in emergencies.
- Bicycle racks for staff.
- Special cleaning.

The report also noted the need to take into account differences between stated present policy of the Division, and what management expects will be policy in future years, for instance on some security needs, and on use of an emergency situation room.

The Division had many significant differences from the requirements of a generic corporate headquarters.

Most differences from private sector are caused by the kind of work this Division does.

On about a quarter of the topics, this Division's requirement levels are significantly different from the Generic Requirement Profile for a Corporate HQ, as developed by the International Centre for Facilities. These differences are not surprising, considering the types of work the Division's people do, and their relationship to various sectors of the American public and to the world. For instance, Generic Corporate HQ has significantly higher requirements on 16 functional areas, including:
– Rates of change and churn in its facilities.
– Freedom from disruption during change and realignment of facilities.
– Security, e.g. separation between secure areas and general work areas.
– Public circulation and wayfinding, particularly for visitors.
– Janitor facilities and ease of cleaning.
– Energy conservation and energy management.

On 7 topics, Generic Corporate HQ has significantly lower requirements. Functional areas of significant difference include:
– Security and protection around the building and site.
– Image of public spaces within the building.
– Availability of food service in the building.
– Cleanliness and cleaning of exterior and public areas, toilets and washrooms, and special zones, such as computer spaces and food service areas.

Use the overall requirement profile to get a quick indication if a facility would be suitable for offices of this Division.

The report presented a single, overall profile of levels for offices of the Division. Management can use it when deciding if a facility which the Division would consider occupying would be suitable. For instance, this profile can be provided to GSA, or to a rental agent, to screen properties on offer for rental. Then it can be used to describe and compare specific changes that would be needed to make a property fully suitable for the Division, and to rank those changes in order of importance for the Division's operations. This knowledge is particularly useful when negotiating with a potential landlord.

Some requirements must be met for the whole building, so are higher levels than many in the Division would expect.

Some requirement levels for one of the Division's occupant groups affect what will be provided for all the others. For instance, some of the occupants may require a large, secure loading dock area, while others have only minimal need. Because the loading dock area serves all occupants of a building, the requirement of a few can only be met by a facility from which all will benefit.

Some requirements could be met on a zone-by-zone basis.

In some other instances, where an occupant group's requirement is higher than the overall level set for the Division, the group could be accommodated in a zone of the building with this higher level.

The Division can compare functional requirements to the proposed designs of future facilities.

The Division can use this requirement profile to assess how well the design for a proposed new facility will meet its functional needs. Similarly, private sector corporations, and other government agencies, have used their requirement profile to consider how well an architect's design proposal meets their needs, to audit the functionality of a design, and to select among design-bid proposals in which design and price are combined in each proposal.

How suitable is a facility, or inventory for its intended purpose?

***Suitability* of a facility = how well serviceability, condition and remaining service life meet requirements.**

A facility that is being assessed should be classified into categories from A to D according to how suitable it is for a specified occupant group or function, which can be the current or future occupants. This is determined by comparing the requirement profile, or profiles, of the occupant group(s) or function(s) to a composite classification of serviceability, condition and remaining service life, from A to D. (Refer to Figure 3 for details and an example.) Categories are as follows:

A = OK at present.

B = Thresholds and/or 10% to 30% of topics miss significantly.

C = Serious problems, but not immediate.

D = Immediate action needed, e.g. for health or safety.

In dealing with an inventory, it is likely that a generic or typical profile, or a set of requirement profiles will be use as benchmarks.

A first scan of an inventory can be very low cost.

A quick scan of all major facilities in each regional portfolio is recommended. This might include all buildings or tenancies of size that is larger than a certain limit. (e.g. larger than 50,000 sq.ft. or 100,000 sq.ft.)

The first time the inventory is classified this way, the data can be gathered by interviewing building managers and their outsource operations providers. This should cost, on average, a fraction of a cent per square foot.

When classifying an inventory for the first time, it is usually not necessary to rate on all topics. A short list of the most important topics, typically half or less, will likely be sufficient.

For the first scan, if requirement profiles for occupants are not yet available, facilities can be compared to generic requirement profiles for comparable organizations, having similar work functions. Then, the profiles can be updated at milestone events, such as a change in occupants, or a change in lease, or if a major renovation or remodel is planned.

How the Functionality-and-Serviceability approach fits into the Life Cycle of Facilities

Profiles of facilities in the portfolio

The F&S approach can be used at several specific points in the life cycle of a facility. Just when, and to what purpose, depends on whether the facility is leased or owned, on whether or not there will be a prospectus-level project, and how the facility fits into the Local Portfolio Plan.

At the end of this report are three diagrams. Figure 4, Life Cycle of Facilities: Three Main Phases, gives an overview of the life cycle. Figure 6 goes into more detail.

Figure 5 is the Diagram: Life Cycle of Facilities: Processes

In Figure 5, the diagram that is titled, "Life Cycle of Facilities: Processes," each task in which use of the F&S approach is appropriate is indicated by *italics*. The text in italics at left in this section repeats words in italics from Figure 5.

The text in this column, below, summarizes appropriate use of the F&S approach at that time in the Life Cycle.

Asset Management Plans

This is more inclusive than what has been a typical Asset Business Plan. For instance, the Asset Management Plan should include a serviceability rating that expresses the capability of the facility to meet the functionality requirements of *any* tenant. In addition, the Asset Management Plan should include the functionality requirement profile of the present occupants, and a graph showing the fit (or lack of fit) between the two. Often, levels on only selected topics will be included in an Asset Management Plan, e.g. about half the total list of topics.

The Asset Management Plan should include not only the Building Evaluation Report or Building Engineering Report (BER), but also a translation into levels on the scales of Condition and Remaining Service Life (C&RSL). (These are new scales, now being prepared for standardization by the International Centre for Facilities.) This task typically takes less than half a day for someone knowledgeable about the facility, such as the person who prepared the BER, or the building manager. Then, this profile of Condition and Remaining Service Life can be compared graphically with the C&RSL requirement profile for the facility, that implements the overall portfolio management plan. The proposed fiscal year of any indicated remedial action should be indicated. (Refer also to Figure 3 for an example of a portfolio-level recap of this information.

Overall Portfolio Management Plan

The strategy for portfolio operations is summed up in the Overall Portfolio Management Plan. It is the framework within which individual Asset Management Plans are created and carried out. It takes into account both the Serviceability profiles of facilities in the portfolio, and the business strategy of operating units, translated into the overall real estate strategy.[3]

The Requirement Scale for Condition and Remaining Service Life can be used by portfolio managers to set the target levels for major assets, and by asset managers to compare against ratings of actual condition and remaining service life.

Compare, then Strategic Programming

Shortfalls and surpluses of capability are easily and quickly recognizable when using the F&S approach. As diagrammed in Figure 1, above, it permits direct comparison between what is required, against what is provided, or what is proposed in a design. A summary of significant differences can be graphed to facilitate management decisions.

Functional Programming in the Macro Statement of Requirements

Each Feasibility Study should include a functionality requirement profile. If the prospective occupants of a facility are known, their functionality requirement profile should be ascertained, either by the occupants or by the real estate organization. If the prospective occupants are not known, then one of the organization's prototypical profiles can be used, or one of the generic profiles created by the International Centre for Facilities.

If existing facilities are to be altered or repaired, then the serviceability rating profile of those facilities should be included in the Feasibility Study. If a design for changed or new facilities already exists, it should be rated and its serviceability rating profile should be included. These profiles should be compared to the functionality requirement profile.

Technical Programming in the Micro Statement of Requirements

Technical programming produces the Micro Statement of Requirements, as shown in Figures 5 and 6. Functionality requirement profile(s) should be a core component of Technical Programming. The functionality requirement profile(s) should be confirmed, because in the intervening period, often a few years, occupant mission and project requirements may have evolved.

Until this point, it is likely that requirement levels will have been determined on only a portion of the topics. For a major project, the requirement levels on all remaining topics should be determined.

In the process diagrammed in Figure 5 and Figure 6, Program Development System (PDS), and therefore Technical Programming is often carried out by the design Architect-Engineer if one has been selected, or by a separate professional services consultant. Interviews with executives for a PDS will likely provide sufficient information so that no additional executive interviews will be required for the functionality requirement profile, or at most only a few executive interviews.

However, at the PDS phase, at least an additional three group interviews are recommended for each functionality requirement profile, particularly if there are many topics on which functionality requirement levels had not previously been set.

If a bridging process will be followed, with a design-builder being selected at the completion of design development, then the above process is usually still appropriate. However, if a fully integrated design-build process will be followed, with design intent being provided by the design-build team, then the technical programming typically needs to be further developed, and to include much information otherwise left until Programming for Fit-up (see below).

Programming for Design or for Fit-up

If the design Architect-Engineer team did not prepare the Micro Statement of Requirements, then one of its initial tasks is design programming, in which it confirms the requirements of the project to the client. For a rental project, or a remodel of existing facilities, this may be the immediate predecessor of space planning and definition of all unit spaces.

In this task, the existing functionality requirement profile should be a vital reference document, because the resultant design will be compared against it, to ensure compliance.

Compare with Statement of Requirements

When the procedure calls for three design options as the product of the Design Intent phase, the serviceability of each option should be rated and compared to the functionality requirement profile(s) in the Statement of Requirements. Normally, this objective ranking of relative functionality of the design options takes only a day or two. It is also vital because it can uncover latent issues that if not resolved would cause major functionality, cost or time problems later during the project, or after completion. Usually these are design issues, but sometimes they show that the implications of a particular tenant requirement, or of an organizational constraint or site constraint, had been inadequately understood.

A second serviceability rating should be conducted at completion of design development, and before the start of construction drawings and specifications. When compared with the functionality requirement profile(s) in the Statement of Requirements, it should show that any significant shortfalls have been corrected since the rating at end of the Design Intent phase.

It is strongly recommended that the Architect-Engineer (A-E) team conduct its own serviceability ratings from time to time during the design phases, so that surprises are avoided when the client rates the design. Some wise project managers even require that the A-E team provide their serviceability rating(s) of the design at each presentation milestone. This speeds the project, and further protects against surprises.

Integrated Process of Design and Construction

In a fully integrated design-build process, Design Intent is provided by the design-build team. Under government rules the design-build team usually cannot be chosen to prepare the Micro Statement of Requirements. Therefore the technical programming typically needs to be developed more completely than for a design-bid-build process. In this case, it should include much information otherwise left until Programming for Fit-up.

If a design-builder is selected at the completion of design development, and also if template drawings and specifications are provided to the design team, then the above process is usually still appropriate. Both are a form of the Bridging Process, discussed above.

When a special purpose facility is being designed, for which the design team members have little experience, and for which template drawings and specifications are not available, then it is particularly important that the PDS include more detailed information that in Design-Bid-Build would be left until Programming for Fit-up. It is then strongly recommended that the full list of topics be used for the functionality requirement profile.

Commissioning and Compare to Requirements

A Facility Management organization seeks to ensure that major new construction and renovation projects support client organization missions, meet functional and financial goals, and meet its standards for quality work environments. It is important to know if the functionality and service life requirements were met. The F&S approach allows the Facility Management organization to measure this achievement on every project, objectively and consistently. Furthermore, it is of the greatest importance to its tenants / customers.

Therefore, after move-in and as part of the shakedown phase of commissioning, a serviceability rating with fine-tuned text profile should be obtained on each newly-completed facility.

If a Post-Occupancy Evaluation (POE) is conducted, the report from this rating may be included POE package.

Update Functionality Requirement and Serviceability Ratings. Compare

Over time, as occupant mission and objectives evolve, their functionality requirement levels change. Typically, these changes are only one or two levels up or down, and occupants work around any deficiencies between what is necessary due to changes in mission, and the existing facility. However, occupant satisfaction may decline.

At the same time, the facility ages, and its serviceability and condition levels decline, often most obviously in the roof, the mechanical systems and the finish materials on walls and floors. Again, these changes are often only one or two levels up or down, but occupant satisfaction may decline some more, because of the physical deficiencies.

It is therefore recommended that the serviceability ratings of all major facilities be reviewed and updated periodically. Doing it after about five years since the last rating may be appropriate for an office building, but whatever the occupant functions, the elapsed time should depend on the level of wear and tear to which a facility is subjected. If a major refit, remodel or rehabilitation occurs, then the facility should be rated as part of commissioning, as noted above.

Proposals for Major Repairs and Alterations

As noted earlier, each Feasibility Study should include a comparison between the functionality requirement profile(s) and the serviceability rating profile(s). This comparison is needed for the Feasibility Study for a proposed Repair or Alteration project in the same way as for a new tenant requirement.

End Notes:

1. *ASTM Standards on Whole Building Functionality and Serviceability, Second Edition*, ASTM International, West Conshohocken, PA, 2000. ISBN 0-8031-2734-0. ASTM Stock Number WBDG2000. pp277.

2. This paper is based in part on work by TEAG-The Environmental Analysis Group, under contract to the US Government Services Administration. This work is included here with permission from TEAG.

3. *Strategy and Space: managing corporate real estate and facilities for corporate advantage*, by Martha A. O'Mara, The Free Press, 1999, ISBN 068-484-4898.

Figure 2. List of Functionality/Serviceability Topics

Letters alongside a topic number and name indicate the topic was selected as most important for one group. The left column of 54 "***F***"s indicate which topics were selected by the group that provides facilities to the components of a large organization. The next column, of 54 "***P***"s, nearest to the topic number and title, indicates topics selected by a unit with a "people" priority to attract and retain high quality staff in the changing labor market of the next decade or two. A total of 36 topics are in both selections, and 34 are in only one selection, so the total of topics in one or the other selection, or in both, is 70.

A. GROUP AND INDIVIDUAL EFFECTIVENESS

A.1 Support for Office Work

P A.1.1 Photocopying and office printers
A.1.2 Training rooms, general
A.1.3 Training rooms for computer skills
A.1.4 Interview rooms
F A.1.5 Storage and floor loading
F A.1.6 Shipping and receiving

A.2 Meetings and Group Effectiveness

F P A.2.1 Meeting and conference rooms
F P A.2.2 Informal meetings and interaction
F P A.2.3 Group layout and territory
P A.2.4 Group workrooms

A.3 Sound and Visual Environment

F P A.3.1 Privacy and speech intelligibility
F P A.3.2 Distraction and disturbance
F A.3.3 Vibration
P A.3.4 Lighting and glare
F P A.3.5 Adjustment of lighting by occupants
P A.3.6 Distant and outside views

A.4 Thermal Environment and Indoor Air

F P A.4.1 Temperature and humidity
F P A.4.2 Indoor air quality
F P A.4.3 Ventilation air (supply)
P A.4.4 Local adjustment by occupants
P A.4.5 Ventilation with openable windows

A.5 Typical Office Information Technology

F P A.5.1 Office computers and related equipment
F P A.5.2 Power at workplace
F A.5.3 Building power
F P A.5.4 Telecommunications core
F P A.5.5 Cable plant
F A.5.6 Cooling

A.6 Change and Churn by Occupants

F P A.6.1 Disruption due to physical change
F A.6.2 Illumination, HVAC and sprinklers
F P A.6.3 Minor changes to layout
A.6.4 Partition wall relocations
A.6.5 Lead time for facilities group

A.7 Layout and Building Features

P A.7.1 Influence of HVAC on layout
P A.7.2 Influence of sound and visual features on layout
A.7.3 Influence of building loss features on space needs

A.8 Protection of Occupant Assets

F P A.8.1 Control of access from building public zone to occupant reception zone
F P A.8.2 Interior zones of security
A.8.3 Vaults and secure rooms
F A.8.4 Security of cleaning service systems
A.8.5 Security of maintenance service systems
A.8.6 Security of renovations outside active hours
A.8.7 Systems for secure garbage
F P A.8.8 Security of key and card control systems

A.9 Facility Protection

F A.9.1 Protection around building
F P A.9.2 Protection from unauthorized access to site and parking
P A.9.3 Protective surveillance of site
P A.9.4 Perimeter of building
A.9.5 Public zone of building
P A.9.6 Facility protection services

A.10 Work Outside Normal Hours or Conditions

F P A.10.1 Operation outside normal hours
F A.10.2 Support after-hours
P A.10.3 Temporary loss of external services
A.10.4 Continuity of work (during breakdowns)

A.11 Image to Public and Occupants (E 1667)

F A.11.1 Exterior appearance
F P A.11.2 Public lobby of building
F P A.11.3 Public spaces within building
F P A.11.4 Appearance and spaciousness of office spaces
F P A.11.5 Finishes and materials in office spaces
A.11.6 Identity outside building
F P A.11.7 Neighborhood and site
A.11.8 Historic significance

A.12 Amenities to Attract and Retain Staff

F P A.12.1 Food
A.12.2 Shops
P A.12.3 Day care
F P A.12.4 Exercise room
A.12.5 Bicycle racks for staff
P A.12.6 Seating away from work areas

A.13 Special Facilities and Technologies

F P A.13.1 Group or shared conference centre
P A.13.2 Video teleconference facilities
A.13.3 Simultaneous translation
A.13.4 Satellite and microwave links
F A.13.5 Mainframe computer centre
A.13.6 Telecommunications centre

A.14 Location, Access and Wayfinding

F P A.14.1 Public transportation (urban sites)
A.14.2 Staff visits to other offices
F P A.14.3 Vehicular entry and parking
P A.14.4 Wayfinding to building and lobby
F P A.14.5 Capacity of internal movement systems
F P A.14.6 Public circulation and wayfinding in building

B. THE PROPERTY AND ITS MANAGEMENT

B.1 Structure, Envelope and Grounds

F B.1.1 Typical office floors
B.1.2 External walls and projections
F B.1.3 External windows and doors
B.1.4 Roof
B.1.5 Basement
F B.1.6 Grounds

B.2 Manageability

B.2.1 Reliability of external supply
B.2.2 Anticipated remaining service life
B.2.3 Ease of operation
B.2.4 Ease of maintenance
B.2.5 Ease of cleaning
B.2.6 Janitors' facilities
F P B.2.7 Energy consumption
F B.2.8 Energy management and controls

B.3 Management of Operations and Maintenance

F B.3.1 Strategy and program for operations and maintenance
B.3.2 Competences of in-house staff
F P B.3.3 Occupant satisfaction
B.3.4 Information on unit costs and consumption

B.4 Cleanliness

F P B.4.1 Exterior and public areas
F P B.4.2 Office areas (interior)
F P B.4.3 Toilets and washrooms
F B.4.4 Special cleaning
P B.4.5 Waste disposal for building

	Site 7	Site 5	Site 11	Site 9	Site 10	Site 6	Site 1	Site 3	Site 4	Site 8	Site 2
Count of Topics considered	54	54	54	54	54	54	54	54	54	54	54
Topics for which information is lacking, so level cannot be set	3	1	1	2	3	7	6	4	6	5	3
Topics with sufficient information to be able to rate	**51**	**53**	**53**	**52**	**51**	**47**	**48**	**50**	**48**	**49**	**51**
Topics with Significant Problems of Fit											
Serviceability or condition **does not meet threshold level**	**0**	**0**	**0**	**1**	**2**	**2**	**2**	**4**	**5**	**4**	**1**
Exceptionally important topic, and at least 2 levels below requirement	1	2	1	4	3	4	4	5	7	7	3
Important topic, and at least 3 levels below requirement	1	1	3	2	4	3	4	6	4	5	5
Minor importance topic, 4 or more levels below or above requirement	0	0	2	2	3	3	4	5	2	7	4
Count of Topics with Significant Problems of Fit	**2**	**3**	**6**	**9**	**12**	**12**	**14**	**20**	**18**	**23**	**13**
Topics with Priority Issues											
Issues identified for **immediate** action, e.g. health & safety	0	0	0	0	0	0	0	0	0	0	**1**
Serious problems require action, eg: to prevent serious deterioration. **Not** immediate	0	0	0	0	0	0	0	0	**2**	**1**	**1**
Count of Topics with Priority Issues	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**1**	**2**
Category for action											
Percent of topics without problems or priority issues. Formula is: = Topics with sufficient info – Topics Problems of Fit – Topics with Priority Issues Topics with sufficient info	96%	94%	89%	83%	76%	74%	71%	60%	58%	51%	71%
Category for action	**A**	**A**	**B**	**B**	**B**	**B**	**B**	**C**	**C**	**C**	**D**

Calibration Rules for Categories for Action	
A = **OK at present**. Close fit for the functionality requirement profile.	Percent of topics without problems of fit is greater than 90%, meets all threshold levels, and there are no problems of degradation nor "immediate" issues.
B = **Threshold(s)** and/or 10% to 30% of topics **miss significantly**.	Miss one or more threshold level(s) and/or significant problems of fit on 10 to 30 percent of topics, but there are no problems of degradation nor "immediate" issues.
C = **Serious problems**, but not immediate.	Need action to protect the asset from serious deterioration, and/or significant problems of fit with more than 30% of topics, but there are no "immediate" issues. Percent of fit is less than 70% and/or need action to protect the asset from serious deterioration or failure. May not meet some threshold levels. There are no "immediate" issues.
D = **Immediate action needed**, e.g. for health or safety.	There is one or more issues identified for immediate consideration, e.g. health or safety. When all the "D" topics are remedied, then the site will be re-categorized as an A or a B or a C.

Figure 3. Example of Categories for Action on a Portfolio of Facilities

Diagrams of process over the life cycle

Below, in Figures 4, 5 and 6, are diagrams which illustrate the life cycle of facilities, and the main phases and processes by which they are managed.

Figure 4 is an introductory summary diagram.

Figure 5 is more detailed, and has been discussed in the preceding pages.

Figure 6 contains the most details, and is intended for use when considering the tasks that comprise each process.

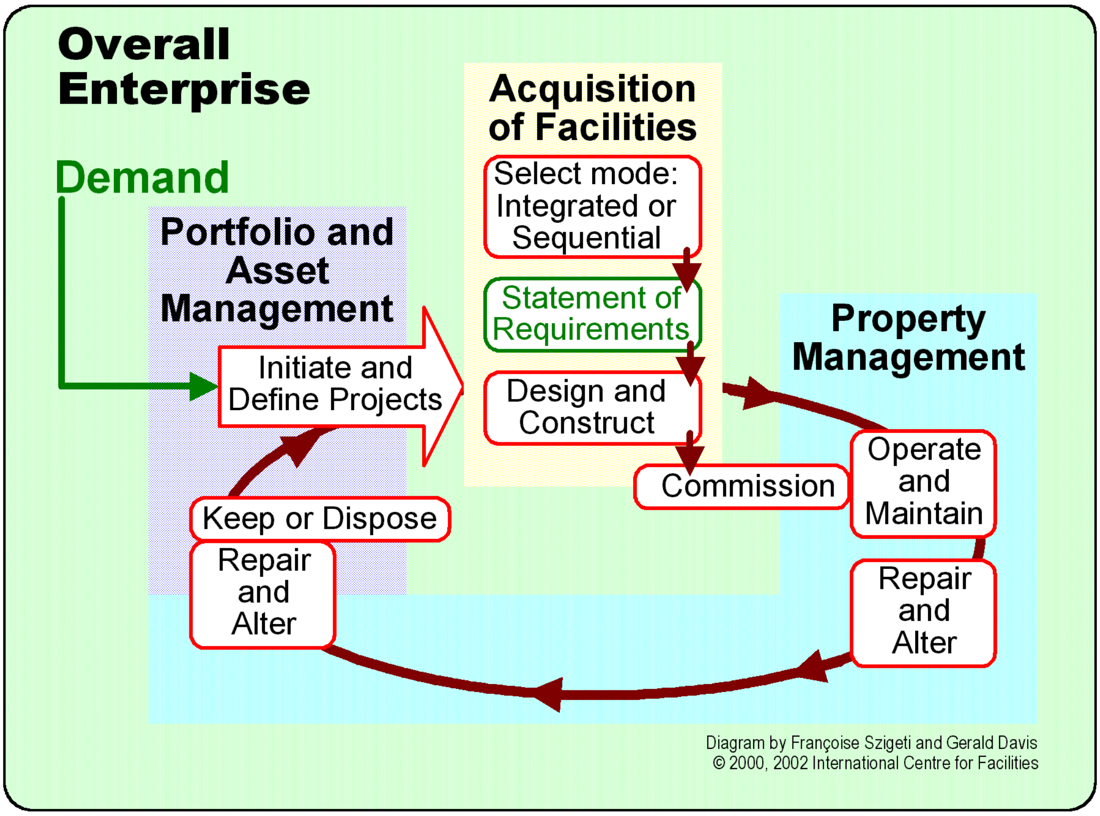

Figure 4. Life Cycle of Facilities: Three Main Phases

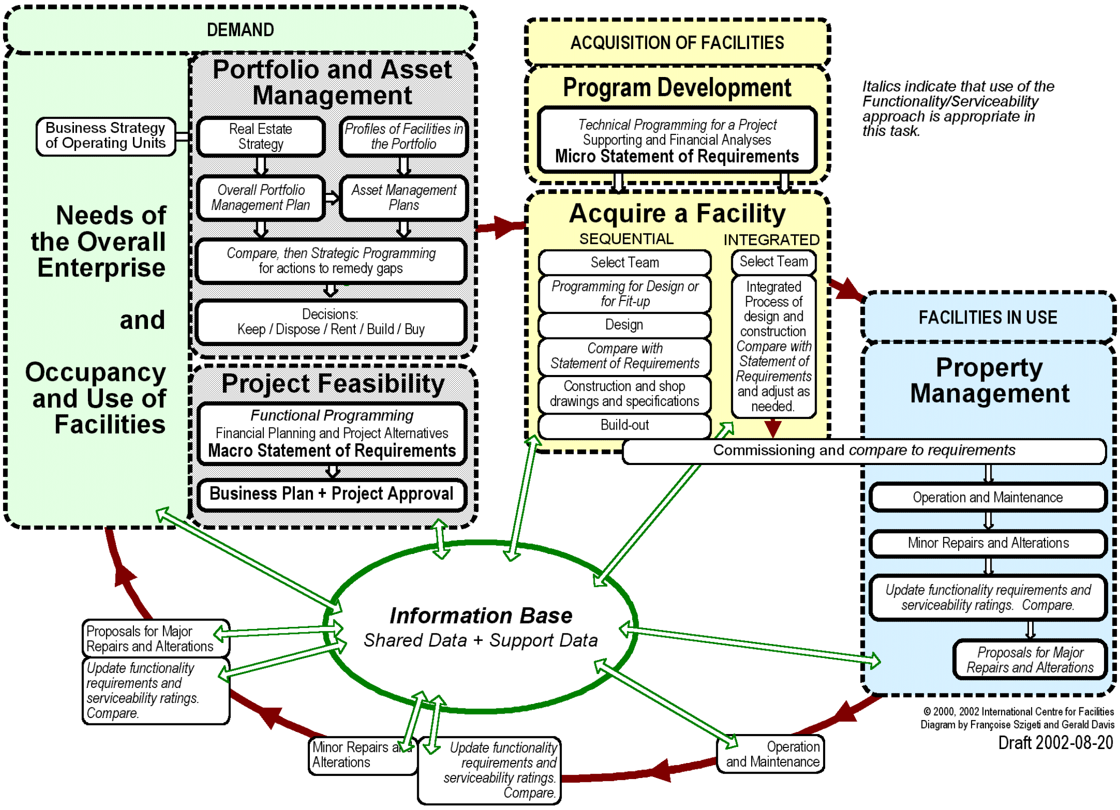

Figure 5. Life Cycle of Facilities: Processes

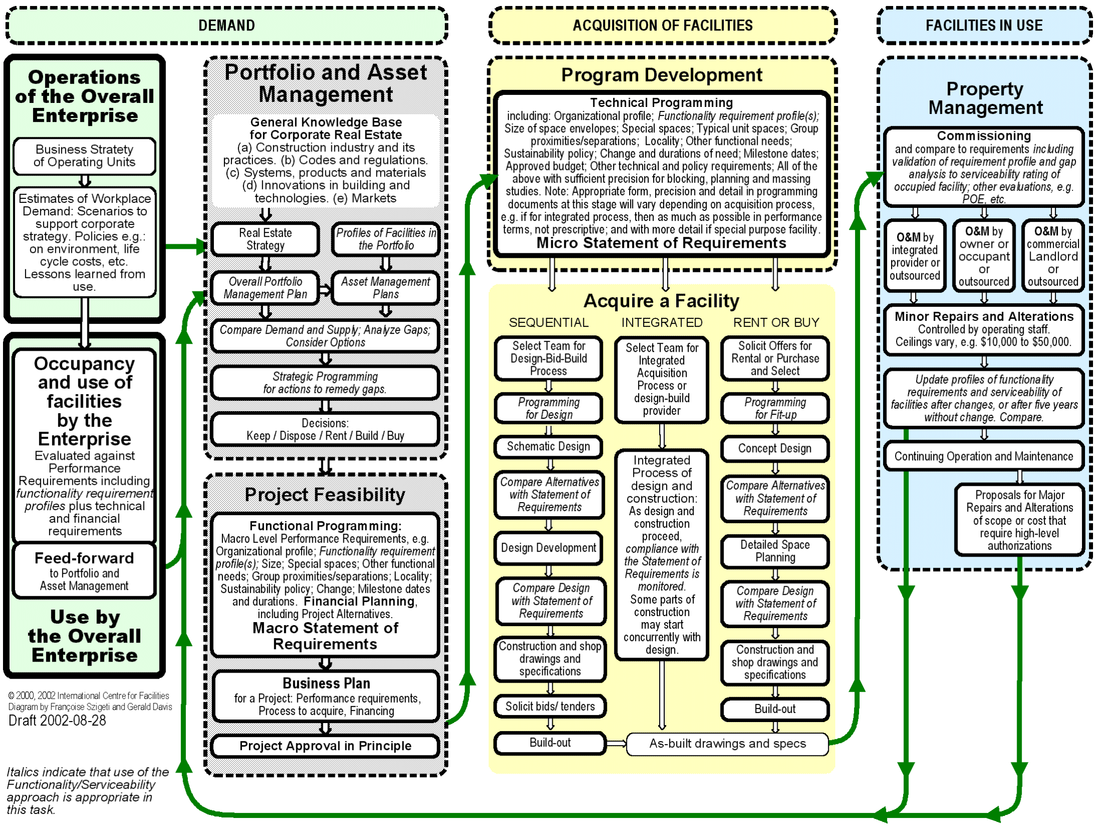

Figure 6. Main Tasks in the Life Cycle of Facilities

Asset Maintenance Management

Facility Management and the Design of Victorian Public Hospitals

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Abstract: *It is the thesis of this paper that discipline of asset & facility management has not been given sufficient opportunity to participate in determining a hospital's capacity to deliver services and the involvement of FM is critical in the early planning and design phases. This requires a change to the thinking of planners, architects, engineers etc. from stages such as functional briefing and master planning. A close link between FM and the design disciplines will assist in the development of concepts, assessment of impacts on facilities' operations and associated recurrent costs.*

Keywords: Hospital design, facility management

Emerging Challenges

The design of a hospital and its supporting infrastructure has a major influence on the delivery of health services. The design phase is crucial in determining the facility's capital cost and operating efficiency. How are people receiving the design to if they are getting a hospital that is fit, safe and sustainable?

Experienced professionals from the private sector are employed to design or reconfigure hospitals. Generic briefs, standards and guidelines[*1] have been developed to help, however hospital design processes relies on the skill of architects, engineers and cost planners to translate users' needs and functional requirements into built form concepts estimates and construction documents. These documents describe the form and manner of the outcome in terms of fit for purpose, robustness, durability, flexibility, compliance and ease of operation.

The hospital designs are normally presented to the client for acceptance at several stages (See Attachment 1) in order to ensure the proposed works meet the requirements and here in lies a challenge. How can people knowledgeable in provision of medical care come to grips with the meaning and implications of a bunch of lines, drawings and words when the outcome is difficult to predict? Translating reports to built form is as hard to visualize as interpreting a dream.

Consultants are in the business of selling ideas. The consultant's most important audience is the board of management and senior hospital executives. The importance of design to these clients can be measured in terms of how much attention and energy is directed to the creation of images, designs, perspectives and models.

Design consultants are specialists in disciplines associated with the front end of projects and often have little or no appreciation of the difficulties associated with daily operations, maintenance, recurrent cost and related asset management[*2] concerns. This is a challenge that designers must strive to overcome.

The lack of workable designs that allow for ease of maintenance or introducing changed operating regimes to be introduced is testimony to the inflexible schemes developed through all planning stages. Scant attention is given to longevity of replacement items or doing routine maintenance without disturbing theatre operations and day-to-day functions such as replacing lights and cleaning filters etc...

A hospital can continue to function with very rudimentary facilities; surgeons can even operate in a tent if they have access to basics such as potable water and electricity to perform surgery.

Yet the disciplines associated with the ongoing provision of these engineering utilities are virtually invisible in the design process. Whilst the Facility Management sector (FM) is responsible for hospitals' energy, communications, environmental, safety and emergency systems, FM has not yet achieved recognition or prominence to influence the design of health services

Designers often relegate those involved in sustaining maintenance and operations to an incidental or marginal role. FM is seen as a discipline dealing with cleaning contracts, preparing purchase orders for minor works or helping out when the hospital is seeking accreditation.

The third challenge is to encourage design professionals to bring FM into the design process when assessing risks, dealing with business continuity threats and putting in place contingency arrangements. FM advice regarding functionality fitness and safety is seldom sought and becomes evident as it is often at the time that an emergency such as an electrical grid outage coupled together with back up generator failures that the problems are recognized.

At what stages should designers and FM interact? Discussing risks are best begun at early steps in the planning process as shown (See Attachment 1). Designers can use FM insights and guidance to identify key elements dealing with emergency and disaster planning.

Summing up the challenges, the value that FM can bring to the design process can be identified as critical in key areas such as:

- Preparing Briefs and Performance Benchmarks.
- Formulating Facility & Building Services Design.
- Review Expenditures and Capital v Operating Costs.
- Undertaking Risk Management & assessing Contingent Liability.

Commissioning programs and working within the unique cultures of hospitals and the building industry are also important areas where the design and FM disciplines overlap.

The Brief

Where should we start? What should the brief contain? Who should be involved in preparing it? It is not easy to make a design robust when requirements are vague, inconsistent or ill defined. There may be no documented hospital brief or the brief may not have been through an approval process. The brief may be based on invalid assumptions, preconceived outcomes; lack clarity and/or fail to distinguish between demands and needs.

Successful projects require a good team working on a clear vision with a knowledgeable client. Starting at the briefing stage, including FM is necessary for the client becoming an “informed consumer” with a well-prepared brief. The client hospital has many roles from user, operator and provider etc. and allowing for FM input to the design brief will assist in setting performance targets for accommodation, flexibility, durability and reliability. The brief also includes criteria for the purposes of selection and FM can be most useful in setting such criteria so that the best consultants/contractors are selected. In turn the designer, by responding to such a brief, will be provided with the best opportunity to meet the client’s requirements.

The brief preparation process should provide for FM to determine:

- How the building could be used and allowing health services to continue while works are underway.
- Identifying potential problems associated with practical issues such as accessibility or security.
- Providing for flexibility or expansion at the early design stage that may be negligible in terms of costs for a substantially beneficial outcome.
- Identifying resources needed to operate and maintain assets.

The aim of providing FM input to the design brief is to bring value to a capital project by way of less maintenance and operating costs. Too often technology is ‘smeared’ around the building and ends up taxing the brains and resources of the occupants and operators.

Buildings systems may be tweaked up to operate satisfactorily. By understanding how the underlying systems work and the design capabilities of engineering systems, FM can obtain better performance and exploit the full potential of building’s performance capacity. It may be simple yet effective as small changes at the conceptual stage are as easy as the stroke of a pen without impacting capital costs. The consequential impact on resources, staffing and associated costs can be huge.

If the design brief is set by FM then solutions will be sought to issues such as minimizing the length of perimeter wall, maximizing natural light penetration into buildings or overcoming circulation systems conflicts such as the delivery of produce and the removal of infectious waste.

Issues that need to be raised in regard to a project brief are:

- How is the facility to be managed following handover?
- What is in place to link funding approvals to operations?
- What are the performance criteria to be used to determine the operational viability of a new or refurbished facility?
- If the life of building services were changed how would this affect the design?
- Should a payback period of less than 3 or 5 years be justification to approve additional capital expenditure?
- Will the building and services easily be modified or do they require major change to plant and infrastructure?
- What are the recurrent costs associated with operating a new or refurbished facility and how does this compare to present costs or other similar projects?

The commercial sector provide examples of how facilities can best satisfy internal and external customer needs, support innovation, improve responsiveness and ‘cycle times’ in response to the changing business environment, reduce the cost of a product or service, reduce levels of risk and improve reliability – so why not hospitals?

A brief that recognizes needs that arise over the long term, accommodates users’ requirements in a practical manner and sets down requirements is needed before people can tackle the language of plans, technical drawings and specifications. Needs described in this way can be discussed and priorities determined.

Undertaking post occupancy evaluations can assess the success of a hospital project by comparing the result with the initial brief. FM who is familiar with the facility is best suited to testing compliance with the brief.

Benchmarking

Performance criteria and benchmarks are beacons for designers - they are of use when preparing briefs, assessing plans and to compare proposals with hospitals that have been found to operate efficiently. The difficulties associated with establishing benchmarks arise because of insufficient relevant data and the lack of definition for standards terms. However FM is in a prime position to clarify hospital needs for redundancy, flexibility and reliability and translate these into quantities for the designer.

The benchmarks used in the Victorian public hospital sector include physical characteristics such as ward and theatre sizes, financial characteristics relating to costs / square meter and functional characteristics such as number of operations per theatre.. There have been different benchmarks applied for new and refurbished facilities and the department has confirmed the benchmarks by undertaking post-occupancy evaluations and functional reviews.

DHS is now seeking to establish even better ways of measuring performance requirements such as life cycle, and recurrent aspects. Examples of this are measuring consumables such as area, energy or capital costs to support services delivered. Facility managers are often in the best position to ascertain performance measures because of their familiarity with facilities operation and maintenance.

The key responsibility of FM when dealing with designers of new or redeveloped facilities is to set the performance criteria for engineering and building services. This then forms the basic framework for an "Asset Management Plan" that is a requirement of government policy on Asset Management[*2] including the establishing an asset register, undertaking condition assessments and maintaining essential service records.

Issues such as the lack of standard terms, increasingly complex-engineering considerations, changing models of service delivery and technological changes can influence the method of operating and maintaining hospitals. The use of benchmarks and maintaining of historical databases are methods to establish better outcomes that are long overdue.

The key performance indicators used to measure and monitor facility suitability need to be derived from discussions with users and management to give the organization design objectives based on an integrated view of the facility as a whole. FM can do this task rather than relying on poorly documented needs that overlook a goods and materials management system that meets the needs of engineering, accounting, nursing, cleaning, disposal, security and safety.

Hospitals are comprised of functional areas that vary in terms of physical and economical life. It is important to appreciate the differences in functional areas at the design stage when evaluating the differences between redevelopment and building of a new facility. The DHS has undertaken studies of functional areas for the purposes of benchmarking facilities across the state of Victoria. Functional areas can then be benchmarked against other facilities e.g. hospital administration and office areas can be compared with their counterparts in the commercial sector as can kitchens, laundries and engineering [*4]. The cost of construction and expected life, period between major refurbishment has been benchmarked by the department, and is now used by hospitals to compare the plans produced by designers. Until recently this has been directed to area and cost and more recently has been extended to energy use and maintenance cost

There are several areas that are unique to hospitals, such as wards and treatment areas. In these areas the benchmarks and performance indicators are considered to be unique to the hospital sector. The department has found that in these circumstances benchmarks may be more applicable between hospitals with the same classification, e.g. tertiary teaching facility, metropolitan or regional based hospital.

The following Table 1 sets out the key performance indicators for use in the design of new acute health facilities.

BENCHMARK	UNIT
Facility energy cost ($/m2)	$19.60
Facility energy efficiency (GJ/m2)	1.32 Gj
Hospital services energy consumption ($/unit)	$39.26
Hospital services facility utilization (unit/m2)	0.61
Facility income efficiency ($/m2)	$2.42
Capital utilization (%)	69.42%
Facility management ratio (%)	4.00%

Table 1: Benchmark values of the Key Performance Indicators

Facility energy consumption and costs are now required to be produced by the design team at the schematic plan stage and annual management expenditure can be compared to budgets so the overall cost of managing and maintaining can be established for the hospital and its component parts.

Facilities Design Stages

What are Critical Success factors to bringing about a successful hospital design? Complying with accreditation, policies and regulations to mention a few items. However, it is possible to bring better value to the hospital at the design stage by bringing the right expertise to bear at the outset (See Attachment 3). The opportunity to maximise value and minimise waste at early design stages via access to FM knowledge and focus on through-life issues so as to minimize the total cost of service delivery. The most important costs are service related with efficiency, absenteeism, interruption and churn being of most concern. The facility manager can assist in the process by providing critical knowledge and expertise.

Important decisions taken at the design stage that will have a significant impact on the hospital recurrent costs for years to come need careful consideration including:

- Building footprint, rehabilitation, height and mass of the building mass
- Selection of structural systems, equipment, and cladding materials
- Flexibility and ability to operate areas independently.
- Selection of communications, services, energy & security Systems technology.

A design maxim stipulates that the biggest savings can be most easily achieved at the early stages of design. As documentation becomes more developed, and designs become refined and fixed, changes are more difficult to introduce. Accordingly there is greater resistance and less ability to achieving lower recurrent costs. There are fewer opportunities to examine areas of impact on capital and recurrent budgets. Approvals and commitment to designs become entrenched and links between architect, mechanical and electrical, structural, and civil engineers are more complete and detailed.

The outcome of recognizing the role of FM in addressing recurrent issues during the design phase will help ensure that increased reliability, lower recurrent operational costs and reduced replacement requirements will lead to better service delivery.

Redevelopment Versus Greenfield Solutions

Redevelopment of existing hospitals is far more frequent than development of new facilities. Designers overlook the fact that this typically occurs every 5 to 8 years for a regional base or metropolitan hospital. These upgrades, fit outs and refurbishments are well understood by FM who have to deal with these demands on a regular basis.

The rule of thumb that is used is that if the cost of refurbishing a facility is 65% of a new building or more, then the likelihood is that a new facility may be better option to pursue.

If the refurbishment of existing infrastructure were taken into account using normal discounted cash flow techniques, then the value of initial capital cost component would be greatly reduced. The impact of retaining existing facilities and the inherent continent liabilities these buildings and services represent would be explicit. FM is in a good position to provide realistic advice of how extensive these costs are and the areas that can be affected. Unfortunately, the bulk of our allocations continue to be drawn to areas of replacing existing infrastructure.

Strategic issues for existing refurburbishment:that are well understood by FM

- Ability to determine facility life cycles & consider in the design
- Ensure compliance with statutory obligations
- Review inclusion of deferred maintenance
- Determine future expansion of the facility
- Consider operating budget in the design

New site strategy issues for FM include

- Selection of appropriate equipment and services for the installation
- Provide practical advice on simple no cost specification changes that provide measurable benefits to the maintenance of the built facility
- Implement an asset management system at the construction stage of the project
- Install systems at the outset that facilitate outstanding monitoring and controlling of operations

How often is it that we look back with regret on a redevelopment project that has been undertaken at great cost? That cost is often found to be within a few dollars of a new facility that could have been provided with new infrastructure, plant & equipment. If FM were involved the choice would be subject to far greater scrutiny and may have led to lower contingent liabilities associated with obsolete and dilapidated reticulation systems, engineering plant and dysfunctional buildings.

Refurbishment of hospitals is a time honored design activity that needs to be scrutinized much more carefully and recognized for what it really is – a compromise to achieve some functional benefits that often carries a host of long term problems and financial penalties.

FM will bring a level of reality to the consideration of redevelopment versus new construction debate. They can do this by raising practical issues to be considered before adding another refurbishment and additional square meters to what are obsolete and dysfunctional areas supported by exhausted and decrepit infrastructure services.

Building Services

The building services in a modern hospital including mechanical and electrical systems represent more than half of the capital cost, or replacement value, of a facility. Building services' designers specifically deal with the area of mechanical and electrical systems. FM expands this view to a wider vista and seeks to focus on the mechanical and electrical systems that compared to the building structural elements they have short life cycles.

The importance of major Infrastructure design in terms of accessibility, spare parts and servicing availability is often not given sufficient consideration by the design team. Too often maintaining hospital functions during routine maintenance, providing appropriate redundancy and spare capacity as well as reducing average time and frequency of failures are not adequately addressed in major health facilities building services' design.

These same services account for the majority of ongoing non-clinical costs although they often have shortest life span of the building components such as foundations, structure or cladding.

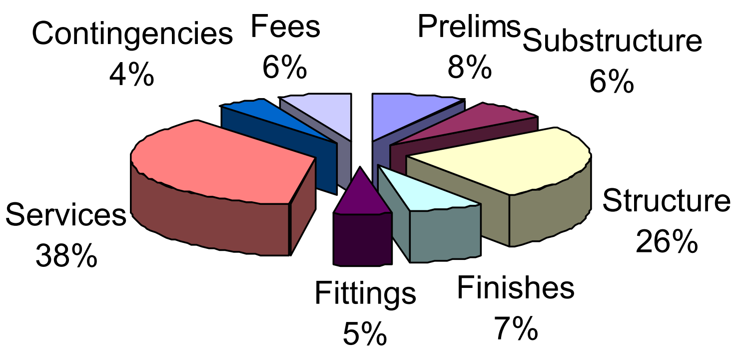

Diagram: Cost Plan composition for a typical hospital project

The design of building services is often devolved to technically competent persons who are rarely interrogated closely at the time of their engagement or at the time the concepts are being formed FM asks the difficult questions to get solutions that are closely aligned to reliability, redundancy and lower recurrent operational costs and reduced replacement requirements that will ultimately lead to better service delivery. The impact that service interruptions have on staff effectiveness and the consequential delays and costs associated with carrying out procedures are never taken into consideration when the assessment of building services systems is carried out.

Value Management

The approval of funding of Victorian public hospitals capital works requires a formal value management (VM) exercise be undertaken for all key stages of projects exceeding $5 million. The VM process is to assess the viability of proposals and to be assured the key design objectives have been met appropriately. The VM can raise issues for action, to determine if sufficient consideration has been given to alternative methods of achieving the required outcome or possibly to identify if there are better/cheaper ways of reaching the desired outcomes e.g. does the design accord with the principles of sustainability.

However the use of FM expertise in VM or similar reviews is often inhibited due to the views of the design professions, project managers or even the management of the agency itself. There is a need to recognize the skill base that exists and obtain feedback from FM who has experience without inhibiting the opportunities to be innovative and develop alternative methods of solving design and development problems.

The assumption is often made that the user groups reflect the operational requirements of the facility. This assumption is unproven, and can be incorrect or qualified to the extent that user group inputs must be restricted. It is often decisions made at the design/documentation stage that preclude efficient operations or even lead to replacement of or reconfiguration of various pieces of plant, equipment or controls.

Close scrutiny of potential problems or possible costly variations are matters often more easily identified by FM than designers and may build confidence into investment decisions to avert future difficulties. Some aspects to be examined include:

- Target budgets for operation and maintenance energy and cleaning requirements
- Capital funding for replacement - life cycles of major elements of plant and reticulation systems
- Building automated systems, monitoring, control & risk management systems

Administrators, financiers and managers are increasingly concerned about value for money. Price is just one element of value. Assessing value over time is a challenge to old conventions with a view to achieving the best match of customer expectations and available funds. This assessment often requires skills and knowledge of the FM sector so that designers can exploit the opportunities that are available.

Estimating the initial, recurrent and replacement costs of operating the hospital under differing regimes is a requirement to achieving a selection based on full understanding of life cycle costs. This may require background and recurrent records held by FM. Unfortunately the design teams' knowledge and attention can become fixed on capital implementation issues rather than what happens afterwards

Expenditure - Capital Versus Operational

A major challenge that continues to face hospitals is finding funding. Competition for capital works funds has always been intense but in today's environment this pressure is even fiercer. It is clearly important to manage capital costs during the design and construction phases. However as a consequence of the competition to obtain funds, a culture of minimising costs at the early stages of design has arisen. This can lead to solutions that offer short-term savings.

Where are recurrent facility costs going? There appears to be little empirical data or practical research about the failure to accurately forecast recurrent costs for new or refurbished facilities when design are prepared. Anecdotal information suggests the trend is for recurrent costs to increase exponentially when moving into new premises. Records show that cost/m^2 can by up to 300% in various functional areas of the hospital.

A host of contributing factors drives the recurrent costs of a hospital. These costs can depend on matters such as demand for higher levels of comfort control, greater intensity of use (throughput & operating hours), condition, capacity, occupancy rates (of beds), number & type of pieces of equipment. There are benefits in having FM contribute to the work by the design professionals to predict the cost of the proposed works and how to assess the trade off between various items of equipment when maintenance is taken into considerations.

There is no agreed conformity between hospitals within a region, State or nationally included in maintenance expenditure. The elements that are typical areas of inconsistency include laundries, photocopying, vehicles, MATV, medical equipment. Furthermore, in some hospitals there appear to be one record kept by the accountancy department and another by the engineering department. There is no assurance that their records correspond.

When the hospital is being designed, reports include cost information such as estimates of construction costs and cash flows. These capital works cost plans are expected to be accurate to around 10-15%. However these cost plans normally provide construction estimates only at the master plan, feasibility, schematic design and the tender stage.

If the link between facility management and design were well established the cost information would include projected operating & maintenance costs and compare them with previous projections. In Victoria the formal approvals for project commences with initial allocation being set out in the state budget. The supporting document, the Investment Evaluation is the means to put up a proposal for funding to the Treasury boffins. FM can assist the design team in calculating of total facility investment over time by input into recurrent operating costs.

Too often when capital cost reductions are required as part of the design process it is the facility management area that suffers the most. Therefore what is needed to change the approach to the design process in order to achieve better outcomes? In answer to this query, the following issues need consideration:

- Cost planning focus is still concentrated on construction rather than operation.
- New or redeveloped hospitals are costlier to run than the older facilities.
- The healthcare funding sector demands greater benefits, more efficiency and reduced waste from new technology, flexible facilities and new work practices.
- Clients have higher expectations and seek better quality services
- More rigor and alternative solutions are sought from consultants and contractors as well as seeking competitive tendering of services.
- Governments have sought private sector participation in the delivery of facilities to defer the burden of costs and transfer risks in capital works projects.
- The private sector is seeking to provide services and facilities to complete service/building/finance/operations.

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Payback periods for additional capital costs has long been recognized as providing a justifiable case to increase in the capital budget for example by bringing forward recurrent cost savings to fund better outcomes or seeking 3rd party financing in order to provide facilities that meet long term objectives[*5].

The inclusion of FM in selecting the appropriate procurement model for hospitals is unconventional. Facility managers are not usually involved in selection of services or equipment and rarely consulted when choosing between contracting and financing options such as Design and Construct, Build and Maintain, Construction Management or Performance Contracts. This exclusion denies the sharing of experience or critical considerations when establishing selection criteria, identifying benefits and liabilities and setting out terms and conditions to mitigate risks. The role of the FM should be considered when selecting a procurement method and the consideration of pros and cons when different methods are being evaluated.

Business Continuity

FM can contribute to the design of hospitals capacity to meet their operational robustness by identification of risks, critical points of failure and exploring means to overcome these potential failure areas. It is often difficult for the originator of a design or solution to a problem to assess the outcomes that may arise from a multitude of different scenarios. The ability of the facility to continue working the delivery of critical utilities (electricity, water etc) may need to be provided in unconventional ways not considered by the original designer, especially after the facility has been functioning for a period during which modifications and additional requirements have occurred.

There is a need to have a practical knowledge of what aspects are likely to arise in various scenarios such as failure of various systems simultaneously – e.g. the communications systems could fail at the same time as the electricity outage occurs.

The FM is in a position to propose/consider the scenarios of how the facility is to be used in emergencies to appropriately manage its operation when the unforeseen occurs. It is necessary to find different ways of maintaining the business of health care in a range of situations even at the design stage. It is also useful for designers if facility managers reconstruct previous incidents in planning for future incidents and in streamlining any issues related to liability or insurance.

Facility managers are often the best placed to advise designers on business, human, building and regulatory components in matters associated with essential services such as:

- Preventative actions to reduce the chances of an emergency occurring through initial design including surety and reliability
- Detection and notification requirements
- Responding to long-term outages and multiple events.
- Provision of backup systems in the event the primary system breaks down.
- Evacuation and decanting needs e.g. identifying decanting areas.
- Control and mitigation measures involving human intervention e.g. firefighters and staff.

Contingent Liability

The term ‘contingent liability’ has yet to find a place in today’s designers’ vocabulary. There is a need to involve the design team in understanding the range or risks associated with facilities and their management in the early design and cost planning stages. FM can assist especially during the conceptual and design stages by providing input into the identification and mitigation of risks for all parts of the hospital.

Objectives such as being fit-for-purpose and safe facilities have been set out in a variety of regulations such as the Building Code, Fire Risk Management, Legionella Risk Management, OHS requirements, statutory requirements of the Electrical and Plumbing Commissions, the department’s Capital Development Guidelines and Essential Services Regulations. Often various regulatory areas have conflicting requirements that cannot be resolved simply by “design” but need the practical views of the hospital FM to resolve and prioritise how operational matters can be dealt with.

For example, in dealing with the emergency services and authorities (Fire, SES, police etc) as well as the hospital administration and culture of the organisation, FM are well placed to comment or even direct the solution to matters such as principal points of access, control of precincts, isolation of services or areas and/or establishing alternative control regimes.

The bulk of capital work in the health sector today involves the redevelopment of existing facilities. It is clear that the risks associated with existing major plant and reticulation systems are very important and need greater consideration when planning projects because of the level of complexity when overworked and obsolete infrastructure is utilized. Typically these issues are never fully funded when new additions are built and may lead to disastrous outcomes if these essential service systems fail.

The hospital board, CEO or chief finance officer can appreciate an asset represents an increasing drain on resources. Budgets for operating and maintaining a hospital are now viewed as ballooning costs that provide little by way of increased return. Too often the estimated recurrent costs associated with new or refurbished hospital designs have been considered superficially at the design stage rather than becoming the platform for a serious forward look.

Buildings and infrastructure become a liability from the day they commence operation. Facilities represent both a resource and a liability and accordingly they are an amalgamation of benefits and risks with impacts that include contingent liabilities that have:

- High likelihood and high impact such as technological changes and increased community expectation & statutory regulations.
- Low likelihood but high impact such as war, environmental disasters, accidents and sabotage.
- Low impact such as changes in tenure, methods of procurement and corporate structure.

Risks termed contingencies are reflected in the project budgets. Allocations in new construction are generally 30-40% less than for refurbished projects based on experiences with difficulties in dealing with existing conditions such as asbestos, demolition, working in functioning facilities and poorly documented engineering services. Elements that need to be considered in the assessment of contingency requirements are set out below.

ELEMENT	Cost of provision	Operating Cost	Life cycle	Recurrent Impact *
Land	High	Low	Long	Negligible
Decanting	Medium	Low	Short	Negligible
Fees & Charges	Low	Low	Short	Negligible
Substructure	Low	Low	Long	Negligible
Structure	Medium	Low	Long	Medium
Cladding	Medium	Low	Long	Medium
Fitouts	Medium	Medium	Medium	Significant
Building Services	High	High	Medium	Most significant
Site works	Low	Low	Long	Medium
Commissioning	Low	High	Short	Significant

Table: Hospital contingency elements

* The recurrent impacts are considered only for non-clinical sectors.

When project estimates are found to be too high, cost reduction activities come into play such as reducing quality or contingencies for a project. While the net effect of these actions is to reduce costs, it may involve shifting of risk with undesirable long term consequences. What of these and other contingent liability risks that can be managed by good planning and design? Over the past several years, a number of disasters have occurred across the nation. Earthquakes, gas and electricity outages, contamination of water supply, fires, workplace shootings, and vandalism have all grabbed headlines. These events have led to an increased focus on being prepared for emergencies with a contingency plan.

FM is best placed to ensure best service delivery outcomes can be maintained by engaging with designers at the concept and design stage to ensure consideration is given to contingency planning. The arrangements to be built into the facility's structure and fabric to make sure robustness and the ability to remain operational under a variety of circumstances are fully examined. .

In order to deal with contingent liabilities and derive most benefit from the opportunities available at the design phases, it is necessary persons familiar with managing facilities to consider

- Environmental concerns
- Maintaining essential service requirements
- Maximizing reliability
- Obtaining low energy costs
- Providing for a healthier lifestyle

The facility management budgets may represent only a portion within a total hospital budget but its impact far outweighs the relative amount. Without electricity and potable water, nurses and doctors would be left with little to do. It is then puzzling how little consideration is given to facility management factors regarding risks associated with these elements when considering building service systems, material selection and equipment specification. When preparing designs for a new or refurbished facility the design team should report to the client on cost contingencies and liability factors including those set out above.

Commissioning

There are several commissioning processes that take place including the building procedures to get all physical facilities working as per the designs and another process involving he future occupants of the facility to become familiar with the day-to-day operations. FM should be involved in the planning of both processes and in attendance and also fully involved. FM will need to address normal operating conditions, dealing with alternative operating modes and coping with emergency and crisis situations.

It is the facility manager's responsibility to narrow the differences between occupants' needs and the designer's goals. Because user groups e.g. clinicians, are rarely able to understand fully the specifications and drawings in spite of any assurances they provide, FM can assist in bridging this gap and helping to learn how to understand plans and specifications through workshops and referral to built examples.

Commissioning involves a 'get well' period. This is known as the Defects Liability stage and starts with the building consultants, suppliers, contractors and sub contractors returning to the facility to adjust, fix or rebalance their systems following occupation. This is usually the time when the hospital administrators and staff are under great pressure to commence operation from the new facility while the consultants and contractors are trying to finish up their work and where budgets have been almost or fully expended.

Problems to be corrected that were overlooked at the design stage suddenly become potentially disastrous and affect the budget and program; and eventually penetrate a wide range of areas involved in the delivery of health services. Facility managers have a vested interest to achieve a positive outcome even when the building designs are being developed. Having a facility manager available to interpret drawings and designs will mean is invaluable to users and staff. The use of models and in some instances prototypes built at full scale can avoid costly and embarrassing mistakes at the time of hand-over. The commissioning stage is too late to undertake significant changes. If functionality and operational issues are not picked up prior to the commissioning phase then the issues may become compounded/costly/dangerous.

Post occupancy evaluations are important but come about too late and monitoring previous operating and management costs is rarely considered when designing a hospital. Determining the effect of the health facility design on patient health outcomes and assessing design applications based on real findings may be an agenda for the next ten or more years. Research is needed to determine the ways patients' clinical outcomes might be improved through designed elements of the healthcare environment.

Glitzy buildings tend to be feature-packed, but too often the features don't sit on top of a functional core. This can be evident when examining why monitoring and metering had been omitted restricting the ability to measure, manage & monitor costs. Introducing capital charging or determining performance becomes impossible. The designer may be completely unaware of the benefits of spending $20,000 on a controls upgrade rather than spending the same amount on a presentation model. How are we to deal with that?

Culture

How are the right people selected to work on hospital projects? Would you select a surgeon to perform your open-heart surgery based on the lowest price? Would you want a gynecologist even if they were the most highly regarded in the field performing your open-heart surgery? Surely you would want the best-qualified professional?

FM is a discipline that provides for the ongoing operation of hospitals and unfortunately has not achieved prominence until recently. In spite of the fact that facility management also has a major influence on the delivery of health services, the discipline is relegated to being one of a host of routine considerations when dealing with annual budgets or accreditation. Too often when cost reductions are required it is the facility management area that suffers the most.

The continued functioning of hospitals' energy, communications, environmental, safety and emergency systems is critical to the continuity of delivery of the health business. It is the thesis of this paper that discipline of facility management has not been given sufficient opportunity to participate in determining a hospital's capacity to deliver services.

The involvement of FM is critical in the early planning and design phases. This requires a cultural change in the mindset of those involved from functional briefing to commissioning to assess impacts on facilities and associated recurrent costs.

What is needed is a mechanism that cuts across the professional and institutional barriers. Currently design activities reside in a ghetto of politically astute project managers, enlightened architects and building services engineers who have never had to lug tools and spare parts up a restricted access designed for a yoga contortionist. Designers tend to talk up visions, the upsides, integrity and rich urban fabric and not necessarily talk about insufficient resourcing or meeting budget cuts while maintaining higher levels of compliance.

Design consultants directly affect hospitals in the quality of their water and air, the reliability of their electricity supply, the safety and quality of the environment in which health services are provided. Hence the selection of professionals for building projects needs to be based on the right mix of skills and knowledge which includes an understanding of the facility management sector. Are questions put to prospective engineers and architects about their knowledge of facility management issues prior to engagement? In considering necessary competencies, there needs to be an understanding of how building services are delivered and maintained following the design and construction phase.

Engaging an appropriate skilled professional provides greater value to the hospital by allowing for open dialogue to discuss the project thoroughly throughout the conceptual and design stages up to and including the operations. This results in better understanding between conceptual thinkers and those responsible for day-to-day issues of the building’s capabilities.

Cultural Change is needed. The outcome of recognizing the role of FM in addressing these and associated business continuity and contingency planning issues during the design phase will help ensure that increased reliability, lower recurrent operational costs and reduced replacement requirements will lead to better service delivery. New directives that now are to be considered include energy and sustainable conditions. FM has a prime position to provide source info and evaluate the impacts.

Establishing this new approach starts with the need to gain the input of Facility Managers who may be engineers, contractors, building operators, asset managers or administrators in the hospital. It is now important that the FM be regarded as a team member with direct access to the CEO/Board with status of importance equivalent to the DON, CFO and Head of Surgery.

Recognition of the knowledge base and corporate wisdom that resides in FM is long overdue and attention should be given to the contribution that can be made by the and maintenance personnel as seen in commercial sector’s e.g. manufacturing industry, hotel and entertainment complexes.

Educators are aware of the lack of knowledge in the design sector have now developed courses and programs to address these needs such as RMIT, FMA and Melbourne University. A range of educational opportunities has arisen in asset and facility management and the range of areas extend from short term to extended or degree programs for experienced people or tertiary qualified graduates.

Conclusions

The way to deliver projects is through meaningful interaction between the design and FM areas supported by long-term partnership. The payoff for this is improvement in productivity that can be measured in higher outputs/less staff absenteeism due to sickness/absence/churn. This must be nurtured and maintained as any relationship by being based upon communication, trust and co-operation.

Relationships between parties involved in the non-clinical sector of hospitals should strive to achieve high-class performance by adopting a culture dedicated to continuous improvement throughout the design pro, reducing unnecessary costs, shortening wasted time and increasing quality. It also means getting the design team to revisit the facilities they have helped create to see how well they have achieved the original intent.

The emphasis is to shift from price of design at tender stage to long term value and to extend the horizon kept in view from construction to lifetime.

There is a need to control, approve and review – but by whom and of what?

Balancing long-term benefits and short-term gains, undertaking determination of life cycle period and trade offs between recurrent savings and capital expenditure is carried out. The commitment to outcomes and making the best decision occurs at a variety of times and locations. It is important these decisions not take place as though the people making them operate as though they are in a vacuum. The decision makers need to be guided in part by facility managers.

The thesis put forward is that the FM having been identified as having a significant role and that there should be a number of opportunities for interaction at key stages to ensure the hospital re/development designs meets the ongoing needs of the patients, staff, visitors and other stakeholders.

The key to the involvement of FM in the design process is to have a Facility Manager position with the Hospital recognized, be it an Engineer, CEO, CFO DON, Manager or Administrator. The position should directly report on a regular basis to the Executive of the hospital on Duty of Care and governance issues. By this means it would be possible for the agency when engaging consultants to work on capital projects to have a principal point of contact with a representative who understands and deals with matters such as asset condition and its inherent issues of compliance and functionality, negotiates for annual budgets to ensure service delivery can be maintained and sustained and prepares reports needed to continue operations such as accreditation, annual statutory reporting.

FOOTNOTES

*1 Refer to DHS sites on Generic brief & Capital Development Guidelines on the following address: http://www.dhs.vic.gov.au/capdev.htm

*2 Refer to the policy set out in the Victorian Governments Asset Management Series.

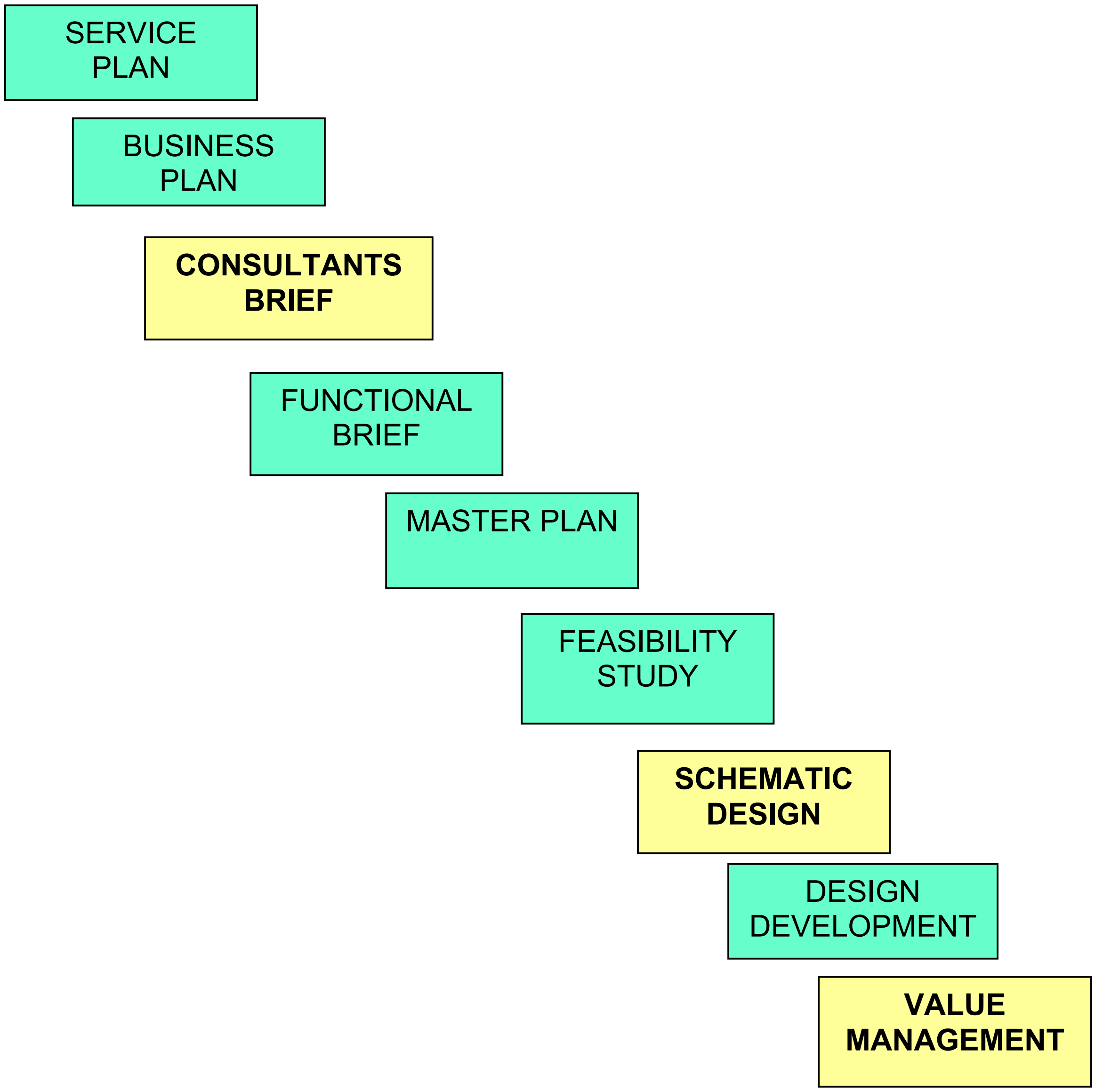
*3 Refer to the Construction Industry Institute study by researchers from CSIRO, QUT and SAU 'Benchmarking Energy Use in Victorian public hospitals'.

*4 Refer to Attachment 2 - Table of Functional Areas: The components of a hospital can be viewed as functional areas such as an office, warehouse (stores and archives), engineering, laboratory, retail and hotel facilities as well as specialized areas (operating theatres). Each of these building types has an operating cost, life cycle and contingent liabilities that vary in accordance with intensity of use, hours of operation or performance requirements and the maintenance regime. CEO's and hospital boards need to recognize these functional areas have differing needs that arise at a variety of times.

*5 Refer to Partnerships Victoria on the Victorian Government's Department of Treasury & Finance website.

Attachment 1

Diagram of Stages in the Hospital Design Process
Prior to Documentation and Tender.

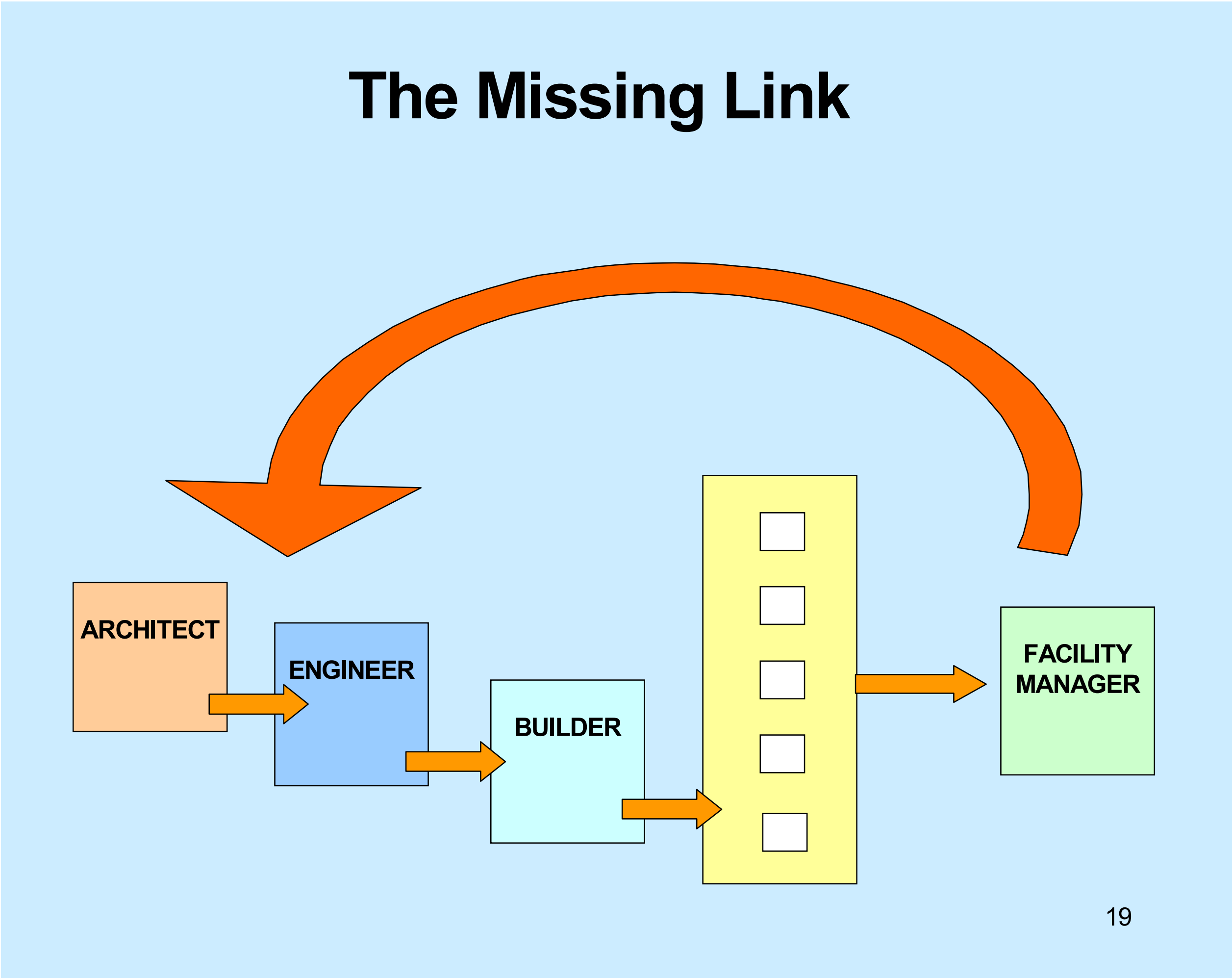


Attachment 2

General Wards/Inpatient	Medical/Surgical Inpatient Pediatric Inpatient Psychiatric Inpatient Aged Residential
Administration/Support	Administration Domestic Services Information Services Linen Services Public Amenities Residential Accommodation Staff & Public Amenities Supply Services
Clinical/Specialist	Accident & Emergency Ambulatory Care Cardiology Coronary Care Critical Care Food Services Medical Imaging Obstetrics Operating Suite Radiotherapy Sterile Processing Services
Infrastructure	Structure/Shell/Building Fabric Site Engineering/Central Plant Trunk Reticulated Systems Circulation/Travel
Day Treatment	Allied Health Day Surgery Unit Endoscopy Unit Pathology/Mortuary Pharmacy
Education & Research	
Miscellaneous	Child Care Center Community Health Care
Commercial	Private Hospital Kiosk/Catering Consulting Suites (Including Private) Car parks (Including Private)

Table: DHS Functional Areas

Attachment 3



Development of an Asset Maintenance Strategy for a Hospital Complex.

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Abstract: *Real estate maintenance is an important factor in maintaining the facilities' ability to serve their purpose. Maintenance should be based on a strategy that aims at maintaining the real estate's ability to serve its purpose as desired throughout its entire life span. The maintenance plans should cover the entire real estate or group of buildings, in which case the most essential factor is not the minimisation of costs but the optimisation of financial investments needed for the maintenance at the desired service level.*

This presentation focuses on a hospital comprising a large group of buildings, for which a maintenance strategy has been compiled. After the strategy had been compiled, it became necessary to further study the real estate because of problems related to indoor air quality. This provided additional information to support the compilation of the strategy, with regard to the significance and importance of the factors analysed in the strategy. In another, corresponding target, the analysis also covers the intensity of use of very valuable technical equipment and its significance for the real estate's overall economic efficiency.

This presentation will describe the factors that led to the compilation of the maintenance strategy, the compilation process and the factors that were considered during the process. The implementation of the strategy is also addressed as well as any tools used therein (such as web-based maintenance manuals).

Keywords: Real estate business, maintenance strategy, ICT technology.

Background

Real estates are elementary operational resources for companies and communities and have a key role among their operational prerequisites. The most essential task of a real estate is to create an optimal working environment for all the activities that take place in it. The service ability of governmentally owned real estates, such as hospitals, grows in importance, as the limited resources no longer allow inefficient real estate keeping.

Real estate maintenance

Real estate maintenance is part of the real estate business' strategic mission. Maintenance should technically guarantee the real estate's ability to serve throughout its entire life span. Thus, it does not mean technical maintenance alone but also the optimisation of service ability maintenance and the prevention of disturbances in advance.

Maintenance strategies

The maintenance strategy of a real estate or a group thereof should be based on the owner's real estate strategy and, on the other hand, also implement that of the user organisation if different from the owner. These strategies define the principles and goals that should be followed within each premises.

The hospital building's maintenance strategy

Maintenance strategy

Repair work programming provides information about optimal means of reaching the repair goals with regard to the entity. Programming refers to the selection and timing of measures aiming at the future and the adjustment of available resources in such a manner that the goal will be reached. Figure 1 presents the factors that cause the need for repairs in real estates.

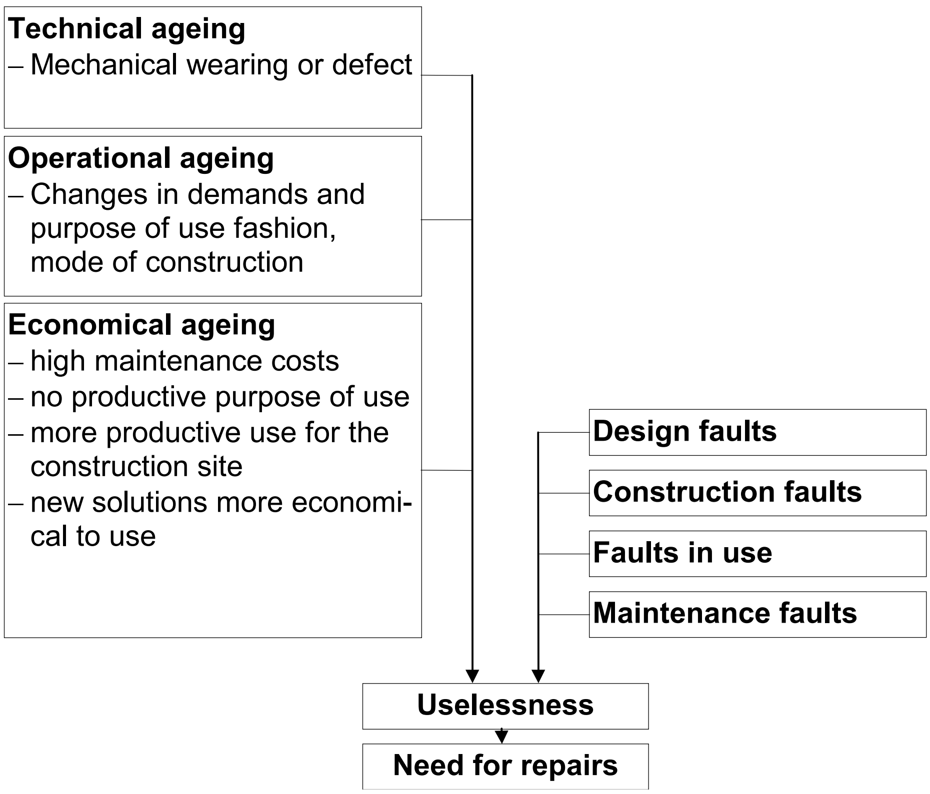

Figure 1. Causes for repair needs

The factors that have proven to be the main problems are the different ages of the existing construction stages, their weakening condition, some surprising repair needs and the timing thereof. As the available resources are limited, not all of the necessary repair measures can be carried out immediately. Thus, the measures must be programmed with a time-span of several years.

The main goals of repair work programming are to guarantee the operational conditions and keep the building's value as high as possible. Defects and the unexpected costs arising thereof should be prevented in advance. Repair needs should be prognosticated. A repair programme is to be drawn up on the basis of the operational and structural alteration needs and the special demands of the real estate, within which the maintenance assignments are to be carried out. The alteration needs and the user's perspective will be taken into account by regularly informing the owners of the building's condition and the repair needs arising in the near future.

The repair plan must be flexible and adjust to the changes that take place in the hospital's operational environment.

Basic information on the target building

The construction of the hospital building that is being analysed here began in 1969 with the construction of the technical premises and the laundry building. The main part of the real estate was completed during 1971-1975. The overall floor area of the premises intended for hospital use is 152 386 m^2. This information is based on the figures in the real estate data system.

According to the annual report, the hospital employed 3 490 people in 1997. In 1997, the total number of in-patient care days was 276 822 and that of outpatients was 301354.

The task of real estate maintenance (the maintenance unit) is to guarantee uninterrupted hospital operations and preserve the appropriate conditions thereof. In 1999, the real estate maintenance unit employed a total of 64 people, see Table 1.

Technical Manager	1
Construction Office Manager	1
Building Maintenance	9
Regional maintenance	3
Carpenting workshop	8
HPV Office Manager	1
HPV maintenance	12
Electrics Office Manager	1
Electrical maintenance	7
Tele connections maintenance	8
Control device maintenance	5
Drawing office	2
Control Centre	6
Total	64

Table 1. Employees in the Real Estate Maintenance unit in 1999.

The number of real estate maintenance employees has constantly decreased. The indicators concerning real estate maintenance operations (of 1998) are as follows:
- Real estate maintenance working hours per care day: 0.481
- Real estate maintenance working hours per floor area: 0.874

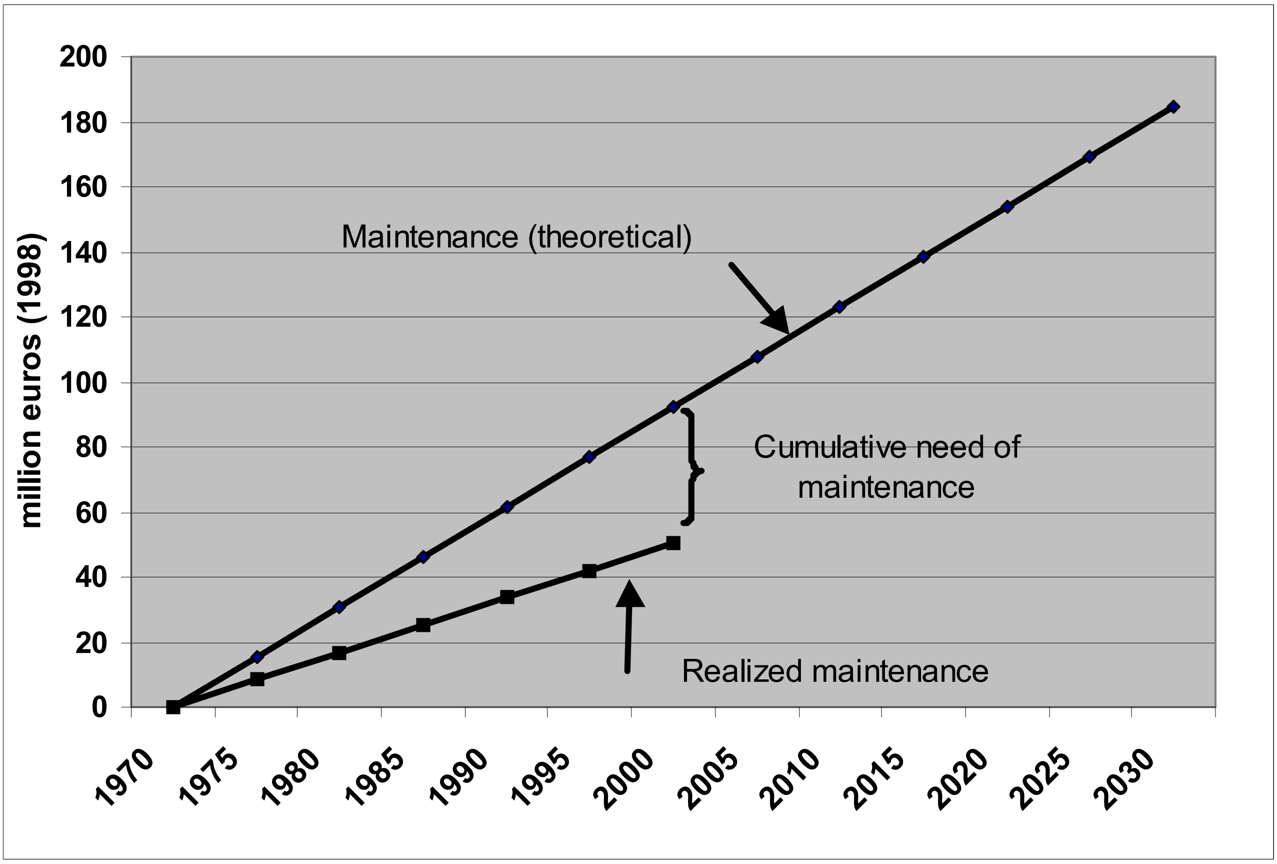

Figure 2. Calculated (theoretical, equal distribution) costs for the entire life-span of the building and realised maintenance.

Real estate maintenance strategy (REMS) options

The aim of this study was to define the hospital's real estate maintenance strategy (REMS) for 1999-2030, on the basis of the building's current technical condition (figure 2) and the hospital's real estate maintenance organisation. This study focuses on three optional variants.

Option 1: the real estate will most likely not be used after 2030. The minimal operational conditions are maintained in the real estate. The real estate will be given up in 2030.

Option 2: secure the real estate's present functions, which means removing the repair needs arising from the ageing of construction parts and technical systems by maintenance measures. Option 2 secures appropriate conditions and, if this option is followed, the real estate can be modernised in 2030 to correspond to the demands of the time.

Option 3: prepare for changes in the operations by applying the modernising maintenance method. This means an increase in the building's quality level.

The results of the studies

The following section presents a summary of the results of the studies and analyses (figure 3).

Option 1, the repair activity costs will total approximately 1,7 million € per year for the entire planned period. The costs will remain at the present level (maintenance expenses in 1997 and 1998). If Option 1 is applied, the hospital operations can technically continue but disturbances in the operations are likely to arise.

Option 2, the annual maintenance costs will total approximately 3,4 million €. By applying this strategy, the latent repair debt can be settled and the real estate will still be in good operational condition in 2030.

Option 3, takes into account the changes in the hospital operations that are to arise in the future. The maintenance activities will prepare for modernisations by applying suspended floors, reserving extra capacity for the building systems and choosing the components on the basis of life-span economics. With Option 3, the annual maintenance costs will total approximately 4,5 million €.

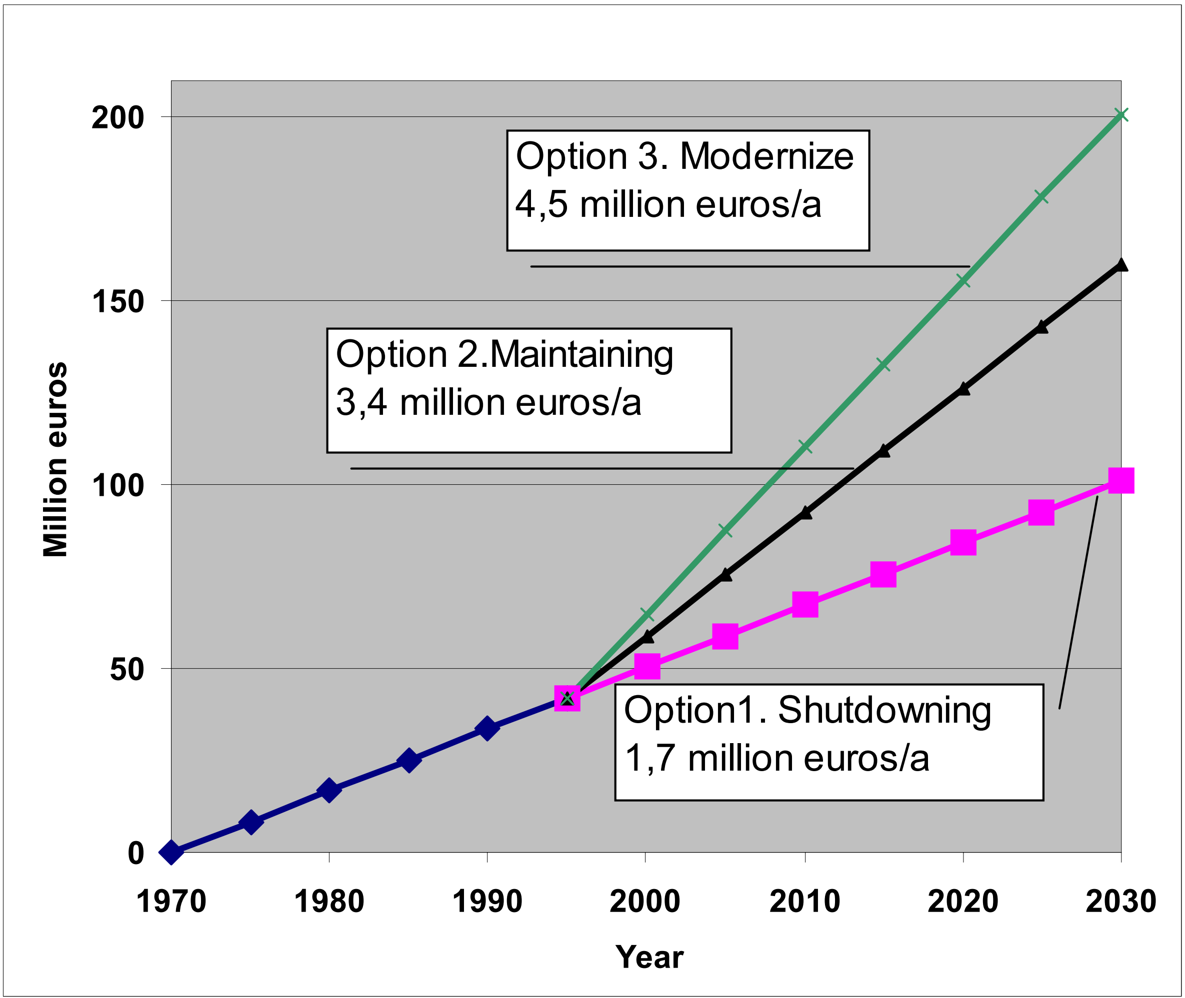

Figure 3. Different maintenance strategy options (cost level of 1999)

Electronic maintenance manual as a maintenance strategy implementation tool

Maintenance manuals

Since 1998, the Finnish construction legislation requires the compilation of maintenance manuals for new real estates. The main tasks of maintenance manuals are the following:

- The maintenance manual is a tool for the real estate's life-span management:
- The desired living and operational conditions are created.
- The desired life-span is reached with optimal costs.
- Sensible energy economics.
- Maintenance becomes systematic and predictable.
- Supports competition in maintenance operations, real estate maintenance agreements, as well as maintenance and repair operations and quality assurance thereof.

Implementation of maintenance manuals

The maintenance manual can be implemented in printed format, as computer files (e.g. Excel tables) or a web-based product via the Internet. The following presentation describes the basic structures of a web-based maintenance manual implemented by VTT to several dozens of office buildings (figure 4). From empirical point of view a web-based system is very suitable for hospital buildings.

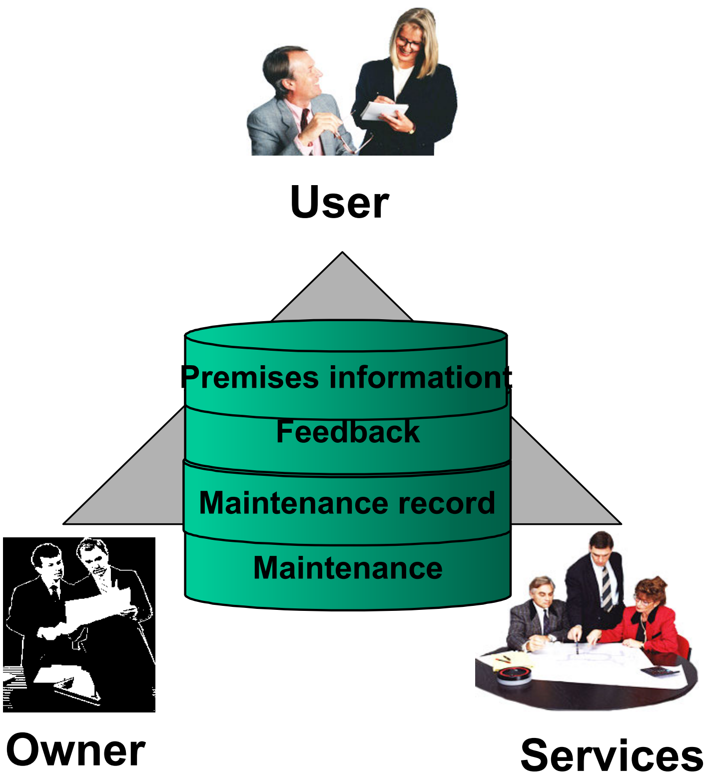

Figure 4. The maintenance system (manual) gathers the operators into one network.

The premises information consists of the following issues:
- basic information about the real estate
- general descriptions of the structures and systems
- performed surveys and studies and contact information

The feedback includes the following information, bringing benefits to the operators:
- user feedback as an integral part of the service, facilitating the communication between the real estate's stakeholders
- feedback will be stored as historical data (easy to analyse)
- part of the real estate maintenance quality assurance

The real estate maintenance includes the following issues:
- intended conditions
- responsibility limits for real estate maintenance
- real estate maintenance service products and maintenance calendar
- localisation drawings and areas of influence

The conditions management comprises the measures included in the programmed maintenance and the maintenance strategy, and the supporting information:
- goals for operational time and maintenance periods
- repair history and follow-up of the warranty period
- list of documents

Summary

With the web-based maintenance manual, the real estate's maintenance strategy can be efficiently implemented in a manner bringing benefits to all of the parties (the owner, users, maintenance personnel). At the same time, co-operation will be easier and, according to prior experiences, clearly improved. In addition, it can be used for the production and compilation of support materials for the correct use of the premises and the inclusion of user feedback in the operations.

With the system, a common data archive that is easy to maintain will be formed. Information will be easy to find and it will also cumulate, contributing to the principle of constant improvement.

The system's usage rights can easily be defined in the desired manner, and its use is not tied to certain times or places (always available).

Another clear benefit is the fact that the use of the web-based browser is easy and clear, and the database-based solution also enables other user interfaces (mobile phones, wireless terminals, etc.).

In addition, the IT solutions are of common nature and inexpensive. The system also possesses clear image-related benefits, as IT solutions are considered "contemporary real estate maintenance".

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Attitudes Towards Prefabricated Housing: Breaking Away From The Past

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Abstract:
The Latham Report (1995) identified a need for greater teamwork within the UK construction industry. The Egan Report (1998) took this principle further and in particular posed a series of challenging targets for the UK house building industry. These targets were focused around greater use of innovative techniques derived from manufacturing, and included the increased use of standardisation, prefabrication and "whole house thinking". In response to these challenges a number of Housing Associations examined the way they procured their new social housing and identified large panel, factory based timber prefabrication as one possible means of addressing the challenges posed by Latham and Egan. However, in proposing this solution the Housing Associations were acutely aware of the history associated with the use of prefabricated timber housing systems in the UK and in particular the long-term maintenance and refurbishment issues.

This paper reports the initial findings from a research programme, funded by the Housing Corporation, which aimed to establish current attitudes towards prefabricated housing systems and identify gaps in knowledge that could undermine their effective maintenance. The paper concludes that attitudes have changed over the past 15 years with all the stakeholders exhibiting a more positive attitude than had been reported previously. In addition the paper identifies key areas of knowledge and skill required within the UK workforce if modern prefabricated systems are not to fall victim to the mistakes of the past.

Keywords: Prefabricated Housing; Attitudinal Survey; Maintenance and Refurbishment.

BACKGROUND TO STUDY

The need for innovation in the construction sector to improve both product and process is widely accepted. In the UK house building has often been characterised as traditional, site based and masonry dominated, partly as a function of perceived consumer conservatism but also as a consequence of conservative attitudes among mortgage institutions, a reluctance to invest in innovation, and risk aversion within the construction sector itself. Whilst there are some notable exceptions the Egan report (1998) identified the weakness of this situation and advocated new approaches to both production and procurement to secure better quality, lower cost, safer and timelier production.

The Latham Report (1995) identified a need for greater teamwork across clients, contractors and consultants and advocated a move towards more Partnering based contracting. Egan took this principle further, posing a series of challenging targets to the industry and advocating a greater use of techniques derived from manufacturing, including standardisation, prefabrication and "whole house thinking". In addition, the

Egan report identified five key drivers that needed to be addressed if the UK construction industry was to benefit from the radical change experienced in other industries. Whilst these drivers were considered applicable to all sectors of the construction industry Egan specifically identified house building for the social rented sector as an area where significant improvements in performance could be achieved. The Rethinking Construction Task Force argued that, as new social housing was commissioned by a few major clients, this should provide the main opportunity for improvements in house building performance.

Specific responsibility for procuring new social housing in the UK resides with Registered Social Landlords (RSL's) however the majority of the funding for new development comes from the Housing Corporation via an annual bidding round. In the annual bidding round individual RSL's submit development projects which, following evaluation, are either adopted as part of the Annual Development Programme (ADP) and funding is allocated, or are rejected. Although the details of the bid process are not relevant to the present paper, the fact that from 2000 onwards a proportion of the ADP had to be deemed to be Egan compliant is.

In the 2000/2001 bidding round 10% of the construction cost element of the ADP had to be procured using the Egan principles set out in Rethinking Construction. Further, in subsequent bidding years this percentage was set to rise until by 2003/2004 the whole ADP would be 100% Egan compliant. As one aspect of this move to full Egan compliance the Housing Corporation introduced the Kick-start Programme (The Housing Corporation, 2001) which ring fenced approximately £80 million of Social Housing Grant to support prefabrication based projects over the two funding years 2001 - 3. In order to bid for this funding RSL's had to identify new development opportunities that utilised one of a pre-selected range of innovative (offsite fabricated) house building technologies.

The application of offsite fabrication methods to the UK house building industry has been the focus of considerable attention over the past few years. The Housing Forum has produced a number of reports in an attempt to promote the technology amongst those responsible for developing new housing. The Housing Forum Demonstration Projects Report (Housing Forum, 2002) provided detailed case study information on the performance of a large number of RSL focused development projects whilst the Homing in on Excellence report (Housing Forum, 2002) clearly identified the arguments for offsite fabrication and the barriers to implementation that need to be overcome within the UK mass housing market. With respect to the latter, the past UK experience of non-standard house construction and the inadequacy of current levels of training / skills amongst the workforce were identified as major obstacles that needed to be addressed if offsite fabrication was to have a major impact on the UK house building industry. These findings were similar to those reported previously by Chandler (CIB, 1988) who examined a range of maintenance issues (including defect recognition and repair evaluation, knowledge and skill of professional and site staff and whole life performance of building components) as part of the Construction Industry Training Board Tern Project. Chandler concluded that research was required not only into the technology of repair for non traditional housing but also into the whole decision making process.

The current project aimed to address these issues by examining whether past (adverse) UK experiences of prefabricated housing and / or inadequacy of current levels of training / skills amongst the workforce were actual rather than perceived barriers to the current implementation of prefabricated housing amongst RSL's, their professional advisors and their house building contractors. The project was funded by the Housing Corporation through their Innovation and Good Practice Grant scheme.

Details of the Research Project

Initial interviews undertaken by the research team with senior RSL development staff had identified that, whilst the majority of RSL's had responded enthusiastically to the broad challenges posed by the Egan agenda (e.g. partnering) there were a number of specific issues that had to be addressed if off-site prefabrication was to become their preferred method of house construction. Amongst these issues was the need to examine the extent to which attitudes towards prefabrication amongst the stakeholders to the social house building process could undermine development opportunities. Within this context, the current project sought to examine the extent to which;

- a lack of skills to effectively project manage prefabricated development projects (both during design and during construction) could prejudice good design and construction; and
- a lack of understanding about key aspects of effective maintenance of prefabricated buildings (e.g. the importance of intact vapour barriers in timber or steel framed buildings) could prejudice good maintenance and potentially undermine warranties.

Whilst either of these issues alone would prove problematic to RSL's as they sought to promote the greater use of off-site prefabrication, the combination of the two together would cause concerns to valuers and funders, and ultimately prejudice mortgageability. This paper reports the results from the maintenance and refurbishment part of the project.

Details of the Questionnaire

Following the review of previous studies (outlined above) and a telephone interview with Professor Ian Chandler, a semi structured, telephone based interview questionnaire was developed to address the attitudes and experiences of the five key professional (Built Environment) stakeholders sets who, through the inputs they provide to the housing development decision making process, have a significant impact on whether prefabricated housing solutions would be adopted ahead of more traditional ones. In developing the survey instrument consideration was given to the need to distinguish between the pre-fabricated housing systems identified in the Kick-Start programme. The survey matrix for

	RSL Developer	Architect	Contractor / Producer	Maintenance	Implementers
Timber Frame					
Advanced Timber Panel					
Steel Frame					
Concrete Frame					
Composite Construction					
Structural Integrated panel					

Figure 1. Survey Matrix

the project is shown in Figure 1. Results for this paper have been drawn from the responses provided by the RSL development team and their professional advisors, (i.e. Architects, Surveyors, and Implementers / Employers Agents).

The survey questionnaire was developed in five sections, contextual, procurement, project management, skills audit and maintenance issues. Results for this paper have been drawn from the contextual, procurement and maintenance sections.

Summary of main findings

Details of Respondents

Initial contact was made with selected representatives (who, through a review of recent housing development projects it was believed had been involved in Egan compliant schemes) of the various stakeholders to the social house building process.

Of the 37 organisations approached 19 participated in a formal telephone interview (Figure 2). Those interviewed ranged from Chartered Surveyors through Development Managers to Managing Directors of RSL's. The Chartered Surveyors answered questions on maintenance issues only.

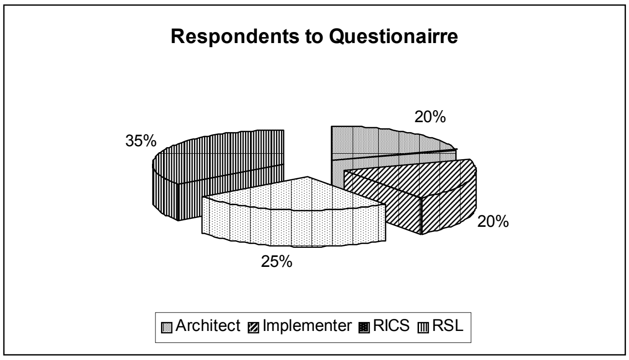

Figure 2. Details of Respondents

Each interview was conducted using a standard telephone protocol in which the interviewer administered a semi-structured questionnaire. All interviews were recorded on audio tape. All interviews took place during April and May 2002.

Egan Compliancy

Eighteen of the 19 respondents interviewed had been involved in the development of at least one Egan compliant housing scheme (one Chartered Surveyor had no experience of Egan compliant housing). The Egan compliance criteria for each scheme are shown in Figure 3. The schemes ranged in size from 8 to 400 house units. In all data was provided on 19 Egan compliant schemes.

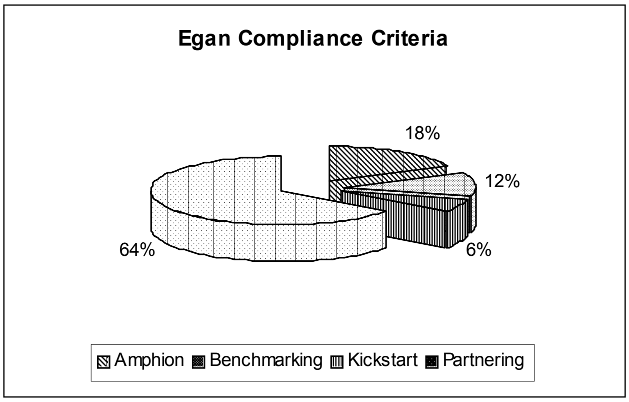

Figure 3. Egan Compliance Criteria

Whilst the majority of the Egan compliant schemes had utilised pre-fabricated construction techniques 6 had not. In subsequent analyses the responses from the implementer that had not used a pre-fabricated form of construction were included in the project management and skills audit sections but not in the procurement and maintenance sections. The responses from the Chartered Surveys and the RSL that had not used a pre-fabricated form of construction were only included in the maintenance section.

Of those that had used a prefabricated form of construction the overwhelming majority had used timber (Figure 4). No respondents had used either Composite Construction or Structural Insulated Panels. The overall consensus from the respondents was that the schemes that they had developed had either met or exceeded their original expectations (Figure 5). The respondents were particularly pleased with the speed of construction (which in many cases was much faster than had been expected) and the quality of the finished product (which was generally as good as the manufacturers had claimed in their literature. By way of contrast, those respondents who generally dissatisfied with the performance of the prefabricated construction cited unrealistically estimates of speed of construction and the subsequent problems with programming as the project ran late as the primary reasons for their level of dissatisfaction. Finally, one RSL noted that, whilst in general they were more than pleased with the finished product they had not envisaged such high amounts of waste from the packaging.

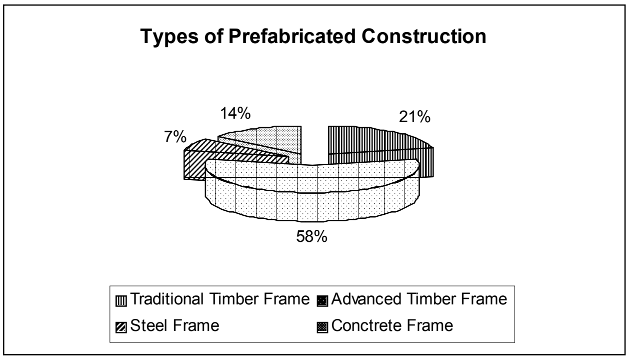

Figure 4. Types of prefabricated construction

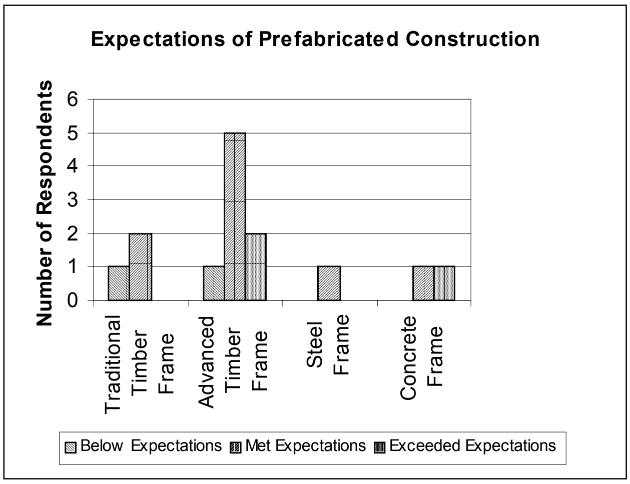

Figure 5. Expectations of Prefabricted Construction

Attitudes towards Prefabricated Housing

In assessing the attitudes towards Egan compliant prefabricated housing the sample were divided into two groupings, those who had been involved in the initial procurement decision making process (the RSL's, their architectural advisors and their project implementers) and those who would be responsible for future maintenance / refurbishment of the housing stock (the RSL's their architectural advisors and their maintenance professionals). The following sections outline very briefly the views of those responsible for procurement (as far as they expressed an opinion on maintenance / refurbishment issues) and in more detail the views of those responsible for future maintenance / refurbishment of the housing stock.

Procurement

Three implementers, 3 Architects and 5 RSL's provided information about the procurement processes they had used for their Egan compliant schemes. The results are summarised in Table 1. Whilst there was some variation amongst the respondent groupings as to the absolute importance of the various issues listed in the questionnaire, all the parties generally agreed on their relative importance to the decision making process. Overall, establishing value for money, convincing funders, the durability of components, the management of risk and ease of future adaptability were all rated as either very or extremely significant to their decision making process (Note: the exceptions to the general rankings were Architects who considered acceptability of the housing to tenants to be very significant and RSL's who considered convincing their board to be very significant.) Amongst those issues considered to be generally least significant were resistance of staff and issues relating to future maintenance. It would appear from these results that those responsible for procurement were focussing primarily of the up-front issues relating to cost and design rather than the whole life issues relating to maintenance and refurbishment. If this is indeed the case then the authors are concerned that this may result in a repeat of the problems associated with UK prefabricated housing of the 60's and 70's.

Issue	Ranking			
	Overall	Implementer	Architect	RSL
Convincing the board	9	10	10	4=
Establishing value for money	1	1=	1=	3
Management of risk	4=	4	3=	4 =
Resistance of staff	11	11	11	11
Acceptability to tenants	8	9	3=	9
Convincing funders	2	1=	8=	1
Durability of components	3	3	5=	2
Ease of future maintenance	7	8	8=	7=
Cost of future maintenance	6	5=	5=	7=
Ease of future adaptability	4=	5=	1=	4=
Cost of future adaptability	10	5=	5=	10

Table 1 Relative Importance of Issues to the Procurement of Prefabricated Housing (1=most important)

Maintenance

The evaluation of the risks associated with innovative forms of construction was one of the major issues to emerge from the experiences that UK maintenance managers gained dealing with the prefabricated housing of the 60's and 70's. These risks manifested themselves in a number of forms including:

- the ability to solve design errors after construction;
- the quality of the design team and of design details;
- the quality / durability of the materials used;
- the consequences of poor site practices;
- whole life performance including
    - the evaluation of maintenance and repair strategies;

- the ability to resolve maintenance problems; and
- the ease of future adaptability of the building.

The current questionnaire sought to establish whether these issues were still of concern today and, if they were, to identify specific gaps in the knowledge / skills which would need to be addressed if they were to be overcome. Seven RSL's and 6 of their professional advisors addressed this section of the questionnaire.

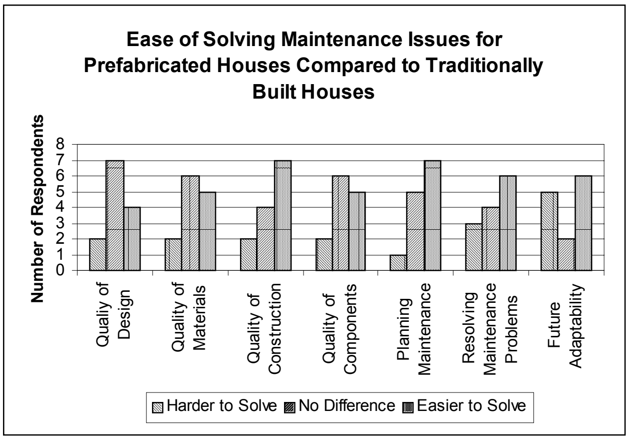

Figure 6. Ease of Solving Maintenance Problems

The majority of respondents believed that maintenance issues would either be easier, or at least no more difficult to solve, for prefabricated housing compared to traditional housing (Figure 6). This view was particularly pronounced amongst the RSL respondents who in general exhibited a more positive attitude towards prefabricated housing than their professional advisors. Where opinions differed was in relation to poor quality of design and materials (where RSL's very strongly believed that there would be no difference between prefabricated housing compared to traditionally built housing whilst their professional advisors were divided on the issue) and the ability to resolve and plan future maintenance activities (where, whilst the professional advisors believed that the planning of future maintenance actions would be easier to solve for prefabricated housing compared to traditionally built housing the RSL's were less convinced. Note: Also within this category, there was a general opinion that any problems associated with timber frame construction would be easier to solve than for the other methods of prefabricated construction.).

Finally, the data from this section of the questionnaire would appear to suggest that the traditional concerns associated with the maintenance of prefabricated housing in the UK are diminishing, particularly where they relate to the overall quality of the finished product and the ability to plan a maintenance programme. The one area where there is concern is the future adaptability of the prefabricated houses. This issue will be examined in greater detail later in the project as it would appear to be at odds with the views of those responsible for the procurement of prefabricated housing.

Knowledge and Skills Map

The final areas addressed by the questionnaire were the knowledge and skills that the RSL's and their professional advisors believed were necessary for the effective maintenance of prefabricated housing. Two knowledge/skills maps are presented in this paper, one relating to maintenance managers and the other to maintenance operatives. Again, 7 RSL's and 6 of their professional advisors addressed this section of the questionnaire.

Maintenance Managers

There was clearly a difference of opinion between the RSL's and their professional advisors about the level, although not the composition, of the knowledge and skills required by those responsible for managing the maintenance of prefabricated housing (Figure 7). Without exception the professional advisors rated all the areas of knowledge and skills as more important than did their RSL clients. Further, on examination of the open text questions contained within this section of the questionnaire it was apparent that the professional advisors were clearly of the opinion that currently maintenance managers were neither qualified, nor had sufficient experience of prefabrication, to effectively maintain these units (Note: it was unclear from the responses as to whether the professional advisors believed that their staff lacked the necessary knowledge / skills to effectively manage the maintenance of prefabricated housing or whether they were referring to the RSL maintenance staff. This will be investigated in more detail later in the project). The knowledge and skills that were considered essential by both the RSL's and their professional advisors were:

- a detailed knowledge of the maintenance actions required for each of the building components;
- a detailed knowledge of the known maintenance issues associated with the prefabricated system being used;

In addition, the following were considered desirable:

- a detailed knowledge of the expected whole life performance of the building components;
- specialist training skills (above those normally associated with traditional housing schemes) in order to identify and evaluate potential repair options.

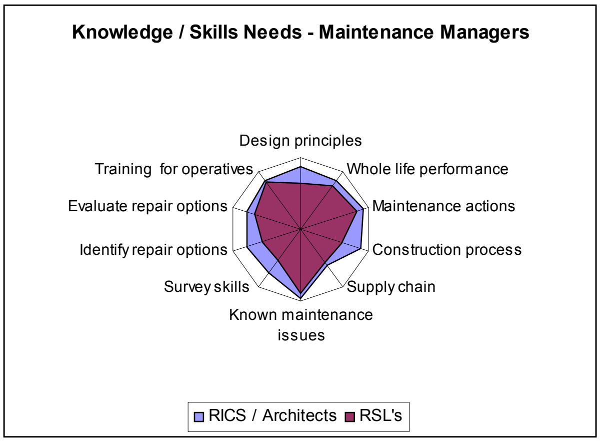

Figure 7. Knowledge / Skills Needs for Maintenance Managers

Maintenance Operatives

Neither the RSL's, nor their professional advisors, rated any of the knowledge / skills identified in the questionnaire as essential for maintenance operatives (Figure 8). With regard to the composition of knowledge / skills required by maintenance operatives, the RSL's generally rated specialist training (survey skills, identifying repair options and evaluating repair alternatives) of more importance than knowledge of the product, whilst their professional advisors rated knowledge of the

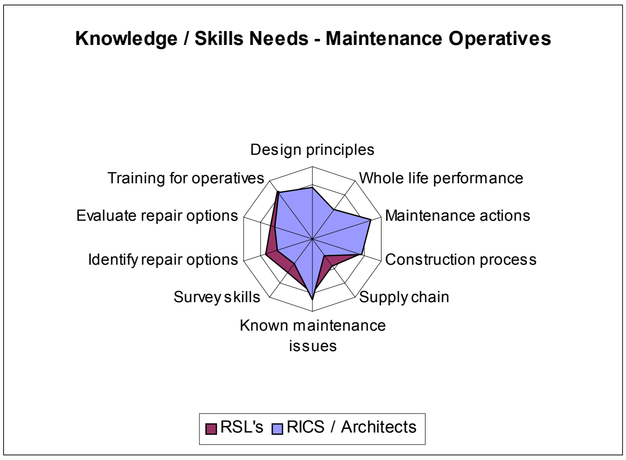

Figure 8. Knowledge and Skills Required by Maintenance Operatives

product more important than specialist training. There was general agreement amongst the respondents that it was desirable that maintenance operatives had a detailed knowledge of the maintenance actions required for each of the building components and a detailed knowledge of known maintenance issues associated with the prefabricated system. The main reasons cited by the respondents for these views was the difficulty of obtaining good quality operatives to work on any aspect of maintenance let alone to try to obtain operatives with specialist skills to work on prefabrication.

Conclusions

It would appear from the results of this study that attitudes towards prefabricated housing in the UK are changing with the perceived levels of risk diminishing.

The following tentative conclusions have been drawn from the study.

- Those respondents who had been involved with the development of Egan compliant schemes using modern prefabricated house systems generally found that they met or exceeded their expectations, particularly with respect to the overall quality of the product and with the speed of construction. Where the prefabricated housing systems did not meet expectations it was generally as a result of unrealistic claims being made by the product developers (particularly concerning construction time) which were subsequently not achieved.
- When procuring prefabricated housing, issues relating to finance, cost and design (including the ease of future adaptability) were generally considered more significant than those relating to whole life performance.
- Both the RSL's and their professional advisors believed that potential maintenance problems which may arise with prefabricated housing would be easier or at least no more difficult to solve than those associated with traditional brick construction. Where there was a difference of opinion was in the strength of this belief with RSL's generally exhibiting a more positive attitude towards prefabricated construction than their professional advisors. The one area of concern was the ease of future adaptability of the prefabricated house systems.
- Whilst there was a difference of opinion between the RSL's and their professional advisors over the level of knowledge and skills required to effectively management the maintenance of prefabricated housing there was general agreement over the composition. A detailed knowledge of the known maintenance issues associated with each prefabricated system and the maintenance actions required to address the issues were considered essential for effective maintenance management. Further, the professional advisors were of the opinion that currently maintenance managers were unqualified to, or had insufficient experience of prefabrication systems to, effectively maintain them.
- The RSL's and there professional advisors had different views regarding the knowledge and skills required by maintenance operatives with the RSL's rating specialist training of more importance than their

professional advisors who in turn rated knowledge of the product of more importance than the RSL's.

Future Work

This project is still ongoing with further interviews of development / maintenance staff and with the various industry wide stakeholder groups being planned. These interviews will attempt to consolidate the initial conclusions outlined in this paper and will address the specific knowledge / skills gap in much more detail in order to develop the educational and training materials that are required by those developing and maintaining Egan compliant prefabricated housing in the UK.

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MANAGING (CHANGE IN) THE BUILT CULTURAL HERITAGE

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ABSTRACT
In recent years the issue of the relationship between built cultural heritage and sustainable development has reinforced the need for a conceptual and practical approach to conservation planning which is both more integrated and more accepting of the need for the effective management of change. One component of the response to this challenge has been the development and promotion of the value of conservation plans. The drivers for the development of conservation include the desire of English Heritage to promote a model which will help achieve its goals of a more holistic integrated and participatory approach to caring for the built cultural heritage.

The main purpose of a conservation plan is to identify "Significance and Vulnerability." Conservation Plans are usually considered to be the precursors to more detailed management/ action plans.

This paper will review the emergence of the idea of conservation plans in the UK including the influence of ideas and approaches developed in Australia. It will consider why and how the idea has been developed in the UK and discuss some initial perceptions of the worth of conservation plans.

BACKGROUND.

In an address to the first Northern European Regional Conference of the Organisation of World Heritage Cities in 1988, Pam Alexander, the then Chief Executive of English Heritage stated that "… it is clear that the management of change in our cities is one of the most important political and intellectual challenges facing us at the end of the 20th Century". She went on to suggest that managing the historic environment of cities - their cultural landscape – necessarily forms part of this wider debate and that this management " has to be done with great sensitivity, and in a sustainable way, to meet todays needs without compromising the ability of future generations to meet theirs. This will only be possible with widespread support and understanding." She observed that legislation alone, even with funding to support it, would not be sufficient. What must come first, and is more powerful, is a shared understanding of what is interesting or important about a city, what gives it its identity. She went on to emphasise the importance of Management Plans for all World Heritage Sites as a means of reconciling differences and resolving future pollicies on a basis of partnership, but observed that "Plans were not an outcome in themselves but part of an overall process, requiring implementation by partners to be effective. In essence they were about the management of change in a sustainable way"

Although Pam Alexander was talking specifically about World Cultural Heritage Cities and sites, the acknowledgement that conservation of the built cultural heritage is about managing change, and that this can be achieved in part by "management plans," has been the focus of much discussion, and some action, in the UK, in recent years.

In part the development of Conservation Plans is an acknowledgement that heritage, or at least the majority of it, cannot and perhaps should not be preserved untouched. In reality conservationists have long recognised this, (and the associated issue of trying to integrate heritage into the wider dynamics of urban evolution), both from a pragmatic viewpoint but more importantly from a philosophical perspective: the term conservation can be seen to as an holistic concept which implies identifying what is culturally important about a place and protecting those values whilst allowing the place to change and evolve i.e. conservation is a dynamic rather than static process - it is about managing change, albeit in the context of "do as little as possible, as much as necessary" (Australia ICOMOS1979). Indeed an English Heritage discussion document (English Heritage 1997) explored the possibility of conceiving the built cultural heritage as consisting of:

> critical environmental capital – those elements of the historic environment that "are sacrosanct, and which we expect to be able to pass on virtually unchanged to our successors.
>
> tradable environmental capital - those elements of the historic environment " which society may have to be prepared to sacrifice in return for adequate benefits of other kinds"
>
> constant environmental capital - (the majority of the built cultural heritage) where " some changes may be sustainable if the overall character of the environment is unchanged.

The Management Guidelines for World Cultural Heritage Sites (Feilden and Jokilheto, 1993.) reflects this idea that the evidence of change and evolution is part of the value of historic sites in its reference to an 'Historical Time Line'

It suggests that the relationship of a 'heritage resource' to time and history may be broken down into three phases:

- the first phase which resulted in the creation of the object;

- the second phase which extends from the end of the creation phase to the; present time
- the third phase which is associated with the perception of the monument in our consciousness at the present time.

According to the guidelines ‘The time line is irreversible….being the product of the specific cultural, social, economic and political conditions of the phases that contributed to its creation and evolution’. The guidelines also raise the related concepts of original and authentic by observing that:

> “Generally speaking authenticity is ascribed to a heritage resource that is materially original (i.e. as it was constructed) and as it has aged and changed over time …….The contribution of all periods to the place must be respected. If a place includes the fabric of different periods, revealing the fabric of one period at the expense of another can only be justified when what is removed is of slight cultural significance, and the fabric which is to be revealed is of much greater cultural significance”.

Of course one of the issues that has to be acknowledged is the extent to which recent or current change and evolution is considered to be, potentially, of equal value as changes that occurred in the ‘distant’ past.

In theory the statutory framework in the UK reflects this sense that cultural heritage will change and evolve. The listing system is intended to provoke a consideration of the consequences of any proposed change rather than prevent it. The purpose of listing is to provide “protection from unsuitable and insensitive alteration.” (Department of the Environment and Department of National Heritage 1994). However it is probably true that many see the system as one which seeks to “fossilise” a building and prevent all change, irrespective of any benefits that such change might bring. The references in PPG 15. (Department of the Environment and Department of National Heritage 1994.) to preservation, as against conservation, only serve to reinforce this impression.

Instead of a dynamic system which evolves with increasing knowledge about historic places, designation is seen as static and resistant to change. (Carman,1996) argues that the process of designating assumes that the historical resource in question is already wholly understood, and so an evaluation process develops which cannot cope easily with changes in understanding of a known historic resource, or the identification, or creation, of new types of resource. It is even seen as necessary that the process does not change, in order that common principles are applied over an extended period of time. This conflicts with the view that historical material does not have a single meaning, nor a single kind of value; it is a subjective process dictated by the context, the point in time and the person evaluating the resource (Carman, 1996). Another issue is raised by Cherry (Cherry 1993) who sees a particular problem with listing for ‘historic interest’, as “every historic building needs to be set in context in order for it to be fully appreciated or understood”, the implication being that listing will fail to protect the historic place in its entirety. Listing is thus seen to offer no assessment of the context of the building:

> "buildings were looked at in isolation as if they were museum artefacts. The context was not fully realised and now, when the context is more fully appreciated, the law of listing does not allow us to fulfil the potential" (Cherry, 1993).

It has also been observed that systems of designation have not been sufficiently accountable or democratic. With the exception of the English Heritage campaign to win the public over to post-war architecture (English Heritage, 1995), little is published outside professional circles to explain or justify designation:

> "too often … arguments for the social, psychological and aesthetic significance of the conserved townscape are taken for granted and rarely addressed in any explicit manner, and the actual grounds for listing buildings remain unclear" (Hubbard, 1993).

Shanks and Tilley also identify a lack of democracy. As they see it, professionals exert control over the past by identifying what is worth preserving or excavating; the non-professional is simply required as consumer and 'the effect is to deny people their active participation in history' (Shanks and Tilley, 1992). They believe that a feeling of alienation and dispossession is the result. Tunbridge and Ashworth also see the role of the professional as problematic. Professionals are seen as a 'sensitive minority of custodians' or 'self-chosen arbiters of public taste' who are 'decreasingly representative of an increasingly pluriform public taste' (Tunbridge and Ashworth, 1996).

If the view is taken that historic places are an inheritance from our predecessors, the possibility of disinheritance emerges. As Tunbridge and Ashworth note, selecting any heritage for presentation to the public carries the risk of 'disinherit[ing] non-participating social, ethnic or regional groups, as their distinctive historical experiences may be discounted, marginalised, distorted or ignored' (Tunbridge and Ashworth, 1996). This of course is to some extent an inbuilt problem with selectivity: some pasts are not selected and even when they are, their interpretation, and therefore their perceived value or significance, can be elitist.

It has been acknowledged that, although designation can only take account of the importance of a place at a national cultural level, a historic place has equal meaning to a group or individual:

> 'the meaning of architecture and architectural styles is in the person and their interpretative mechanisms rather than being intrinsic to a set of physical characteristics' (Hubbard, 1993)

but the subjective response to a place is beyond the capacity of systems of designation to accommodate (Shanks and Tilley, 1992).

There has been a growing acknowledgement that

> ‘heritage did not exist in a fixed and once-and-for-all endowed quantity that could theoretically be included in a comprehensive inventory, but was infinitely creatable in response to demands and expectations’ (Tunbridge and Ashworth, 1996)

and that systems of designation, whilst they may select historic sites for protection, do not assist owners or managers to manage change at the site or distribute resources between competing needs:

> ‘neither listing nor scheduling provides an owner or manager (or anybody else with a locus in the process) with much detailed information on what kind of merit different parts of a building or structure might be considered to have’ (Keystone Historic Buildings Consultants, 1999).

It can be suggested that there is now a growing acknowledgement that Inventory systems of designation can be seen as static, elitist, and undemocratic, placing no value on the context in which the historic resource is found and devaluing the ordinary and the local.

THE RISE OF CONSERVATION PLANS.

The emphasis on managing change in the built cultural heritage has been given stronger emphasis in recent years by various documents. For example:’Power of Place’, the recent document produced by the Historic Environment Review Steering Group (English Heritage, 2000), stated that:

“Like people places have to evolve react and grow. We must balance the need to care for the historic environment with the need for change. But to succeed our approach to the conservation of the historic environment must stop being piecemeal….As in the natural environment the overall health of the habitat is as important as that of individual species”

There has also recently been a greater emphasis on the need to understand (and debate) why particular places are important and also to seek the greater involvement of a range of stakeholders in such discussions and the decisions that follow from them. As Power of Place states:

“Decisions about the future of the historic environment largely rest upon value judgements. These decisions must be consistent, transparent and never arbitrary. They need to be widely accepted. This means that they need to be understood. They must be made openly tested and refined by continuing debate. This debate must not be exclusive; everyone should be able to participate easily…….We need to understand better the character of places and the value and significance people ascribe to them.”

In part this emphasis on wider participation in decision making about the built cultural heritage was reinforced by the discussions about the relationship between built cultural heritage and sustainable development. The discussion document “Sustaining the historic environment: new perspectives on the future (English Heritage, 1997) stated: “Sustainability for the historic environment therefore depends on taking a comprehensive and integrated view of the environment and accepting that the values ascribed to the historic environment include personal perspectives and perceptions. One of its central aims is therefore to take account of who makes the value judgements involved: experts, local residents, politicians or business people “.

Conservation plans are being encouraged because they are seen as a coherent management tool, which could help to achieve the objectives of integrated decision making (both horizontally and vertically) and wider participation and understanding. Power of Place (English Heritage, 2000), recommends that the Heritage sector “ should continue to develop conservation and management plans as a methodology for evaluating significance and identifying opportunities and constraints.“ Also “The Historic Environment: A Force for Our Future” (DCMS, 2002), a recent document from the Department for Culture, Media and Sport, refers to the role of management agreements and conservation plans in assessing significance, deciding how to integrate changes and considering long term maintenance and management.

WHAT ARE CONSERVATION PLANS?

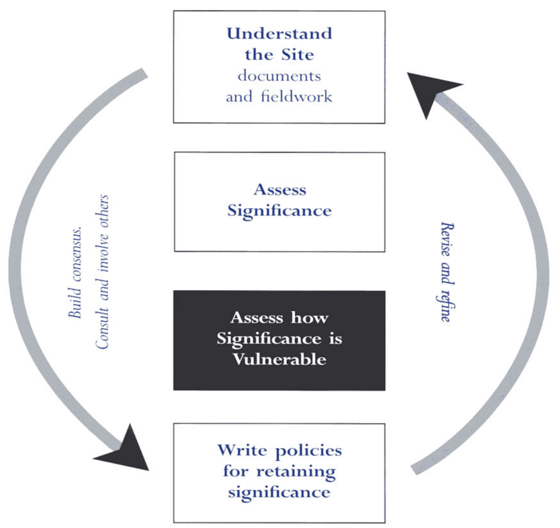
“Conservation is about the care and continuing development of a place in such a way that its significance is retained or revealed and its future made secure’ (Semple Kerr, 2000).

A Conservation Plan “identifies what is significant about a site and how that significance will be retained in any future use, alteration, development or management” (Clark, K .1999). Semple Kerr suggests that “ It is a process that seeks to guide the future development of a place through an understanding of its significance. The objective is to evolve policies to guide work that are feasible as well as compatible with the retention, reinforcement, and even revelation of significance. These twin concepts of compatibility and feasibility are the bases on which the policies are built.” (Semple Kerr, J. 1999). The Document “Conservation Plans for Historic Places” (Heritage Lottery Fund 1998) states that “A conservation plan focuses on the significance of a heritage asset and which policies need to be in place to retain this. It is part of the process of understanding the asset at the outset”.

The document goes on to suggest that they are particularly relevant for:

- places of exceptional heritage merit
- places in split ownership
- places with more than one type of heritage major monuments and their settings (e.g. cathedrals)
- large complex objects such as ships
- historic sites with associated collections

The Conservation Plan Process



(Heritage Lottery Fund 1998)

The Conservation Plan process begins with understanding the site and moves logically through an assessment of significance, to understanding how that significance might be vulnerable and thus what policies or guidelines are needed to retain that significance. (Clark,K. 1999)

Conservation plans then are a based on the rather obvious truism that in order to manage an historic building or site you first have to know what it is that is important about 'the place.' It is clear that the simple concept behind conservation plans masks a potentially powerful management tool. The use of conservation plans, at least in an explicit way, are a relatively recent phenomonum in the UK. In part their rise can be seen as a response to the need to manage change in historic sites and buildings but the Heritage Lottery Fund has also had a significant, influence (albeit in connection with a limited range of sites) because it requires the production of a conservation plan for some funding bids.

According to the Heritage Lottery Fund guidance (Heritage Lottery Fund 1998) a Conservation Plan is a document that explains:

- why the asset is significant or has heritage merit
- how that significance is vulnerable or sensitive to change
- what policies you will adopt for retaining that significance in any future use or development.

The production of a Conservation Plan is usually seen as the precursor to action, in the form of perhaps a management plan. Clarke (Clarke, K. 1999) asserts that "Once a conservation plan is in place specific strategies or actions can follow……The Conservation Plan can be the first stage of a management Plan but not vice versa." The Heritage Lottery Fund guidance reinforces this by stating that a Conservation Plan is the first step in:

- preparing management proposals
- planning any major repair or restoration schemes
- planning any new development
- managing a programme of regular maintenance

THE EMERGING IDEA

The basic idea of conservation plans is not new and certainly in Australia for example they have been developed and applied for some time now. This is perhaps not surprising given that it is possible to see the basic ideas of a conservation plan (identifying significance and vulnerability) embedded in The Burra Charter (Australia ICOMOS 1998) a document that was produced in 1979 and stimulated by a need to produce " an Australian version of the Venice Charter- the Venice Charter being a Eurocentric document more applicable to ancients monuments than antipodean structures" (Semple Kerr, J.1995). Burra was perhaps the first charter to articulate a coherent management approach to the care of the historic environment and is, according to Burman, "the most useful document a practical architectural conservator can have in his (*sic*) hand" (Burman,P. 1997). Burra, in comparison to say the Venice Charter, refers to place rather than buildings and highlights the overarching need to establish cultural significance. It also attempts to set out a methodology for managing sites in the way that it concentrates on setting out principles and suggesting a logical order of work. The charter embodies some key ideas that can be seen to have influenced the way that conservation plans have developed. An example of this can be seen in its insistence that the place itself is important and there is a need to understand the significance of the place and that significance should guide decisions:

"cultural significance means aesthetic, historic, scientific or social value for past, present or future generations….. the cultural significance of a place is embodied in its fabric, its setting and its contents; in the associated documents; in its use; and in people's memory and association with the place…….the cultural significance of a place, and other issues affecting its future, are best understood by a methodical process of collecting and analysing information before making decisions…..
(Australia ICOMOS 1998).

There is also an implicit link between the thinking behind conservation plans and some of the discussion documents that emerged in the late 1990s on the link between sustainable development and the conservation of the built cultural heritage. Some of this work (in, for example, 'Sustaining the Historic Environment' (English Heritage 1997) drew on ideas from the natural environment (see for example 'What Matters and Why' (Environment Agency 1997). We can see, for example, the ideas of environmental capital and environmental capacity being recontextualised in relation to the built cultural heritage. There is also a growing recognition that much can be learnt from the way environmental Impact assessments have been used (Clark,K. 2001).

REFLECTIONS ON THE VALUE OF CONSERVATION PLANS- AND SOME CONCERNS.

Conservation Plans have come to be seen by some as essential in situations where major development is being considered, as Cox identified in the brief for a plan:

> 'successful redevelopment means ensuring that elements of opportunity and constraint arising from the importance and character of the site are clearly understood at an early stage, [and] can be readily communicated to all interested parties and implemented …The conservation plan will be the key document in the process' (Cox, J.2000).

A proactive approach has been adopted at English Heritage (in relation to sites which they manage), where sites facing development or some other form of threat have been identified as requiring a conservation plan (Steene, 2000, pers.comm.[1]). Where appropriate, Semple Kerr advocates using a scaled down version of a plan as a 'rescue operation' to prevent an adverse outcome. However Clark (Clark,K. 2001) comments that there is a degree of risk in making major decisions based only on a conservation statement.

Other uses of Conservation Plans include the assessment of complex sites with more than one type of heritage; sites in multiple ownership; where major works are being contemplated or where there is a history of many small applications for consent (Clark, K. 2000).

Comparison has been made between conservation plans and other forms of assessment and management, such as management plans, conservation area appraisals and local plan policies, in so far as some attempt is made in each of these to identify the significance of a place. The difference is seen to be one of process and emphasis (Clark, K. 1998). A logical progression is followed from understanding the place, and expressing its significance, to a formulation of policies to retain that significance; the emphasis throughout is on understanding the site and translating this into policy. It is the process, the intellectual exercise, which is seen to confer benefit on the place and its stakeholders:

> 'The value of conservation plans lies not in their format, or even in their content, but in the process they oblige us to go through, a process with value for everyone involved in the practical management of the historic environment' (West, J.1999).

[1] Interview with Tim Steene Of English Heritage , South West Region.

Conservation plans have been identified as part of a trend towards ‘increasing emphasis on the management of the historic environment as a whole, exemplified by countryside *characterisation* rather than classification and grading’ (Drury, 1999), and their place can thus be seen alongside statutory systems in promoting positive change at individual sites. According to Suhr, conservation plans produce ‘a holistic approach to conservation that statutory designation has for so long oppressed by failing to recognise context’ (Suhr, 1998).

The process should be an open one, with participants required to be accountable: “they make managers be explicit, transparent and open about their assumptions. They make those assumptions available to be tested” (West,J. 1999). As a consultative exercise, a conservation plan can bring groups with conflicting interests together to achieve a consensus (Semple Kerr, J.1999). In the end, a holistic view of the site is developed which encompasses a variety of disciplines: archaeology, architectural history, landscape history, ecology, science and technology and the social perspective (Clark, K. 1998).

A further benefit of the process is seen to be the facility to incorporate both tangible and intangible elements of importance: “it also allows us to take into account the atmosphere of the place” (Clark,K. 1999).

Some concerns

An increasing level of standardisation, in both briefing and the plan itself, is seen by some as one of the principal obstacles to the full expression of the unique nature of the site and the values that it represents. The flexibility of the methodology is thus compromised. The conservation plan has been described as a ‘one stop shop’ for the Heritage Lottery Fund, with the model brief and template for a plan introducing a level of standardisation which has been criticised. As Semple Kerr sees it:

> ‘the type of place, needs of owners, range of problems encountered and skills available all mean that the scope and approach must be flexible if the contents are to be both useful and succinct’ (Semple Kerr, 2000).

The potential dangers of over-standardisation can be seen to include the possibility that policies are developed that are generalised and ineffectual (Brooks, 1995).

Other issues have been raised concerning the extent to which a conservation plan can express the range of values which a historic place holds for stakeholders, and produce policies, which respect those values. For the most part these relate to how the plan is produced and to what extent issues of sustainability, including stakeholder involvement, are addressed in the process and the plan.

Even before an assessment of significance is made, the process of trying to understand the site can present problems. It is essential that sufficient time be allocated for understanding before any assessment of significance is made. As Steene (2000, pers.comm[2].) observed, in relation to a conservation plan he

[2] ibid

commissioned for an English Heritage site, simply understanding the site took three people six months. Problems associated with understanding the place can include an overemphasis on one aspect of the site, a lack of attention to chronology or a presentation which is poorly illustrated (Clark, K.2000). Historic sites in Britain will very often will be 'old, deep and well documented' (Clark, K.2000) necessitating a lengthier process and greater consultation than is the case at the Australian sites on which Semple Kerr developed his ideas about conservation plans.

Views differ on whether a team or individual effort produces the best results in a conservation plan. Semple Kerr (Semple Kerr, J. 1999) believes that "the more disciplines and people involved, the more difficult it is to evolve a coherent product", resulting in a fragmented view of the place. In the UK, however, a team-based, project management approach is often adopted (Wood, 1999) based on the assumption that the more viewpoints included, the more objective the end result (Drury, 1999).

At its best, the process should be 'a creative integration of efforts and skills by both client and practitioner' (Warr, 1995). Clark has said that an outside consultant is often essential to 'cast a fresh eye over the site' (Clark,K.1998). This has been questioned by Emerick, however, who observes that conservation plans "have become tainted in some quarters because they have been perceived as a developer's charter, nearly always written from the outside looking in". (Emerick, K. 1998)

The process of briefing a consultant might introduce constraints through being too prescriptive:

> 'the brief should … describe the scope and intensity of the work but not … the structure, criteria and hierarchies of significance which will finally be used in the report' (Semple Kerr, 1995)

or too general:

> 'It is no longer appropriate for heritage authorities, property owners or project managers to call for a conservation plan to be prepared in accordance with the *Conservation Plan* and *The Burra Charter*. Briefs must be more specific, to identify the circumstances of the case, the issues to be addressed and the extent of detail which must be covered' (Brooks, 1995).

Several authors have suggested that the use of a plan to support an existing scheme will place an unwarranted constraint on the expression of significance and the resulting policies (Clark, 1998, Warr, 1995). Semple Kerr suggests that significance should be assessed 'away from extraneous pressures and without regard to those practical requirements, which must subsequently be taken into account when developing policies'. He recommends a two-stage process for this very reason, separating the evaluation of significance from the development of policies. (Semple Kerr,J 2000). Warr (Warr,A.1995) also suggests that a plan should be allowed to 'evolve in an independent manner'.

However, it is recognised that financial and commercial pressures will prevail, and the majority of plans are triggered by a proposal for change. Suhr (Suhr, M. 1998) argues that, so long as the process is regarded as iterative, with a mechanism for review built in, then the integrity of the plan will not be compromised by pre-existing proposals. Clark (Clark,K. 2000) suggests that, if a scheme has already been put forward, it is essential to stand back from the process, to let the scheme influence the scope of the plan but not the policies, and to carry out an impact assessment on the scheme once the plan is completed.

The degree of sustainability inherent in the process is also an area of concern. In the context of a conservation plan, the key issues involved are whether the process:

- takes a long term view
- Looks at the place as a whole
- Achieves sufficient public involvement
- Decides which elements of the place are important at various levels
- Avoids permanent damage to the historic place
- Obtains the best possible information to inform decisions, and adopts caution where there is insufficient information

(adapted from Fairclough, G.1999:)

The need to produce a 'long term commitment to the stewardship of the site' has been noted (Drury, P.1999). A conservation plan can be seen to contribute to a sustainable historic environment in so far as it achieves an:

> 'understanding and appreciation of the historic environment and its values …[which identifies] the present and likely future forces for change affecting the resource' (English Heritage, 1997).

thus the identification of the vulnerability of elements of the site can contribute to a sustainable process.

The holistic approach to a place within a conservation plan is identified as another aspect of sustainability and both natural and built heritage concerns should be incorporated (Clark, K. 1998).

There are conflicting views regarding the participation of the wider community in the development of a plan. Where a conservation plan balances the inherent significance of the place with its significance – cultural, aesthetic, economic etc – for all stakeholders, then sustainable policies are likely to ensue. As Fairclough (1999) notes, the needs and understanding of the community should be regarded as at least as important as the resource itself. The National Trust have admitted that this has not always happened in practice:

> 'it [the National Trust] has placed particular emphasis on surveys which reflect specialist views of archaeologists, nature conservationists, architectural historians. It has tended to place less emphasis on local people's judgements of what is significant and must now consider how to restore the balance' (National Trust, 1995).

Warr (1995) believes that a plan 'can be a good tool for involving the community in the development and protection of heritage property', but this is not seen as one of our strengths in the UK, as another delegate to the Oxford Seminar observed:

"the North Americans are amazed by the strength of our legislative provision,but appalled by our inability to find and draw in members of the public with any kind of community vision" (Clark,K. (1999).

CONCLUDING REMARKS

A conservation plan can be seen to be a rigorous approach to understanding of place and the identification of significance, although subject to constraints introduced both by the process and the subject matter. The extent to which Conservation Plans are taken up more widely, is clearly linked to a continued debate about where they are most appropriate, but also to practicalities such as cost and the extent that they are seen by those with direct responsibility for historic sites and buildings to have value - particularly in situations where they are not required in order to receive funding. However it seems clear that an approach to managing the built cultural heritage based on an understanding of significance and vulnerability will continue to be an important concept in future considerations of how the historic environment can be protected, and enhanced, whilst at the same time managing change and integration. As Power of Place observes:

"An integrated system of planning and conservation controls based on character appraisal and conservation plans would provide a simpler , more efficient system for everyone"

English Heritage (2000)

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Sustainable construction and operation

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Abstract

The aim of the paper is to show possibilities to obtain better sustainability within construction industry and facilities operation. Sustainability has technical, economical, environmental and social aspects concerning the whole lifetime of a structure.

Technical aspect of sustanability consists of items like mechanical, physical, chemical and biological durability, transport and (de)constructability. Economical sustainability is mostly a matter of LCC and LCCP. The environmental aspect of sustainability encompasses resource (both material and energy) use and impacts like emissions and waste. Social sustainability is largely a matter of political will and decision making in favour of tenable solutions.

The construction sector accounts for 10 to 15% of GDP. On average, the construction sector is responsible for one-sixth of total freshwater withdrawals and, with the demolition sector, is responsible for 20 to 30% of waste generation in the OECD countries. Furthermore, sector is directly or indirectly responsible for approximately 30 to 40% of the total energy consumption and greenhouse gas emissions, the operation phase and production processes of construction materials are included (OECD 1999).

To demonstrate this statement the next topics are described in this paper
1. *the effect of life time of materials and building elements on environmental sustainability*
2. *the principle influence of*
    - *construction on operation*
    - *construction and operation on environmental sustainability*
3. *the most relevant sustainability aspects of construction and operation*

Sustainability concerns both quality and quantity of the listed aspects. In this paper sustainability is restricted to technical aspects and main concern is the resistance of a structure against the occurrence of an undesired state.

Keywords: sustainable, construction, operation, maintenance, durability, failure, time

Introduction

Sustainability is demanded by clients, local authorities and neighbours of construction sites and structures and it is therefore an evolving concept in present day design and physical built structures. Design is an ideal process, which is usually divided in feasibility study, concept, outline design and detailed design. Detailed design includes in principle planning. The design process is usually cyclic on 3 – 5 levels of defining for built structures. Physical existence of a building consists of the real process of construction, operation and demolition (Bjerg, N. S.; Meyer, F. 2001). This process is desirably linear.

Sustainability is in this context regarded as resistance of a structure against the occurrence of an undesired state. The concept of sustainability has economical, environmental and social aspects concerning the whole lifetime of a structure (Hui, S. C. M. 2001). In this paper sustainability is restricted to technical aspects, i.e. environmental sustainability. For environmental aspects Life Cycle Analysis (LCA) systems are an established framework (ENCORD, 2001). In LCA the life cycle of materials is divided in 5 stages, of which the last 3 concern built structures:
1. raw material extraction and processing
2. manufacture of building materials
3. construction and alterations
4. operation and maintenance
5. demolition and removal

For each of these stages environmental impacts can be nominated and classified in such a way that the classes are similar for each stage but the impacts per class and per stage are different. The classes may for materials e.g. be (ENCORD, 2001) energy and water consumption, waste production, emissions to air and soil, wastewater, noise, vibrations, dust, change in physical surroundings, working environment.

In general the comparable classes show interactions per stage. For construction and operation this interaction however appears to be small. This may on the one hand be due to the separation of both activities in practice. It is often assumed that this separation is predominantly a consequence of contracts and that it is profitable to overcome this contractual separation. For this reason, integrated contracts for design, build, operate, facilitate etc. are coming into use. On the other hand may it be that indeed the effect of construction on operation is restricted. This aspect is investigated in this paper is in qualitative terms by assuming that the effect of quality in construction is the dominant link to operation.

Construction

Sustainable construction is defined as “the creation and responsible management of a healthy built environment based on resource efficient and ecological principles” (Kilbert, C. 1994). Sustainable designed buildings aim to lessen their impact on our environment through energy and resource efficiency. It includes the following principles:
- minimising non-renewable resource consumption
- enhancing the natural environment
- eliminating or minimising the waste production

According to (OECD, 1999), "Sustainable building" can be defined as those buildings that have minimum adverse impacts on the built and natural environment, in terms of the buildings themselves, their immediate surroundings and the broader regional and global setting. "Sustainable building" may be defined as building practices, which strive for integral quality (including economic, social and environmental performance) in a very broad way. Thus, the rational use of natural resources and appropriate management of the building stock will contribute to saving scarce resources, reducing energy consumption (energy conservation), and improving environmental quality.

The construction process may have positive effects on sustainability in two ways:
- by realising high product quality
- as a sustainable construction site

Both aspects are in practice often related. A nice example regarding QA was found by Schiesl, investigating carbonation of largely identical concrete structures, one group of structures having carbonation depths of ca. 5 mm, the other one of ca. 35 mm. No correlation to any plausible physical potential cause was found. Finally a correlation was spotted with the project diaries: in the cases of ca. 35 mm diaries were remarkably untidy, opposite to the ca. 5 mm structures. The effect of quality has been sketched before.

Sustainability of the site encompasses a large number of factors, which makes optimisation practically impossible. Suggested is to nominate a (small) number of factors as indicators. The idea is that by control of these factors most factors will be controlled. Apparently a high correlation is accepted, conform the example above. Another complication of sustainability, the lack of an unequivocal unit for sustainability, is also reduced. Comparison and optimisation of sustainability of alternatives is made more objective.

Sustainability concerns all phases of the physical structures life cycle. In each of these life cycle stages construction companies may be involved, depending on their policy. So in each of these stages process and site aspects appear. Contractors that realise environmentally friendly projects, sustainable construction sites and processes gain in image, efficiency and acceptability. The effect on share value prospects is appreciated by financial analysts and pension funds for environmental criteria and social criteria.

Present day large companies usually operate globally. Manufacturers focus on favourable conditions like the presence of cheap or qualified labour, suitable environmental demands, sufficient infrastructure, political stability, presence of raw materials etc. Construction is usually bound to the location of the structure to be built. Transport of elements, which are usually heavy and of low cost compared to transport costs, is often not economical. Therefore sustainability demands on the construction industry differ from those on manufacturing. As some manufacturers use materials and types of energy which are strongly unwanted, demands on manufacturing are in those cases usually more severe. Due to the large quantities in construction demands on construction may also be stringent.

Regarding the whole life of a structure the consumption and eco-system effects of the construction process are usually small due to the shortness of the construction period (ENCORD, 2001). The impact on the neighbourhood during this period on the other hand usually is large.

Operation

The strategic impacts of any asset management can be mainly channelled into two modes:

1. The loss (natural wastage) decreases, thus the vacant resources can be allocated elsewhere and usually more effectively
2. Unit costs of operation can be reduced; thus the profitability of the branches and the entire national economy improves.

In facilities management the structural maintenance and repair costs range in different types of buildings from about 10 to 20 % share of the total maintenance costs, whereas tightly energy cost related share of HVAC (heating, ventilating, air conditioning) costs accounts form about 20 to 50 %. Accordingly, the input-output analysis of buildings has proven that the two items especially worthy of improvements are the extending of the service life of building by repairs and lessening of energy use (Timo Aho. 1995). Furthermore, annual inspections of the condition of structures should be promoted to be provided for the needed repairs and that unnecessary damages could be avoided. The cost share of waste management is modest, but the environmental impact is substantial.

The accuracy of the knowledge concerning the condition of structures and their remaining serviceability also determines the quality of economical facilities management. The concepts of funding and annual costs are inherently incorporating the timing aspects. The material (real) facility is the carrier of values in construction sector. Therefore (at least most of) all the other aspects of sustainability concerning buildings and other structures may be traced back to environmental aspects e.g. flows of material and energy.

Facility management causes environmental impacts through building maintenance, upkeep and repairs, energy use, waste management, and maintenance of outdoor areas. A building or civil structure may be in use through a timespan tens of times as long as was spent in project design and construction. Therefore, it is of consequence how a facility is maintained. The design of a building has a significant effect on the maintainability during the years of use. The care taken during construction has an effect on upkeep and repair needs, and on how the service life of the building and the estimated duration of use of its parts will finally be realised.

If service life is seen as the actual time in service of the building components, the basis of service life prediction models should not be based on durability or economics of the building components only. Durability is of course the limiting factor for service life in the sense that service life can not exceed the limitations set by durability, but in fact the actual service life seldom reaches the full potential life time of the components limited by durability. The forecasting of the timing of the refurbishment projects should not rely on the durability-based concepts only. Asset and maintenance management should pay more attention to the more critical perceived quality of the buildings.

Life cycle economics of the buildings are (according to the empirical findings) covered by technically/economically irrational basis. Decision-makers pay little attention to the condition and remaining potential for service life of the building components. They pay very limited attention to economical expectations. Optimization of economical factors of the buildings is the primary goal in less than 10 % of repair projects (Aikivuori, A. 1999).

An essential part of the maintainability of a building is created by careful service life planning. While the owner, during project planning and design phases, presents the goal of building service life and the requirements of product service life, and the designers propose corresponding structures and products, the framework of a maintenance record for upkeep and repairs is created. The record complemented by inspection, maintenance and repair schedules, and by equipment manuals, functions as a guide for the original as well as eventual future owners. Information concerning the service life of different building components helps to plan maintenance work (e.g. cleaning, equipment adjustments, annual inspections) and repairs (e.g. change of flooring materials, renovation of roofing, renovation of water pipes) so that necessary work is done, with proper initial information at the right time, but unnecessary work is avoided.

In a facility, energy is used daily for heating and cooling, hot water, ventilation, and lighting. In a well-maintained facility, mechanical systems in all these sectors are controlled, equipment is adjusted, and lighting fixture capacities are seen to, in order to decrease unnecessary energy consumption. In energy consumption, it is not only a question of choice of equipment and maintenance, but also of the attitudes of building users. Information and training help observe problems and decrease energy use. By measuring consumption by user (group) (e.g. by each office unit or apartment), directs the requirement of energy saving most effectively, as cost effects are easy to point out.

By organising the waste management of a facility so that there is a minimal need for waste removal is one way of decreasing environmental impacts. The existence of proper waste management spaces, and well-reasoned information concerning waste management, given to building users, are both important. In facilities, many types of waste are created; the separating of which into different factions makes it possible to decrease the amount of waste to be removed, as well as to recycle:

- biowaste is collected to be composted,
- paper is collected to be recycled,
- glass is collected separately, as is plastic,
- metals and problem wastes are sent to separate treatment centres,
- usable and repairable pieces of furniture and building materials are collected to be re-used within the facility, or within a group of them, or are sent to a recycling centre, and
- waste water system is designed to return grey water to suitable uses within the facility, and to send only black water to a treatment centre.

The character of the outdoor spaces creates some of the environmental impacts of a facility
and the demands of their upkeep:

- the natural circumstances of the location,
- the appropriateness of the flora, and
- the surface treatments of the exterior areas.

The more the treatment of the outdoor areas follows the natural qualities of the site, the less work and energy, and the fewer chemical additives are needed for maintenance. If there are exterior areas requiring frequent upkeep, e.g. vast lawns, is possible to consider changing at least some of them into self-maintaining ones, or into areas of only minimal upkeep requirements. If the chosen flora adapts itself naturally to the growth zone, moisture conditions, and microclimate of the location, care is easy compared to using delicate species. The surface treatment of outdoor areas is of great significance to the water balance of the site. The more porous surfaces are planned for the site, the fewer groundwater disturbances are caused in the area, and the fewer sewage lines are needed (Häkkinen, Tarja & Kaipainen, Maarit).

In the operation phase, the construction and building business turns into a chain of service providers: more and more the emphasis is on the acquisition of services to support the core activities rather than the material acquisitions of structures to provide them. Thus the analysis of performance requirements and the matching of the structure to meet the requirements over a demanded period of time is the valid approach. The ultimate client is the user who either accepts or rejects the quality of services as perceived. The extended service life can only be accomplished by maintaining of the user satisfaction. The issue is not entirely a matter of technical condition of the structures, as obsolescence is a major reason for the (technically premature) termination of service life prior to actual failure of the structures.

The prime objective of maintenance should be the upkeep of service level according to the user preferences. One of the key issues in the sustainability considerations of the operation phase is whether the user acceptance can be extended until the technical failure is the cause of the deconstruction.

Principle aspects of construction and operation

The construction industry and the built environment must be counted as two of the key areas if we are to attain a sustainable development in our societies. As an example, in the European Union, buildings are responsible for more than 40% of the total energy consumption and the construction sector is estimated to generate approximately 40% of all man-made wastes. In addition, the construction sector is the Union's largest industrial sector, contributing with approximately 11% to the GNP and having more than 25 million people directly and indirectly engaged (CIB pro-active approach priority theme 1 - sustainable construction. 1999).

Construction is the realisation of a design and has to comply with demands on level and accuracy. Higher accuracy means a reduction of the standard deviation of the resistance of a structure and results in either reduction of the probability that an undesired state occurs or relaxation of the demands on the level. Accuracy complies with quality of work, which can be influenced in the construction process by quality control measures or practising of learned skills. A change of the demands on the level is a change in design, like the choice of lower grade materials; reduction of dimensions or less sophisticated detailing, which is beyond the scope of this paper.

The energy input required to quarry, transport and manufacture building materials, plus the energy used in the construction process, can amount to a quarter of the 'lifetime' energy requirement of a very energy-efficient building (Hui, S. C. M. 2001). Figure 1 illustrates the impact of time on the average of sustainability parameters. Both positive (desired performance per unit) and negative (use of resources, emissions, waste) parameters should be seen as continuous flows of impacts, where extended time in operation phase may outweight the initial impact at winning and processing phase.

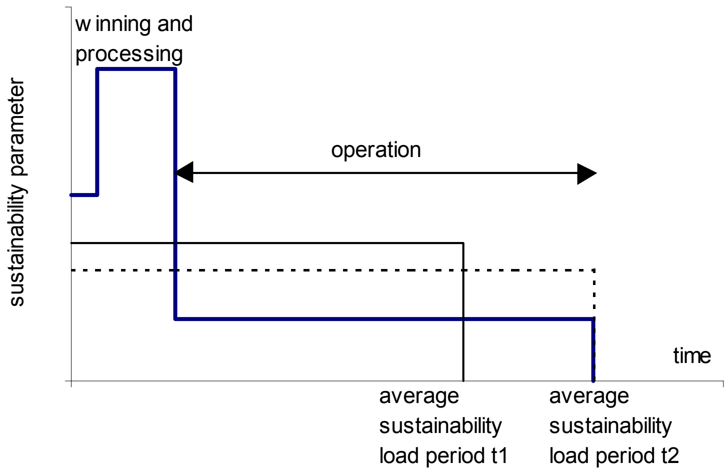

Figure 1: integral measure of sustainability parameters

Resource efficiency can involve using fewer materials overall in construction, but it can also lead to the choice of more resource efficient building products over conventional alternatives for the materials that are used. These resource efficient materials can generally be defined as materials which are more—rather than less—abundant, which cause less environmental impact in their production, which are recycled or reused, or which contribute substantially to the improved performance or longevity of the building as a whole.

When the demands on the performance are set, the consideration should involve the service life. Figure 2 illustrates an example where two optional materials or structures are available for providing certain performance (e.g. thermal insulation). Option 1 has better performance, but the expected service life is short, whereas option 2 has lower performance but a longer service life expectancy. To fulfil the performance demands, a consideration has to be made whether to have the high performance option 1 and replace it during the operation phase (e.g. resulting in energy conservation during the operation phase but double the losses in material winning and processing and waste management) or to have the lower performance (e.g. higher energy use during operation). Thus it is not only the initial performance of a material or a structure but also the performance over time that has to be taken into account.

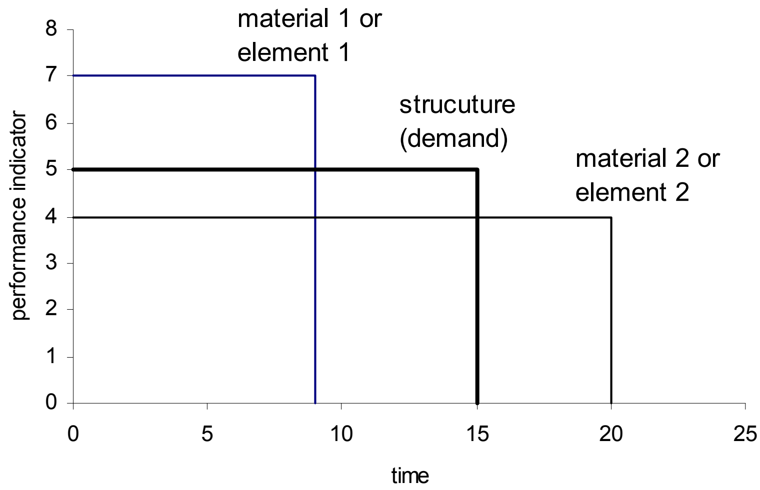

Figure 2: choice based on integral value and element period

The word *sustainable* (suggesting the idea of constant, permanent or continuous) is translated to some languages as *durable*. The concept of "durable construction" may change the vision on the intended objectives, laying stress on resistance in time (CIB Working Commission 82 Future Studies in Construction. 1998).
In this paper, durability is treated as the resistance against actions below the strength. Strength is the ultimate resistance against action. Sustainable design incorporates durable materials, properly assembled to comprise a durable system. Using durable materials avoids the expense and resource consumption of materials that fail sooner, requiring replacement and potentially damaging other systems and components. The need to dispose of failed materials also is avoided by using durable materials. Furthermore, durable materials also should require less time and expense for maintenance. Although durable materials may have a higher initial cost than short-lived or disposable materials, they will save both money and resources over the long run.

An important aspect of durability is not only selecting durable materials, but also making certain that they are properly installed so that they can perform to their full potential. Construction details that prevent moisture and air infiltration and insect or weather damage can be the key to the longevity of buildings and other structures. For example, if the air voids within thermal insulation material get wet, the heat insulation will drop to dramatically compared to the dry material, as the coefficient of thermal conductivity of water (ca 0.024 W/m∗C) is about 24 times that of air (ca 0.57 W/m∗C).

In figure 3 failure as a consequence of an action on a resisting structure is presented in probabilistic terms.

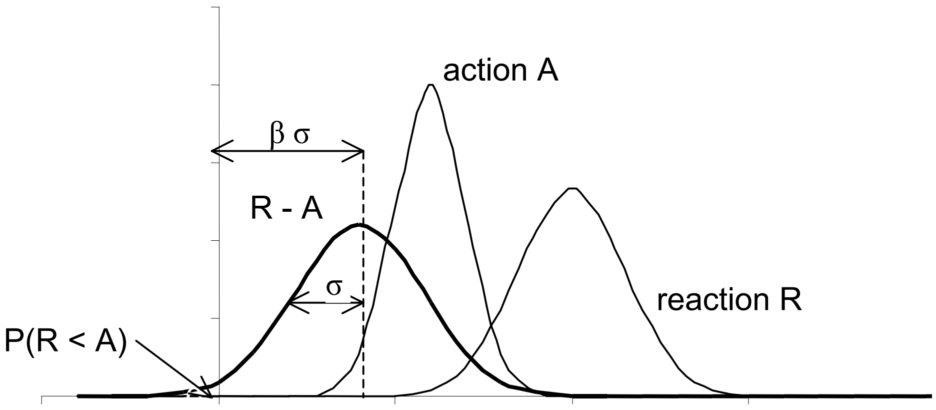

Figure 3: probability of failure

Reduction of the probability that an undesired state occurs reduces operation activities like inspection, maintenance and repair and may result in a longer lifetime of the structure, depending on the chosen operation regime. This is the dominant link between construction and operation. The change in time of a material, a building element or a structure is schematically presented in figure 4.

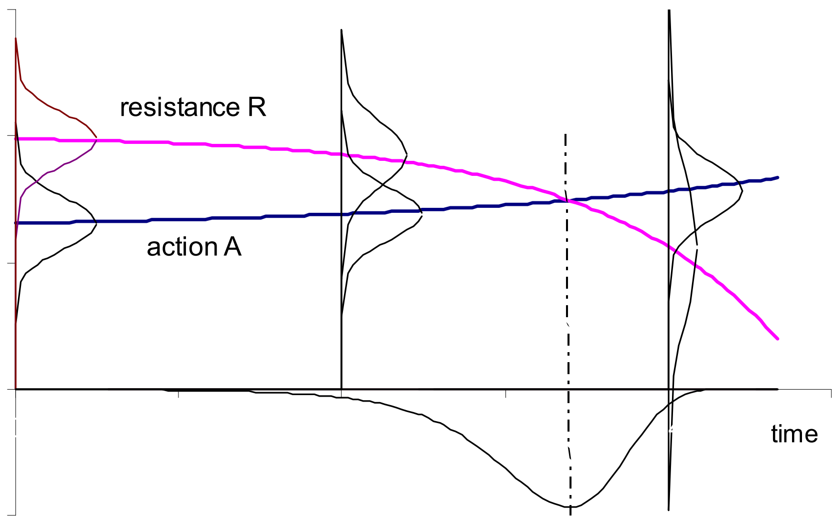

Figure 4: development of the probability of failure in the building period (=life time)

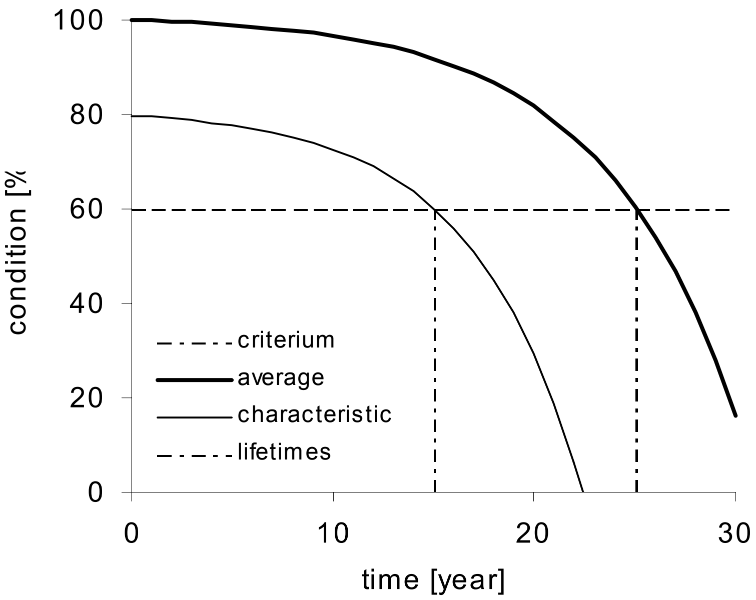

Figure 5: Characteristic lifetime (according to design safety margins) is shorter than achievable

In practice the load increases because confidence is gained after proven suitability of the element and increase of demands are optimistically treated. As a consequence also the deviation increases. Usually the degradation of resistance evolves initially gradual and steeps later on, with similar consequences on the deviation. The deviations may in principle either increase in time (e.g. uncertainty in future, localisation of degradation) or decrease (e.g. specific use, natural selection, and re-distribution of actions).

The probability of failure of an element is sketched along the negative vertical axes. The decrease after the maximum is a consequence of the earlier failure of a large part of the elements; i.e. the number of candidates that may fail as a fraction of the original number of elements has decreased. The distribution is skew due to the non-linearity of A and R and the changes in deviation. For the sketched plausible developments this results in a further reduction of the lifetime, cf. the drawn average and 50% failure probabilities compared to the failure point of the average A and R. It is seen that a small probability of failure in time results in a partial factor on the lifetime larger than 3, which is quite bigger than a partial factor for load design.

In figure 6 is abstained from 2 phenomena. At small times, mistakes and deficiencies are eliminated. Usually a period of guarantee after construction is agreed and the attention level is higher than later on, when confidence in correct operating is gained based on experience. The resistance distribution may initially be skew towards the low values and the deviation larger. At later times, when the low resistance elements most likely have failed, the skewness may be to the high resistance values.

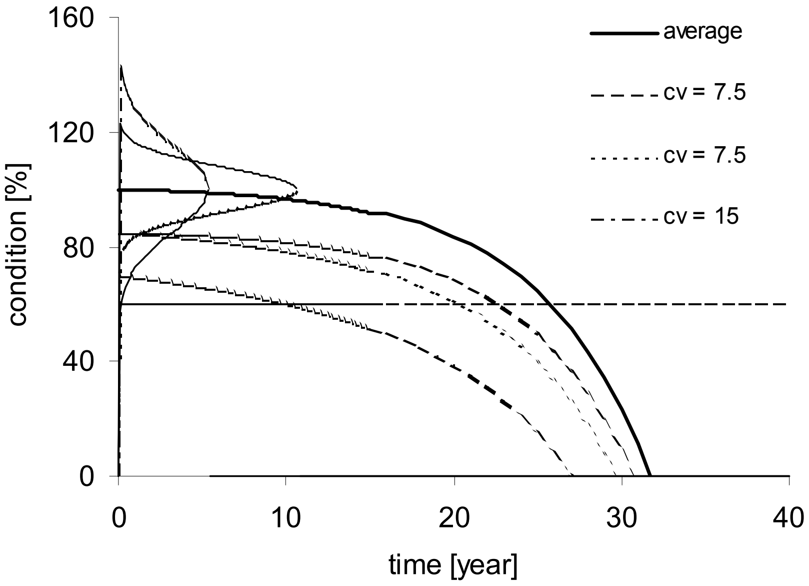

Figure 6: influence of quality of construction

In figures 7 and 8 the consequences of repair and maintenance are depicted. Repair leads to an increase in level and mostly a decrease in deviation. Repair may be upgrading (improvement beyond the original level), refurbishment (restoration) or downgrading. Maintenance normally results in a reduction of the degradation rate, both in level and deviation.

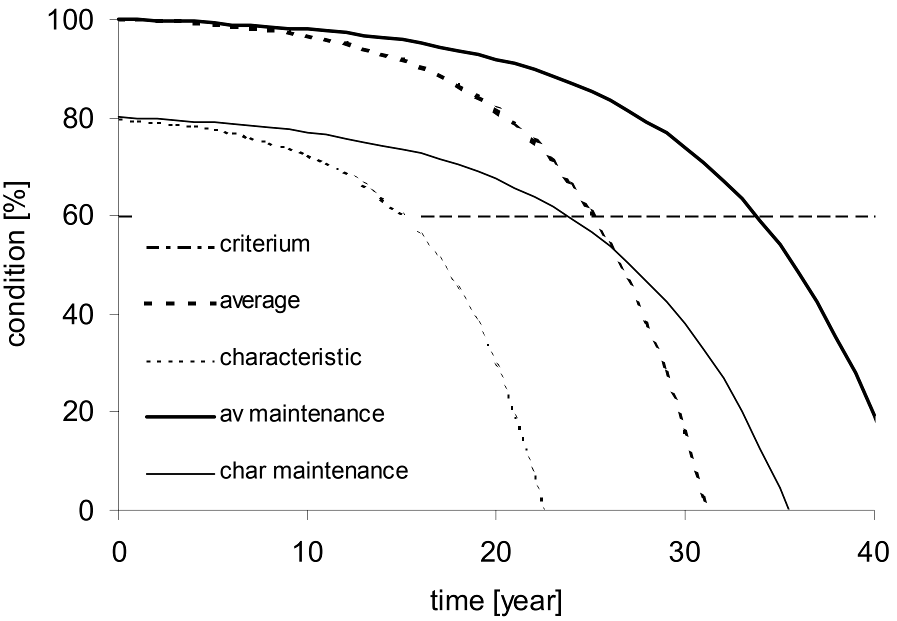

Figure 7: effect of maintenance

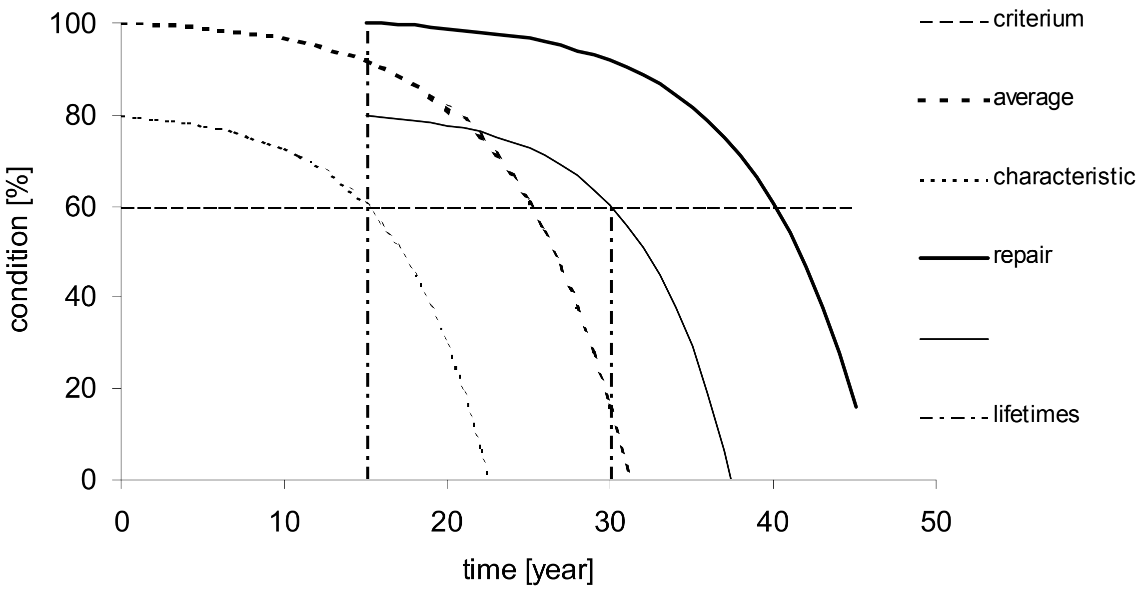

Figure 8: effect of repair

Conclusions

Sustainability is compliance of a structure with demands during a projected period. It is likely that the notion of sustainability of infrastructure and buildings has always been present. The importance of sustainability in general or of aspects of sustainability depends on choices made by society. For structures with a short period of use, especially when produced in series, much attention is paid to compliance for the projected period, while usually only a minimum demand is posed on unique structures with long periods of use. Such structures may thus be over-dimensioned at aspects. For structures of which the speed of availability is large, sustainability usually gets little attention (e.g houses in post war regions) and is mostly low.

Sustainability is the state of being sustainable. Sustainability is therefore in principle quantifiable, as the effort needed to reach the non-compliant state. As sustainability usually is multi-dimensional quantification is not univocal and complete. A way out is to nominate an (restricted number of) element(s) as indicator(s).

Most relevant sustainability topics for construction are:
- achieving the required performance with minimal deviations
- consumption / conservation of materials, space, time and energy
- change / conservation of the environment and production / reduction of pollution / waste
- durability of products

Most relevant sustainability topics for operation / facility management are:
- the extending of the service life of building by maintenance and repairs
- lessening of energy use
- waste management
- furthering the use of passive solar energy
- utilising natural untreated outdoors areas rather than artificial landscaping

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Maintenance management – The case of a University Campus

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Abstract: *Over time our buildings would suffer obsolescence. Unless the rate of building deterioration is checked, we are potentially allowing our physical assets to reach their ultimate functional life faster, while we face increasing user population, a constrained and decreasing maintenance budget and a slow growth in facilities provision. We are in a position to seriously consider the "real impact to improve the approach to management of physical assets of the University campus" and we need to develop appropriate management strategies to better manage and maintain our campus buildings and facilities. The use of additional management indicators that reflect its efficiency and effectiveness are also urgently needed. This study investigates the maintenance management practice in a main campus site, in a local University. The Maintenance and Repair Unit is supported by a maintenance information system, BEAM. In this investigation, we would like to know how the system has assisted in the management of maintenance and repairs. The issues addressed are: the maintenance strategies to be adopted and customer ownership. The data on civil, mechanical and electrical dockets from the BEAM system of the past two years, 1999-2000, were collected. We created the database in SPSS for windows and conducted statistical analysis. From our results, we have identified some areas for improvements: the classification system of building elements, and their nature of defects which could be utilised towards developing the maintenance strategies. We anticipate our research could be further developed to benefit other universities in the country.*

Keywords: Maintenance management, maintenance strategies, classification system

Introduction

Maintenance management can be defined as the systematic and effective management of a maintenance activity in which sound applications are made of the three basic elements of management: organisation, measurement and control (UCOP, 2000). The Chartered Institute Of Building (1990) defines it as the organisation of maintenance within an agreed policy. In university campuses worldwide, facilities maintenance aims to improve administrative services and to become more cost-effective in managing their building portfolio (Rodgers & Teicholz, 2000). Inevitably, these institutions will observe specific ongoing maintenance programmes so as to provide good and acceptable environment for their academic, scientific and public services.

This paper discusses the extent to which the maintenance information deposited in a maintenance system is used as a management tool, in the case study of a local University in Malaysia.

The Main campus

Historically, University Sains Malaysia, the second in the country, was established in June 1969. It operates on a broadly based school system that allows specialists in their chosen fields of studies to become acquainted with other fields of study (Universiti Sains Malaysia, 1979). The main campus, one of the three sites in the University, was acquired in February 1971. The site was a former British Military camp and initially covered 285 acres of land. The early years of the main campus saw to renovations, new building constructions and also substantial infrastructure development to cater for the change of use and the increasing number of students. The enrolment for the 1971/72 sessions was then, 517 students. Seven years on, the enrolment has increased to 3144 students, supported by 1834 full time staff (Universiti Sains Malaysia, 1979). In the same year, the building spaces gross floor area (GFA), were enumerated to a total of 477 712 sq. ft. (Universiti Sains Malaysia, 1979).

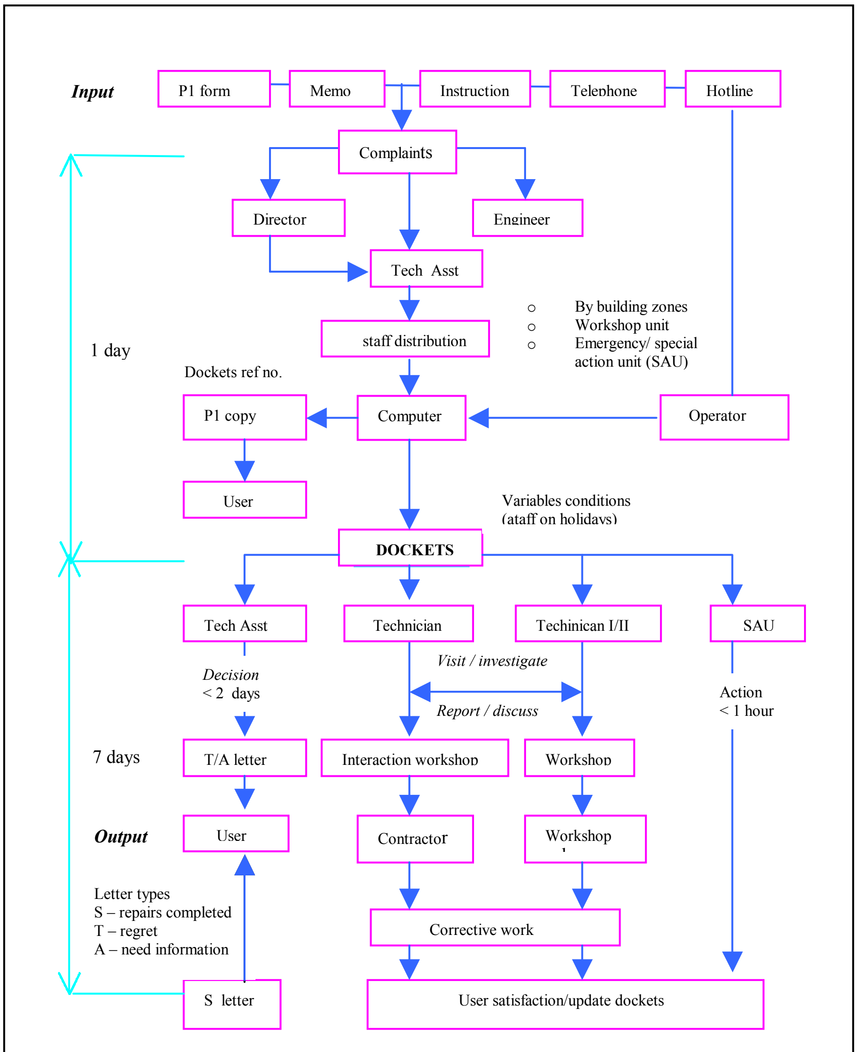
Today, organisationally, there have been significant changes in the University. Within the 1999-2000 period, structural changes have affected the administration. New divisions have been added; new schools and centers of excellence have been established and a change of leadership has also occurred. The 1999/00 sessions showed a total enrolment of c. 19000 students supported by c. 2600 staff (Universiti Sains Malaysia, n.d.). The students' intake has been increasing each succeeding year but it will potentially reach full capacity. The site now stands on 611 acres of land and the surviving buildings from 1971, covering 28.4% of the total number of buildings, would have reached 31 years old today. The GFA has accumulated to approximately 3.8 m. sq.ft. in more than 200 buildings.

Maintenance and Repairs Unit, Development Department

The maintenance and repairs of buildings and infrastructure in the University are the responsibility of a Unit, made up of the Civil Engineering, Mechanical and Electrical sections in the Development Department. Their scope covers all technical and administrative procedures needed to preserve or rectify each facility. The unit's goals are aimed to give user comfort, to ensure clean and safe environment, to ensure cost effectiveness and to provide quality support services (MISS, 2000). The unit is facilitated by a maintenance information software system called, *BEAM*.

The BEAM System

BEAM stands for *Biomedikal Electrikal Awam Mekanikal*, reflecting the four main engineering areas within the department's organisation, in the whole University. This system was an innovation by Ir. Norazman Hj Mahamud, from the Health campus site, located on the east coast of Peninsula Malaysia in 1991. It was officially launched in the Main campus site, Penang, on 3rd August 1993, and in the following year, at the Engineering campus site in Perak. The system supersedes the traditional practice of using memos. It is capable of data capturing, letter processing, statistical analysis, printing and evaluation of individuals and teams. Figure 1 shows the procedures taken when making entries into the system.



Note: Reproduced as a translated version

Figure 1: Flowchart for creating the BEAM docket

In order to get a feel for the practice of maintenance management in the main campus site, we initially conducted a class exercise with the final year students of the Construction Management workshop in the School. This involved an exploratory study between August-September 2000, on a sample of academic buildings reported to have very high maintenance requirements in the main campus.

From our investigation, we began to understand the essential features of the system. We found that the system could capture maintenance data and assess the staff's annual performance in the Unit efficiently. However, other indicators relating to the elements and defects are not usually held in a form which allows immediate measures be carried out. At the same time, we saw that the unit is confronted with the aspirations to move toward upgrading the BEAM system into a window-based version, and implementing a planned maintenance strategy (MISS, 2000).

Literature survey

When we carried out a literature survey we realised that there are many contributions on maintenance management of university campus, worldwide. The HEFCE experience focuses on "effective building maintenance arrangements [to] improve services and achieve value for money" (HEFCE, 1998). According to them, "to maintain their estate efficiently, institutions should create a management framework which: recognizes the interests of different stakeholder, ensures compliance, to manage fund and the agreed priorities in their strategic and operational plans and to deliver value for money" (HEFCE, 1998). We found these issues being addressed in other universities as well. Table 1 below shows a summary of notable developments gleaned from The Association of Higher Education Facilities Officers (APPA) database of University links (APPA, n.d.).

Universities	Identified developments
St. Cloud State University	Their strategic plan aims "to improve and maintain facilities condition" through functional condition assessment and to review the physical master plan (St. Cloud State University, 2000).
Syracuse University	The Physical plant department operates in zone offices where the team and service providers provide most of the maintenance and building services (Syracuse University, 2000).
Temple University	Their Facilities Management plan states the requirement for "planning, construction, operations and maintenance of University facilities" and is strongly supported by clear maintenance operations strategies, for e.g. preventative maintenance and inspections and client initiated work requests (Temple University, 1999).
University of California	The University of California Office of the President has the availability of a Facilities Manual in six volumes. The Operations and Maintenance (Vol. 6) defines the day-to-day, planned, preventative and emergency maintenance for the nine campuses (University of California, 2000).
University of Iowa	The University of Iowa Facilities Services Group has the FSG strategic plan that describes the strategic planning process that builds upon cost improvement efforts. The development of goals and strategies used the balanced scorecard of four perspectives: financial, process, customer and people (University of Iowa FSG, 2002).
Carnegie Mellon University	Their Facilities Management Services Strategic Plan clarifies the definition on core activities, areas of focus and foundations against their goals and strategies (Carnegie Mellon University, n.d).
Ohio University	Their energy performance contract program intends to engage the University population in energy conservation, increase savings and, more importantly, encourage a sense of connection to and ownership of the facilities (Ohio University, 2001).

Table 1: Summary table of some identified maintenance developments of University campuses from APPA

Therefore as seen from the above, in practice, recurring themes revolve around formulating and implementing strategic plans in concordance to the HEFCE's. But other reviews of campus facilities maintenance such as that by Rodgers and Teicholz (2000), has reported the increasing use of internet technology within the management process.

Problem statement

By taking into consideration the literature review and our case study for investigation, we have developed two main research questions:

1. To what extent is the BEAM system as a software programme, utilised as a management tool for improving the Maintenance Unit?

2. How do we assess the performance of our maintenance management system?

Method

The main source for data pertaining to work orders, is retrieved from the BEAM listings, known as dockets. These are listed in a serial order according to the three engineering sections. These dockets are of four categories: 'completed work (S)', 'deferred/rejected work (T)', 'requiring more information (A)' and those that requires 'no remarks'. Listings from the "S" and "T" dockets have been collected for our analysis. The former allows identification of major elements and components that require study, if we have a target to reduce maintenance and repair in the future. The latter, gives an indication on work to be done, the identification of elements that could entail postponement or those that could avoid maintenance and repair jobs in the future. Figure 2 shows a profile of the database fields from the BEAM listings.

Series	Date	Status	Item	Asset no.	Complaints	Location	Room	Maint staff

Figure 2: Fields in the BEAM database

Other sources of data are the internal technical reports from the Maintenance Unit and the annual reports of the University. We also conducted interviews with the Director for corporate division of the University on March 4, 2002 and the Head of the BEAM system, in the Maintenance Unit on March 11, 2002.

We have tapped organisational data such as the total population in the main campus site from the 1994-2000 period, from the Corporate Division's system. On the other hand, our maintenance data is based on the types of elements, locations and complaints as recorded in the BEAM system. This entails observing daily entries of the three sections, for 1999 and 2000, according to the "S" and "T" categories. As our unit of analysis is the docket, we have translated their nominal data points into ordinal by labeling them with values for the elements, locations and defects fields. We processed these to generate frequency distributions, means and other statistics using the SPSS for windows package.

Results

Since the system was fully implemented in the main campus in 1993, the total number of dockets recorded showed that 1996 has the highest number, increasing by 25% from 1995. The succeeding years saw erratic fluctuations in total number of dockets received, with the lowest number of dockets recorded in 1998, a decrease by 21% Table 2).

	1994	1995	1996	1997	1998	1999	2000
Civil	3208	3451	4235	3590	2716	3498	3142
Electrical	2208	2305	2730	2635	2025	2217	2003
Mechanical	917	926	1396	1303	1245	1183	994
Total	6333	6682	8361	7528	5986	6898	6139
% change	-	5.5%	25.1%	-10.0%	-20.5%	15.2%	-11.0%

Table 2: Total number of work orders received 1994-2000

Of the total dockets received, the completed work orders from the 'S' categories, occasionally reached and exceeded the expected target, c. 90% completion as set by the Unit (Table 3).

	1994	1995	1996	1997	1998	1999	2000
Civil	97%	63%	93%	87%	88%	93%	93%
Electrical	89%	74%	92%	86%	85%	86%	85%
Mechanical	94%	82%	86%	86%	74%	89%	76%
Average	93%	73%	90%	86%	82%	89%	85%

Table 3: Completed *work orders in percentage, 1994-2000*

The biggest proportion of completed work orders usually covers the civil work, comprising more than 50% of the total number of dockets, followed by c. 30% in mechanical works and the rest c. 17% in electrical works (Table 4, Figure 3).

	1994	1995	1996	1997	1998	1999	2000
Civil	3104	2159	3940	3139	2380	3240	2933
Electrical	1956	1714	2506	2267	1722	1900	1705
Mechanical	859	759	1200	1118	916	1057	752
Total	5919	4632	7646	6524	5018	6197	5390

Table 4: Total numbers of completed work orders 1994-2000

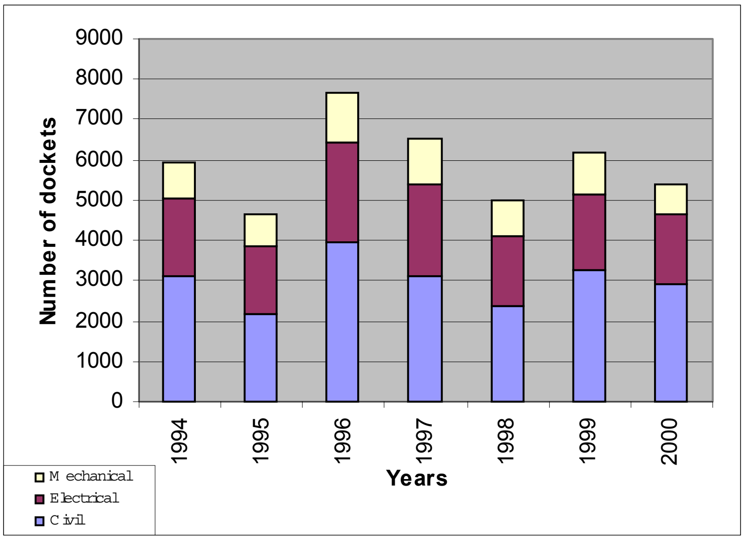


Figure 3: Proportion of completed work orders by engineering sections 1994-2000

On the other hand, the performance on the 'T' - deferred/rejected - dockets has indicated general improvements. Dockets are deferred due to several reasons: from lack of funds; due to operational requirements or that the work requested is not within the services of the unit. The biggest proportion tends to be from the electrical and mechanical work. But in 1995 this situation is manifested in the civil engineering unit (Table 5) showing, at best, one docket is deferred in every thirty, completed, while at worst, one in every two.

	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Civil	104	1292	295	451	336	258	209
Electrical	252	591	224	368	994	315	283
Mechanical	58	167	196	185	329	126	242
	414	2050	715	1004	1659	699	734
% change	-	395.2%	-65.1%	40.4%	65.2%	-57.9%	5.0%

Table 5: Total numbers of deferred work orders, 1994-2000

Complaints and defects commonly arising as reported between 1999-2000

For our purposes, all entries on complaints have been re-categorised into types of defects, where possible. Otherwise they are considered as "not as defects". Some common ones are: damaged/inoperable and inadequate maintenance - affecting all three sections. Defects such as leakage, commonly affect the civil and mechanical works.

However, our data showed that most complaints were reported merely as a "defect"; without being described to detail. This is particularly prevalent in the mechanical and electrical, reporting over 55% of total defects, while in the civil works, reporting about 23%. Other defects being reported are related to leakage, unstable temperatures, disruption in electricity supply and damaged / inoperable elements (Figure 4).

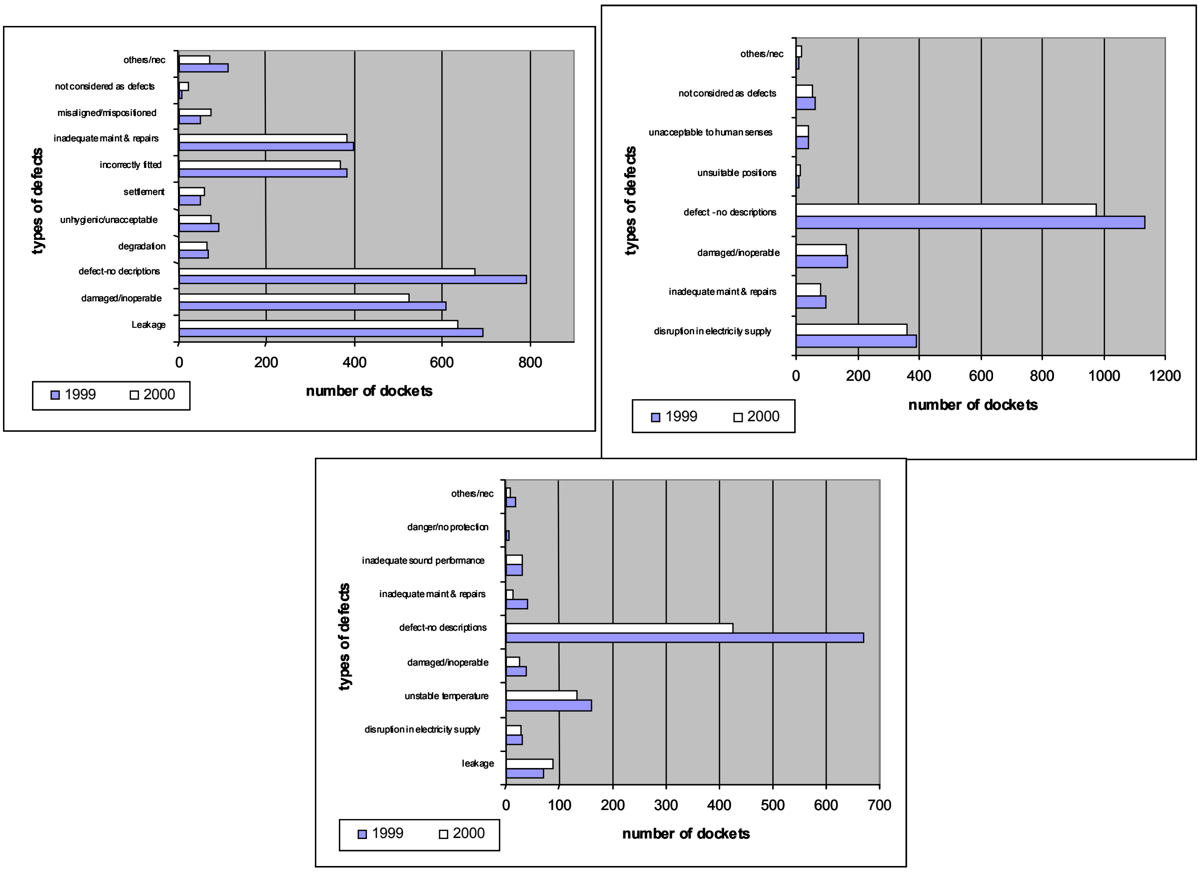


Figure 4: Types of defects by completed work orders in civil, electrical & mechanical sections, clockwise from left,1999-2000

Components and elements frequently reported between 1999-2000

We have re-categorised the items field in the database into ‘elements’. The civil engineering elements are: exterior, roofs and ceilings, floors and interior walls, windows, doors, sanitary, drains, external works, fixtures and fittings and others. The electrical elements are: light fixtures, lightning protection, lightning conductors, metering devices, switchgear, electrical services, equipment, fittings, protective devices and others. Finally, the mechanical elements are: air-conditioning, alarm systems/fire protection, air handling units, shafts, ducts and distribution pipes, pumps, lifts, installations and others.

Our data suggested that in civil works, sanitary elements, doors and roof and ceilings are persistently being reported, up to 50%, 15% and 9% respectively, from 1999-2000 (Figure 5). However, in 2000, the civil dockets on roof elements, fixtures and fittings have shown reducing trends. Electrical works in light fixtures take up the highest number of dockets while mechanical work orders on air-conditioning, maintain as the biggest number of dockets reported for both years.

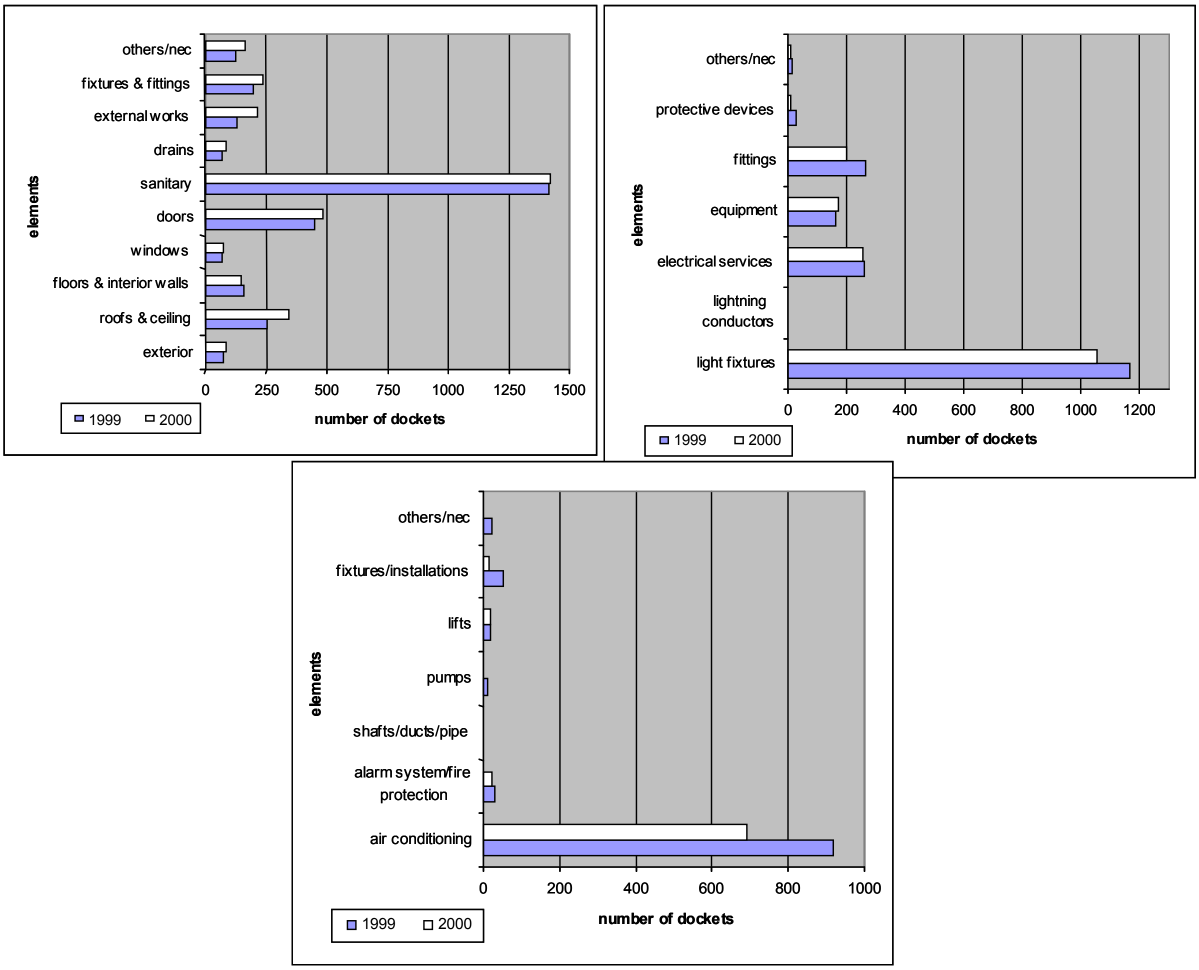


Figure 5: The elements by completed work orders in civil, electrical & mechanical sections, clockwise from left,1999-2000

Buildings that suffer more defects as reported between 1999-2000

The locations of buildings in the main campus site, have been re-categorised into local zones, conforming to the University site plan and the distribution of maintenance staff (Development Department, n.d.). The average age of the buildings is 22 years within a 4 – 35 years range, a median of 26 years and mode of 31 years (*n=201*). Overall, about 18.4% of the buildings are in the H zone, and 15% are in the D zone. Of these buildings, 14.9% are less than or equal to 10 years old. Older buildings are mostly found in zones B, C, D, and J.

Presently, we have enumerated 11.4% of the buildings to be of less than 10 years old, 85% to be more than 10 years old, 71% to be more than 15 years old, 53.7% to be more than 20 years old, 50.7% to be more than 25 years old and 31.3% to be more than 30 years old. From our analysis, the highest recorded work orders in 1999-2000, arose from the buildings in zones G and H (Figure 6), pertaining to civil and electrical sections. Apart from buildings, infrastructure works in roads, lakes and fields have also been identified.

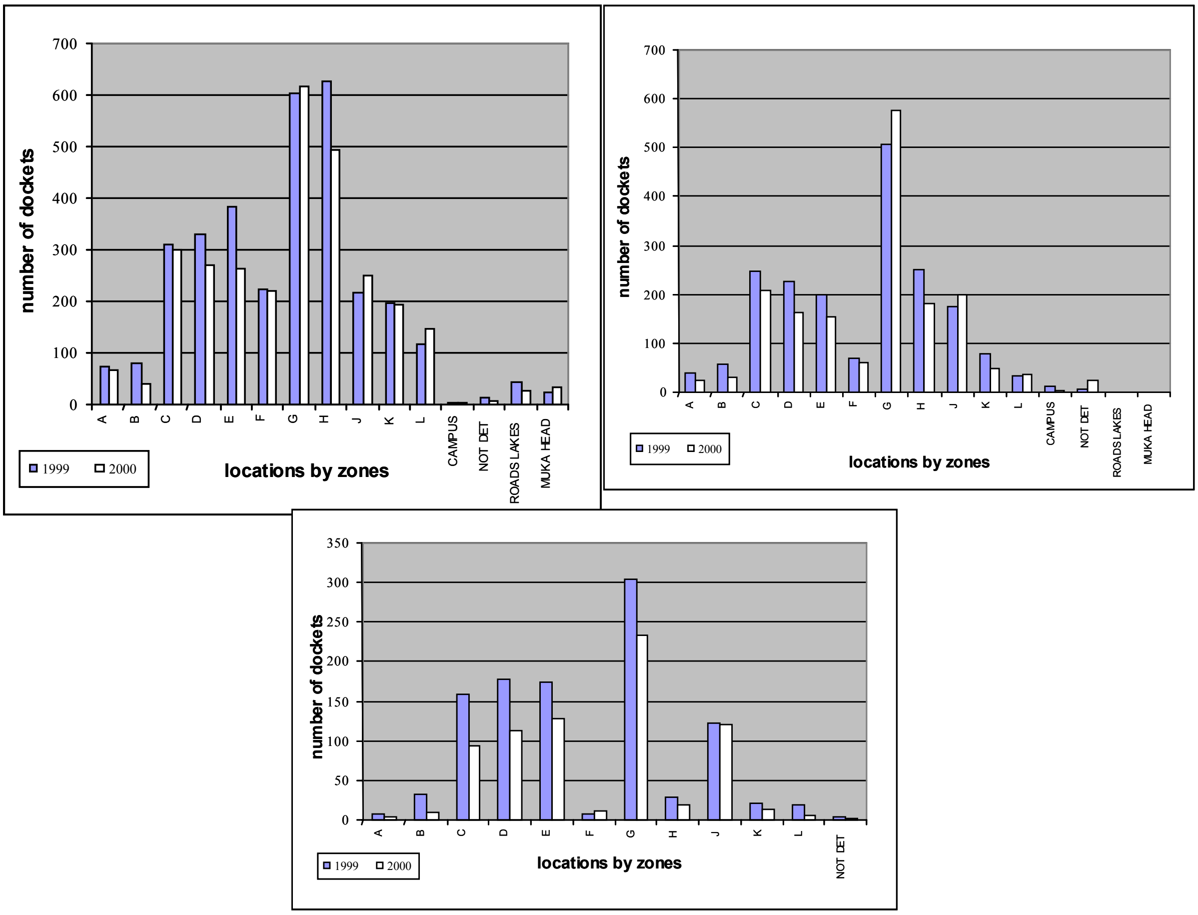


Figure 6: Locations by completed work orders in civil, electrical & mechanical sections, clockwise from left,1999-2000

Patterns of user population and needs for maintenance

Our data indicated that the total number of users, ie. the number of enrolled students and the total number of staff tend to increase every year, albeit not consistently (Table 6). The biggest difference in annual change, showing a significant reduction, occurred in 1999, when the matriculation students are no longer placed in the main campus site. Also, at the time this report is being prepared, we have not considered the visitor's population as part of the users population.

Year	students	% change	staff	% change	Total
1994	12111		2748		14859
1995	13011	7.4%	2762	0.5%	15773
1996	14618	12.4%	2726	-1.3%	17344
1997	16435	12.4%	2701	-0.9%	19136
1998	18467	12.4%	2633	-2.5%	21100
1999	18795	1.8%	2635	0.1%	21430
2000	19321	2.8%	2645	0.4%	21966

Table 6: Total user population on Main campus

However, based on our data (Table 7), there seemed to be no relationship between the user population and the needs for maintenance. A simple correlation analysis between user population and the total number of dockets recorded resulted in a low coefficient (R= - 0.24).

Year	Total users	% change	Total dockets	% change
1994	14859		6333	
1995	15773	6.2%	6682	5.5%
1996	17344	10.0%	8361	25.1%
1997	19136	10.3%	7528	-10.0%
1998	21100	10.3%	5986	-20.5%
1999	21430	1.6%	6898	15.2%
2000	21966	2.5%	6139	-11.0%

Table 7: Percentage change of total user population and total number of completed work orders, 1994-2000

On the other hand, an analysis of the prevalence of completed work orders by months, showed that in the civil section the highest recorded completed work orders occurred in June, followed by the second highest in March and the third highest in September 2000. On the other hand, in 1999, April has recorded the highest number of completed work orders. In the electrical section, December 2000 has recorded the highest number of completed work orders, compared to 1999, when the month of June was recorded to have the highest. In the mechanical section, March 2000 has recorded the highest work orders. In 1999, the highest number was recorded in June.

Overall, our data suggested that June seemed to be the busiest month, where high numbers of dockets were reported from all sections (Figure 7). But more electrical and mechanical work was carried out in this month for both years. Alternatively, not much work orders were recorded in the months of January, February and November for both years.

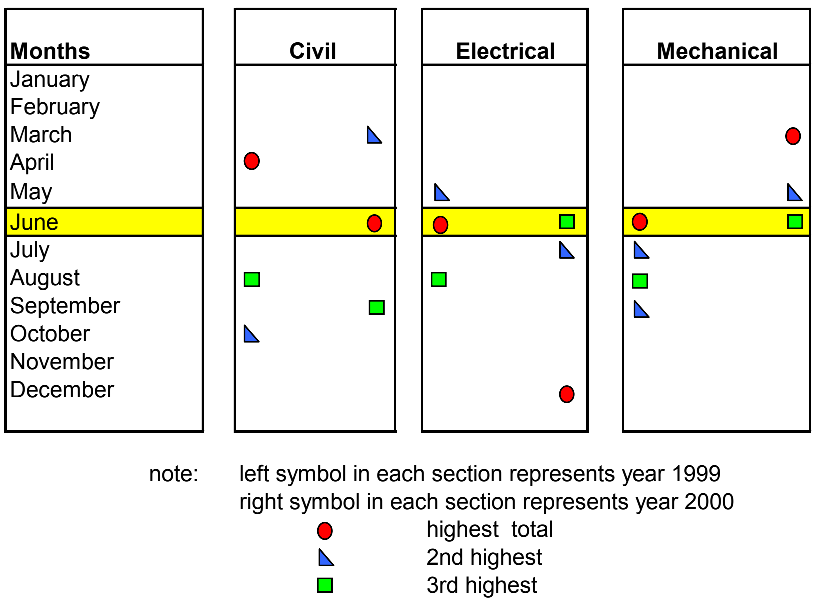


Figure 7: Prevalence of completed work orders by months, 1999-2000

Discussions

The results of the analysis above indicate some issues that need to be addressed relating to:

1. Maintenance management strategies
2. The accuracy of reporting complaints

1. Maintenance management strategies

Currently, the Unit operates on a reactive basis. Throughout the two years of docket analysis of more than 11 000 entries, planned maintenance have been mentioned perhaps four times in the mechanical listing. Obviously, the Unit lacks planned maintenance. When it does attempt toward planned preventive measures, the Unit would carry out condition surveys of academic and accommodation facilities to assess their state of maintenance and repairs. This only happens during the Session breaks between April – June each year.

Since the BEAM system has a wealth of data on maintenance, there is a lack of effort whereby entries are studied and utilized as a management tool. Potentially, two of the immediate contributions could be from: 1) the elements that repeatedly fail and 2) the space use definitions.

In the first, the type of defects corresponding to the elements and buildings involved are less clearly defined. If a large number of dockets area received on pipes, water supply, cisterns and sinks, there is confusion in understanding the causes of defect. Could it be due to a disruption in the water supply? Or could it be due to a leakage or blockage (MISS, n.d.)?

In the second, the identification of room codes is insufficient to understand the use of the space and the complaints/defects being reported. We are inundated with space uses. Our database of campus buildings showed a mean GFA of 15 514 sq. ft., a median of 6720 sq. ft., and mode of 25750 sq. ft., of various space use types.

Therefore in the first, we believe there should be a guideline on the use of or the total replacement of elements in future designs of buildings. In the second, space use definitions of the reported buildings should be incorporated at the input level.

2. The accuracy of reporting complaints

In the process of translating the data into our database, we frequently encounter problems of tracking the nature of defects being reported. We think this occurred at the point while taking the descriptions of complaints - there has been inconsistent reporting of failures. At this juncture, a more accurate description, will assist toward building the classification system in the existing software, for example, the ability to classify *defects* from the source of defects, and *elements* from the main elements involved. Similarly, a checklist could be drawn to enable conditions survey be carried out based on the classificatory systems that has been developed. This development could initially be unique to the main campus buildings.

Conclusions and recommendations

Based on our investigations, we feel that the BEAM system is presently supporting operational purposes alone. We question if we have set the right targets for a better performance in the future of maintenance? Additionally, we ask, how could targets be set when management reports are not prepared quickly?

It is necessary that improvements and modifications are made to the present BEAM system. New fields could be added, and the classificatory system on elements and defects, could adopt existing guidelines found in existing literature (Wordsworth, 2001; Kaiser, 1993). Additionally, it could also be more beneficial, if indents are studied together. The true picture of work completed, comes from the indents issued. Similarly, deferred and rejected dockets should also be considered.

And it is indeed timely that planned maintenance strategies be adopted – preventive and predictive. The former is most applicable to mechanical work orders and the latter as a follow-up from the audit of facilities elements. Literature states that, the advantages of these strategies would create low maintenance costs. We think than when maintenance costs are kept low, this will free up financial resources to be spent on other initiatives, particularly better quality new builds.

But what is perhaps more crucial, is satisfying the customers. Users, as customers, should take charge of their environment. Satisfied users will inevitably make more productive people, which in the long run will benefit the University. We think, a user-friendly maintenance system could facilitate this move.

Acknowledgements

The author acknowledges the research grant provided by Universiti Sains Malaysia, Penang that has resulted in this article.

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Decentralising Asset Management in a University environment using web enabled technology.

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Abstract: *With the advent of web technology and the proliferation of web enabled systems in the last few years, remote Computer Aided Facilities Management (CAFM) and Computer Integrated Facilities Management (CIFM) are starting to assume a more significant role, one of helping de-centralise and disseminate information management. Computerised asset management (AM) has been widely discussed and various conceptual models, benchmarking and best practice principles have been proposed in the past. However the vast majority of case studies involved private corporations as well as public sector institutions with majority using single-site studies, but very little dealt with the education sector spread on multi-sites. The effective management of assets, in terms of property, infrastructure as well as plant, furniture and equipment (F&E), forms an integral part of the management of the University of Sydney's (USYD) overall resources in order to achieve its goals towards excellence in teaching and research. This paper reviews the current, more or less, manual centralised AM[1] system at USYD and proposes a framework for a more decentralised web based AM system built on the existing CIFM system used by the Facilities Management Office (FMO). The paper further examines the strength and weaknesses of the current and proposed systems and the possible application of the proposed system to a range of AM scenarios outside the context of the University environment.*

Keywords: Decentralising asset management, Multi-Site asset management, Multi-Modular, Integrated, Information ownership, Accountability.

Challenges for the New Millennium

The 1990's heralded a brave new world, one of instant global communication, collaborative environments and information dissemination through the Internet and the World Wide Web. The Internet paradigm is so powerful that it affected in some way almost all existing business technologies and solutions and perhaps is at last realizing the potential of the technological revolution evident over the past 50 years (Varcoe, 2000, p. 13, Cox, 2001, p. 26.8). The technology is relatively easy and cost effective to implement for the benefits it delivers while assuming widely distributed, but centrally managed information. According to Teicholz (2001, p. 25.17), the benefits of the Internet (and its associated manifestations in Intranets and Extranets) are clearly discernible and have been well defined and understood. Today, many current applications rely on a free browser to access centrally managed information by distributed users. Given that Information is an important element of business, the idea here is to involve more users with business information, in order to help improve workflow and business processes as well as the elimination of redundant data.

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[1] Reference to Asset Management in this paper is considered in terms of Furniture and Equipment, which are managed by individual Departments in conjunction with the Financial Services Division of the University of Sydney.

In addition to the Internet revolution, the last decade witnessed rapid developments in computer hardware. This in turn paved the way for more sophisticated software applications, in the field of Facilities Management (FM), in terms of Computer Aided Drafting (CAD), CAFM and CIFM systems.

First and second-generation web browser were mostly used by universities worldwide, since they were amongst the first institutions to adopt Internet strategies early on, primarily for education and research. However it was only a matter of time before a growing number of businesses saw the benefits of the web in terms of global reach and started developing technologies, which would render it more usable and accessible to a wider audience. By the time third generation web browsers came into use in the late 1990s, the Internet took on a more dynamic role whereby for example, interaction with and manipulation of relational databases in real time became a reality (for Static vs Dynamic information models see Finch and Davies, 2000, p.96). This in turn meant that remote access to CAFM and CIFM systems started assuming a more significant role, one of helping decentralise and disseminate information management on single or multi-site environments.

With the continuous drop in federal funding in the last decade, Facilities Departments within Australian universities experienced a period fraught with significant changes in their business practices and restructuring to meet tighter budgets. As a result it became a matter of urgency for the FMO, to look at consolidating its practices. Part of this was to bring in new methodologies and technologies in order to maintain the University's facilities in good condition, thus allowing the academic divisions to be in a better position in order to deliver first-class teaching and research programs. This in turn meant the reliance on the strategic management and effective use of the University's assets, in terms of property, infrastructure as well as plant and F&E.

Facilities Management at USYD

Established in 1850, USYD is Australia's oldest university, with approximately 40,000 students and 5,500 staff spread over 600 buildings (equivalent to a large country town with associated services and infrastructure), which in turn are distributed over 15 campuses, *figure 1*. The remote nature of some of those campuses, combined with the vastness of the Australian landscape, render the idea of delivering reliable centralised Facilities and AM services a challenge to modern day Facilities Managers and Users alike. According to Davies (2002) "the University's investment in it's assets is significant, with property valued at approximately $1.9 billion of which $263 million is related to infrastructure, plant and equipment as well as computer equipment."

The FMO is responsible for planning, development, maintenance and operations of the University's facilities. FMO carries out this responsibility through its four operational groups; Facilities Strategic Planning, Project Services, Facilities Services and Environment and Heritage. Following is an extract of the FM information scope at USYD:

- **629** buildings owned by the University of which **470** buildings are maintained by the FMO.

- **19,000+** rooms on **1074** floors maintained by the FMO (to date, data of 5 campuses only entered into the system).
- **550,000+** sqm (5.4Msqf) of floor space maintained by the FMO.
- **22,000+** Items of plant (Mechanical, Electrical and Fire etc) and around **37,000** preventive maintenance schedules and increasing (to date, data of 3 campuses only entered into the system).
- **16,000** average of work requests (WR) p.a. and increasing (current WR from 3 campuses only).

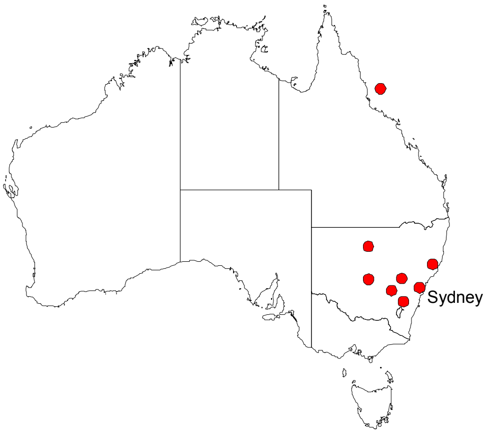

Figure 1: Remote campus locations of USYD.

Strategic Nature of a CIFM System at USYD

In the past two decades, databases proliferated around the University environment from central systems (like finance, student and HR systems) in their various reincarnations, to the 'feral' more localised financial and specialised systems. The lack of integration between those disparate systems often resulted in the duplication of efforts, in terms of collecting and managing data thereby increasing data redundancy. This unworkable situation prompted two major reviews in the past few years. The first reviewed the existing FM systems within FMO and the second was a more general, University wide investigation. However both reviews identified the importance, where possible, of a more integrated approach between the plethora of existing systems University wide. Thus making the University's 'corporate knowledge' more accessible, and in the process reducing the data redundancy factor to a minimum.

FMO initiated its internal FM system 'integration process' in 1999, thereby reducing the number of FM systems used and consolidating them into a single, multi modular[2] CIFM system, Archibus/FM™[3], and as a first step, porting some of its functions onto the web. This gave faculty and department managers for the first time ever, access to graphically report, in real time, on the spatial areas they occupy. In the near future

[2] By multi-modular system we mean an open system that is flexible enough, in terms of customisation and integration, to cater for most of the Facilities and AM divisions instead of being a 'specialist' system tailored for one or two divisions, e.g. Space and Building Management.

[3] Archibus/FM™ is a CAFM program, which is a fusion of a relational database, CAD, graphics and spreadsheet application features. A number of application modules run on top of this unique computer application, which allows users to follow the facilities management methods from start to finish within one environment – an example of a Multi-Modular CAFM system.

those same users would be able to report on the location of their assets by faculty, department, employee or by room, thus further empowering and assisting them when making strategic decisions. This in turn makes the CIFM system more strategic in nature thereby increasing the significance the FMO has in the role of managing spatial and work related information (Gabriel et al., 2001, pp 157-179).

Computer Integrated Facilities Management at USYD

In 1995, the FMO put in place a five-year program In order to implement a CAFM system, since a more integrated approach was required following the FM systems review. A multi-modular CIFM system was seen as an important tool in order to allow the FMO implement it's mission statement while operating within restricted budgets.

Phase one of this project (1995-1999) saw the CAD Group[4] physically survey a total of 7 campuses with approximately 425 buildings, totaling around 475,000 sqm and subsequently producing CAD drawings of architectural floor plans of the surveyed buildings using AutoCAD™. Phase two started in 1997 once part of the CAD data became available. The CAD Group then proceeded to perform 'Space Audits' along space standards on buildings in terms of usage and type (hierarchy and function). In turn, the audited data was entered into Archibus/FM™ and linked to the existing CAD drawings thus producing a space inventory. Space, by definition, incorporates the concept of location and when documented graphically it provides a context for graphically locating all other physical assets e.g. equipment, furnishings, people, etc. (Tracy, 2001, p. 21.1). Following is a list of Archibus/FM™ modules in use at the FMO as well as modules to be implemented, all of which rely in more than one way on the accuracy of the CAD and space databases:

- *Space Module:* (standard Archibus/FM™ module, implemented with minor modifications) the first module implemented by FMO in 1997. This module is at the core of the USYD CIFM system, since it links all information and properties related to the smallest space cell in the spatial hierarchy, the room, to the entity defining that same space in the CAD drawing. This then allows for the effective and intelligent management as well as reporting on any space and it's set of attributes in the database. Therefore the room plays an important role since its hierarchical and spatial attributes make it unique out of 19,000$^+$ current rooms in the database. For example, a room, of a particular type and function[5] with a defined room number, belongs to a particular department, is situated on a floor of a building, which in turn belongs to a campus, has a defined area in sq. meters (calculated from the CAD drawing) has a particular floor finish and has one or more employees who use it. This room could also have data, voice, mechanical, electrical and fire services, F&E and possibly items on the risk management (RM) list, like dangerous goods, as well as Art objects and could have some heritage significance etc., *figure 2*. Therefore all other modules in the USYD

[4] 'CAD Group' in this paper refers to the group of FMO employees (4 full time as well as up to 15 casuals) who have worked on this project since 1995. They included ½ a dozen postgraduate students in Architecture and Engineering as well as architects, system engineers, CAD and Space officers. The physical survey was carried out room-by-room using laser-measuring devices with an overall building tolerance of + or - 50mm.
[5] Standardised room attributes, for example a room could be of a laboratory type with a function of wet or dry laboratory etc.

CIFM system rely on the accuracy of the CAD and space database in order to function properly as illustrated in the USYD CIFM model, *figure 3*.

- *Service Desk Module:* (Customised by FMO, based on Building and Operations module) implemented in early 1999 in order to track and manage corrective WR lodged by USYD staff through the Service Desk. In an effort to improve this service the FMO launched the *e*-Service Desk during December 2001. This facility gives UYSD staff access via the web to lodge WR, receive e-mail updates concerning the status of WR and review the status of their WR directly from their workstations. All WR use the space data for problem location.

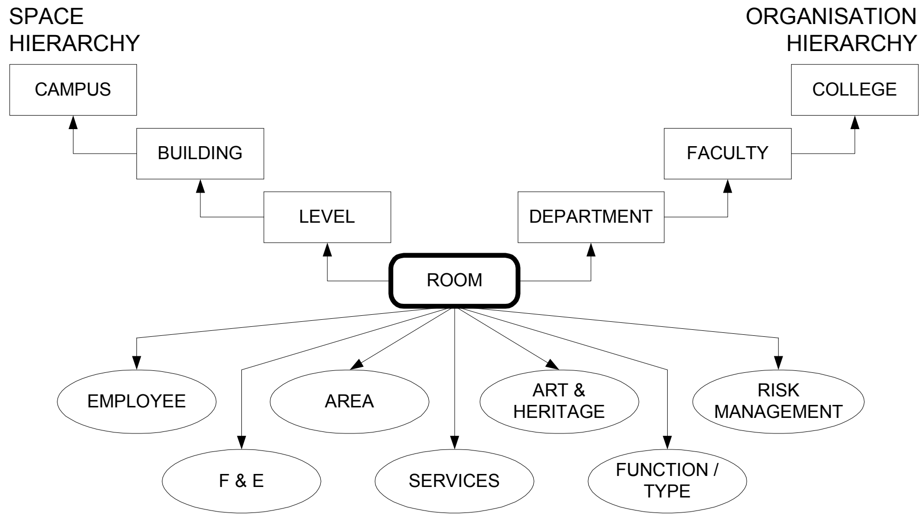

Figure 2: Space hierarchy model, with extract of attributes and objects attached to room level, in the CIFM system used by the FMO at USYD.

- *Building Operations:* (standard Archibus/FM module, Bldg & Opps with extensive modifications) Implemented in early 2000, a maintenance module which helps in managing building operation issues by providing tools for monitoring maintenance and repair jobs, scheduling employees and outside contractors to perform preventive and corrective maintenance jobs, budgeting costs, and analysing all aspects of the building operations process. All plant items use the space data for location and service.

- *Cleaning Module:* (Developed by FMO) Implemented early 2000, this module allows Facilities Services managers to prepare accurate reports for cleaning contract tenders as well as track existing cleaning contract and reports on building areas by floor finish in sqm meters. The space data is used to capture floor finish by room.

- *Venue Management:* (Developed by FMO) Integrates with the room booking/time tabling system and the student system. Some of it's main functions are; managing internal and external venues that include lawns etc. and their 'fitness' for purpose as well as reporting on analysis and utilisation of venues and efficiency of bookings by venues/campus location/No of hrs booked. Therefore full Integration with the space and Bldgs Opps modules allows for coordination between various users of the system in order to schedule Preventive

Maintenance on Mechanical/Electrical equipment in venues with minimal disturbance to venue users.

- *Access Module:* (Developed by FMO) is a module that catalogues and reports on disability access issues relying on the space data for location.

- *Art Module:* (Developed by FMO) The real benefit of a specialised art database, as a module in Archibus/FM™, is the integration of the management of space and buildings, maintenance and services with curatorial functions and AM of the art collection. This is essential for the security of the Art collection and encourages people to work together across departmental boundaries.

- *Heritage Module:* (Developed by FMO) captures the University's natural and built heritage assets by recording their significance and condition. It is also used to prioritise and record essential works that have been carried out and develop and implement responsible heritage management practices.

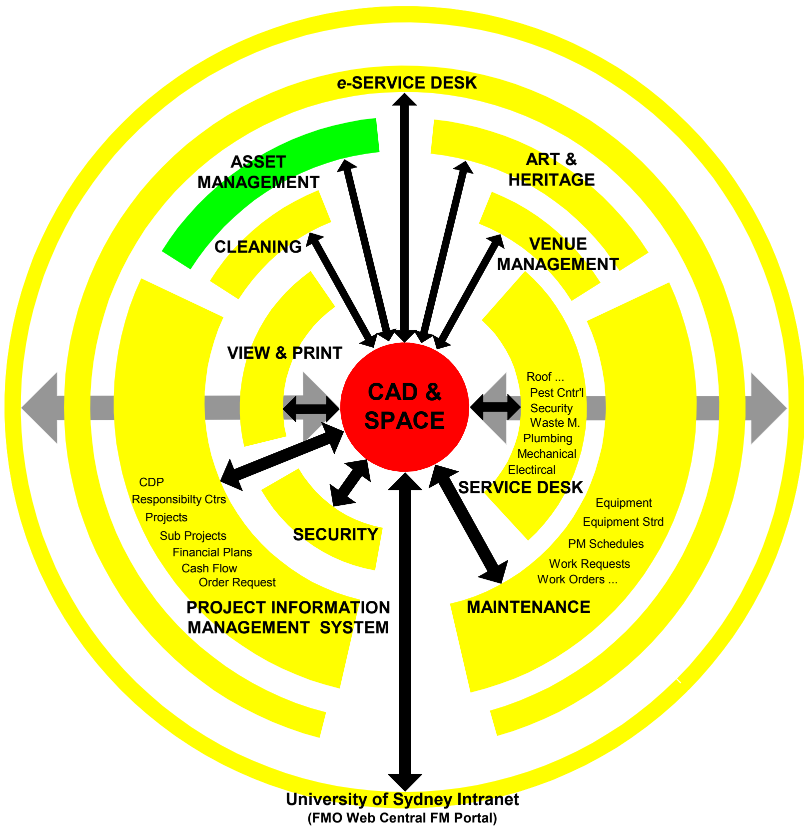

Figure 3: University of Sydney CIFM model.

- *PIMS Module:* (Developed by FMO) Project Management Information System, which integrates with the University's financial system, PeopleSoft™ also running on a Sybase™ SQL platform. PIMS allows project managers (PM) to manage projects and project funding details over 9 years (past 3, current + 5 future years). It also allows PM to manage sub projects within a project and their financial plans, cash flows and order details. It also integrates with Microsoft Project™ in order to manage phases and milestones. PIMS is another critical module, since it plays a major role in the *'notification system'* of the CIFM system (discussed later in paper).

- *Furniture & Equipment Module:* (Standard Archibus/FM – to be implemented) As a prospective AM tool, the F&E module within Archibus/FM™ would provide USYD an integrated approach to facilities and AM, through integration with CAD drawings and the space module. F&E would provide an electronic inventory, as a sub-ledger to the general ledger of PeopleSoft™ financial module, for the management of assets throughout the life cycle.

- *Risk Management:* (to be developed by FMO) would benefit both RM and end users, since the proposed module takes into consideration operational health and safety issues, allows for the location of dangerous goods stores, gene technology laboratories etc.

- *Telecommunication:* (Standard Archibus/FM™ – to be implemented) would for example allow the Information Technology Services (ITS) to locate the servers, cabling routes, down to the face plate location. ITS can benefit from overseeing physical location of all networked servers and networked computers, in turn maintained as assets by the Department Asset Managers (DAM) within USYD, locate them graphically and accurately for maintenance and trouble shooting etc.

Centralised Asset Management at USYD

According to Tan (2000, p. 17, citing DPWH, 1996), "assets exist primarily to support delivery of services. A comprehensive understanding of assets and their life cycle can allow asset owners and users to influence directly the quality of service delivery, and to optimise the value (use) and returns (benefits) from the assets under their control". Therefore in order to ensure cost-effective, reliable delivery of services in the University environment, the adoption of best practice AM is very important. This would cover the asset's whole of life cycle including, but not limited to, planning, acquisition, operation, maintenance, RM and disposal (Coonan, 2000, p. 41, Davies, 2002).

The Financial Accounting unit of the Financial Services Division (FSD) at USYD is responsible for the co-ordination of the annual financial accounts as well as AM amongst other things. The process of capturing and managing asset's details is at the moment carried out in conjunction with individual DAM. While the purchasing policy of the University is fairly decentralised, with departments acquiring assets directly, the management of those assets in terms of warranty, condition, registered location, current user, and monetary value is centralised through the PeopleSoft™ AM module, currently accessible only by the FSD.

At best, the current manual process of creating and managing assets can be described as laborious and time consuming. Laborious because DAMs have to maintain their own records of the department's assets locally, using at times satellite financial systems or simple spreadsheets and "completing numerous paper forms to advise of relocations and disposal to the Financial Accounting Unit (Davies, 2002)." Time consuming since it is not done in real time, with assets entered twice and managed at 2 levels, the departmental and FSD levels.

Figure 4 shows the current AM model used at USYD, whereby the FSD distributes on an annual basis, by internal mail, printed reports to the various DAM detailing the assets in their possession. It is then the DAM responsibility to go through those reports and check whether anything has changed since the last audit and update them where necessary. The report is fairly limited in the information it conveys, in terms of asset description, location, monetary value and current registered users (which are often outdated). The reports are returned to the FSD, by internal mail, where they are used to update the central AM database.

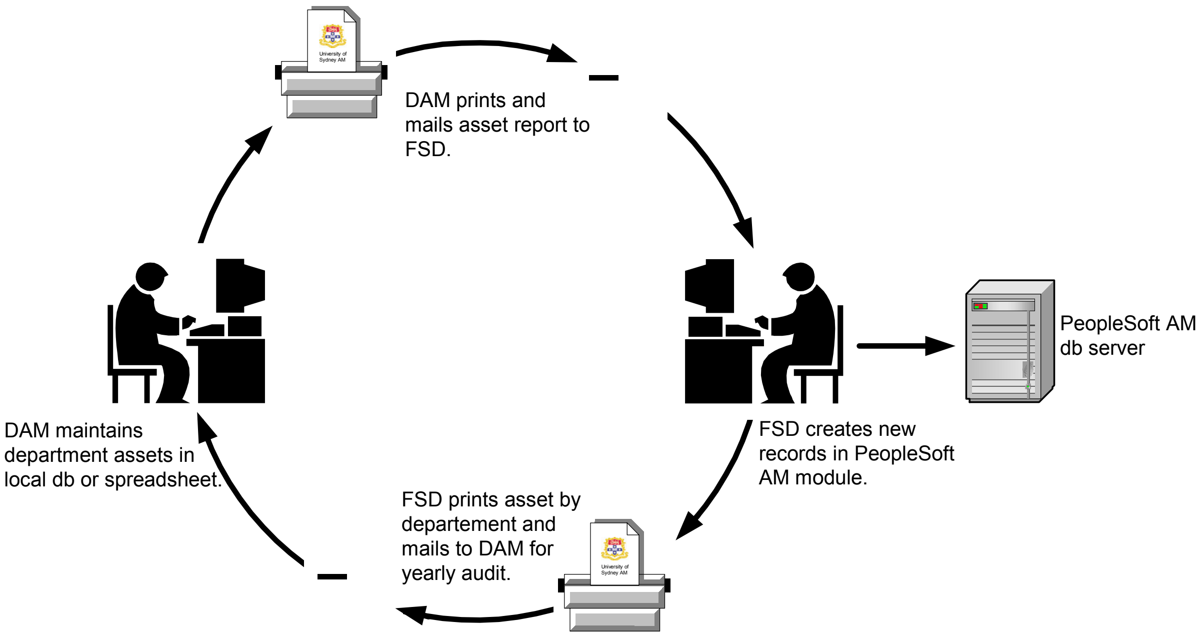

Figure 4: Current centralised AM model at USYD.

Since it's deployment, this model has been unsuccessful and did not live up to expectations in terms of AM, with the high level reporting well below satisfactory levels. Following is a summary of problematic points in the current AM model:

- Duplication of data capture by DAM and FSD creates situations of potential user error and data redundancy.
- Reports sent to DAM for checking often have redundant information, which the DAM had requested the FSD to remove after the previous audit.
- Inefficient management of asset auditing, which in turn translates into lengthy cycle time for stock takes and reconciliation of general ledger in PeopleSoft™.
- The current system does not have the capabilities to capture historical details on assets, e.g. current registered user/location/move history and maintenance history.
- The current system does not provide adequate tools in order to allow DAM to monitor appreciation or depreciation of their assets.
- The current system does not have the capabilities of graphically reporting on location of assets.
- The current version of PeopleSoft™ AM module used by the FSD does not support bar coding of assets.

- The current version of PeopleSoft™ AM module used by the FSD does not support web integration and runs on USYD network through Citrix™ Nfuse.
- The current version of PeopleSoft™ AM module used by the FSD is not fully integrated with the PeopleSoft™ financial module and data is exchanged through a manual interface.
- In the absence of direct access to information stored on the PeopleSoft™ AM module numerous satellite financial systems were created by departments in order to monitor and track their assets.

Decentralising Asset Management at USYD

In order to overcome the majority of issues highlighted previously, the logical and strategic solution would be to opt for a University wide decentralised AM model. The proposed model would be achieved by interfacing the existing PeopleSoft™ financial module with the FMO's CIFM system. The DAM will then be able to remotely manage assets, on the centralised FMO database, in real time through Web Asset Management (WAM) pages via the FMO web applications server, *figure 5*. On the other hand, the FSD will then be able to remotely access the FMO database through the Archibus/FM™ thin-client/server[6] setup in order to access more sophisticated, high level reporting tools.

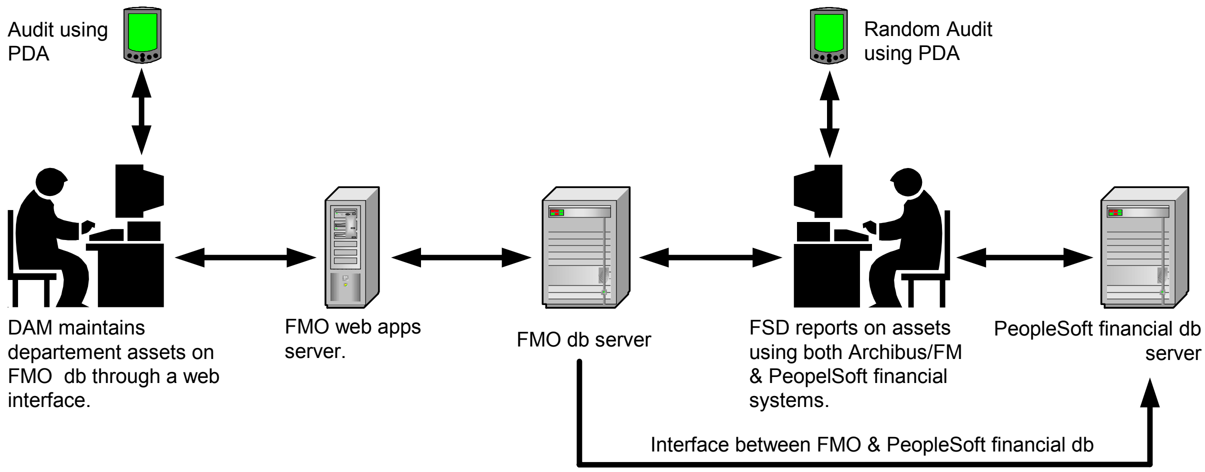

Figure 5: Proposed decentralised AM model at USYD.

Asset Management at Departmental level

At the departmental level, DAM will then take ownership of their data and therefore, through WAM, be able to edit asset's details in real time as well as use a variety of search forms to report on assets by standard, by value, by employee, by location, by maintenance history etc. DAM will be able to better manage asset details like, date of purchase, make/model, price, current location by room and move/location history (through move orders), serial number, condition, maintenance history, current

[6] The FMO and FSD are located on the same campus and the thin-client architecture will run on a gigabyte optic fibre backbone. Speed is not an issue here, but access to the FMO database via a thin-client will give the FSD access to more sophisticated adhoc as well as customised high level reporting tools. However, if the FSD choose to, they can always use WAM to access the database from anywhere on campus.

registered user(s), monetary value (appreciation, depreciation, cost of replacement etc.). Another important tool, accessible through WAM, is the proposed graphical reports to locate each individual asset, using floor plans with asset symbols and asset photographs. This attribute of graphic location is often missing from other AM systems (Tracy, 2001, p21.2).

For auditing purposes, DAM will then utilise a Personal Digital Assistant[7] (PDA) equipped with a bar code scanner to carry out detailed audits on an as need basis. The PDA in turn interfaces with the FMO database to upload/download asset details.

Asset Management at FSD level

The FSD will be able to access executive, high level reporting on University assets through the FMO database using the Archibus/FM™ thin-client. They will be able to report on assets by standard, by value, by department, by room, by building, by campus, by risk factor, or a combination e.g. by building/department/asset/value. They would also have the ability to access assets graphically through Archibus/FM™ and WAM. However WAM will allow them to graphically drill down through the drawings from campus, to building, to level, to room and asset. This kind of reporting becomes very important since it can be used by a multitude of administrative areas across USYD, e.g. RM could report graphically by campus, on buildings with high-risk equipment etc. Also available to FSD, is the ability to use PDA for carrying out random spot check audits throughout USYD.

Benefits of Integrated Decentralised Asset Management at USYD

An important aspect of a CIFM system is that it provides a set of interactive tools whereby groups of users, from diverse sections of an organisation, can benefit from data maintained by other groups and vice versa. An example here would see the DAM benefiting from up-to-date space data (maintained by FMO) to accurately locate their assets, and RM would benefit from the accurate location of those assets in order to report on the location of high-risk equipment. Similarly, the FMO Trades Services Group (TSG) could use the asset location/standard to schedule tests on ‘portable electronic appliances’ according to Australian Standards.

Having said that, such a large CIFM system will require constant on-going maintenance, by the stakeholders, in terms of keeping the database up-to-date. Falling behind on such an important task could spell disaster. Therefore a crucial part of developing the AM system at USYD would be to perform thorough process modeling, given that it helps clarify the existing problem, which the proposed system is attempting to solve, and the way it goes about solving that problem (for process modeling see Alter, 1999, p. 75).

Needless to say that the immense gains from using a decentralised AM system far outweighs any fears of possible bureaucratic data management. The proposed decentralised AM system will address the problematic points of the exiting centralised system, identified previously, in the following way:

[7] In this case the PDA is a Symbol SPT1800™ converted Palm Pilot™, equipped with a bar code scanner, which interfaces with Archibus/FM™.

- Data ownership makes DAM accountable and will eliminate redundant data capture.
- Better asset auditing as well as significant reduction in time and effort of cycle time for stock takes and reconciliation of general ledger, because of DAM auditing and updating asset details directly. In all likelihood, the FSD and perhaps the CAD group using PDA, will perform random spot check audits as well. This way the FSD can concentrate more on verifying the data flowing in from the FMO database into PeopleSoft™ financial to reconcile the general ledger and satisfy the University auditors, as per *figure 5*.
- Better control of move management of assets through 'Move Order Process' and therefore capturing historical information on asset movement as well as current user/custodian. This in time will help in the analysis of the asset's maintenance history, since this is captured through the corrective WR of the Service Desk/*e*-Service Desk.
- The proposed system will provide DAM the capability to monitor asset's value in terms of appreciation and depreciation.
- The proposed system will allow DAM to locate assets graphically through the WAM. The system will populate the designated room with the appropriate asset symbol in real time. Further more updated CAD files, by the CAD group, are published automatically, into vector based web format files, on a daily basis and this to ensure that DAM are always using up-to-date floor plans.
- Archibus/FM™ supports bar coding of assets and that will be carried out by the DAM whenever they generate a new record for an asset. They will also have the capability to print bar code labels locally.
- The proposed system supports web integration through WAM and the FMO has already ported some space reports onto the web. Deploying FM functions and reports through WAM is cost effective and simple to use because of interface familiarity and any training will then stress more on the business processes rather than the GUI.
- The proposed system using WAM will then standardise AM across all departments and campuses of USYD and therefore dramatically reduce the need for alternative financial satellite systems.

Following are some of the functionalities that will also be available through the proposed decentralised AM system:

- Improve employee exit processes, ie asset recovery when an employee leaves the organisation or simply transfers from one department to another.
- Disposing of Assets - Asset life cycle management and recycling/disposal is carried out according to the University's environmental management program. Assets reaching retirement stage will be flagged and disposed off either through special recycling programs or will be automatically listed on a dedicated USYD web site for online or physical auctions, on regular intervals during the year.
- Service Desk/e-Service Desk - Break down or power failure that affects particular rooms, where critical assets are involved, would then alert TSG through WR system, since assets are flagged by degree of importance.
- The ability to graphically drill down through vector based web formatted drawings from campus, to building, floor, room, and to asset details.

- Notification procedures – This central function is probably one of the most important features of FMO's CIFM system. PM at FMO use the PIMS module for all capital and refurbishment work. At the onset of any project, the PM will set out the boundary of the space to be refurbished on the appropriate CAD drawing(s) using a special layer, which is then picked up by PIMS, through the space module. This process will then flag any assets, plant items, artwork etc. that fall within that particular area of the building and automatically notify the PM and the appropriate end users of the ensuing situation. For example, the CIFM system will automatically notify DAM by listing assets located in the area earmarked for refurbishment. Thus giving them enough time to get in touch with the PM for more details on the proposed work to see if there is the need to protect assets or even consider temporary relocation. Similar notifications will be sent to other users of the FMO system, like for example the art curator if any artwork will be affected by the proposed work. On the other hand, If DAM try to use the WAM to locate assets in an area already earmarked for refurbishment by a PM, the system will notify them of any impending refurbishment projects with dates and PM contact details.

Summary

DAM at USYD are responsible for managing a substantial resource that encompasses a broad range of assets. They are also responsible for managing substantial expenditure on maintenance, repair and asset renewal. As a result it is their responsibility to optimise their expenditure and to maximise the value of the asset over its life cycle. This however cannot be achieved using the existing centralised AM system because of the limitations discussed in this paper. Therefore the proposed decentralised model is a radical advance away from the centralised model currently in place, since it empowers DAM to take ownership and accountability of their own assets. Having said that, the benefits of implementing such a model are not only limited to education institutions but can just as well be adapted to a range of scenarios and situations from, large global institutions to local area governments.

In the current climate of reduced government funding, it is critical that all departments manage their assets in a proactive and cost effective manner. This is achieved by integrating accurate asset performance information as well as corporate and strategic asset planning with the needs of the University community in the delivery of the teaching and research programs. Consequently all investment decisions for new assets need to be matched against the business aims of the organisation.

A decentralised AM model as part of a CIFM system will increase the importance of proper data capture and management in terms of best practice, which in turn lead to superior performance as well as overall productivity. Nevertheless, productivity does not improve because information is captured, it improves because it is properly managed in order to make timely better-informed decisions.

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TRAM2 as Effective Repair & Maintenance Management

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Abstract: *Postal Life Insurance Welfare Corporation (KAMPO in Japanese), subsidiary company of Japanese Postal Services Agency, has operated 115 hotels and health facilities in Japan since 1962 as public sector, with total floor area reaching to 877,000 sq.m. with total land area of over 3.5 million sq.m. Total assets in terms of price are valued at 482 billion yen (=4 billion dollars). We also have huge customers. Total number of customers is 13 million people in a year, which is equivalent 24.1 sq.m. per person per a day. KAMPO has been faced on increasing R&M (Repair & Maintenance) cost. It is therefore that KAMPO has launched Total Repair & Maintenance Management (TRAM2). The characteristics of TRAM2 are 1) Reduce Repair & Maintenance (R&M) cost dramatically (57% in R&M cost), 2) Reduce construction time (Shrink lead time), 3) Long Life for facilities (R&M is effective for total renewal.), 4) Balancing the budget (Good timing for R&M creates most adequate R&M), 5) Value added for customers increasing renewal effectiveness (CS up). The purpose of this paper is to introduce new approach to maintain hotel facilities using TRAM2 and the concept of TRAM2 which main tool is concentration of construction works is able to adopt other R&M issue.*

Keywords: Repair & Maintenance, LLC, TRAM2, VFM, public corporation

1 Introduction

The Japanese construction investment, which exceeded eighty-one trillion yen in 1990, has reduced to fifty-four trillion yen in 2003 showing a 33.3% drop, following stagnation of the Japanese economy (Figure 1). We focus on some big changes to the Japanese Construction industry.

First, repair and maintenance cost (R&M cost) has dramatically increased while, like the UK construction investment, the proportion of repair and maintenance to new investment has decreased (Figure 2). Second, clients are requesting severe reductions in the construction cost. These trend shows that the R&M market will grow and the demand for decreases in the construction cost will be a hot issue in the near future.

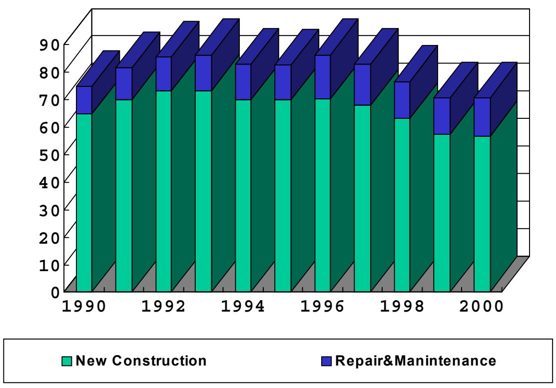

Figure 1: Construction market (Japan)

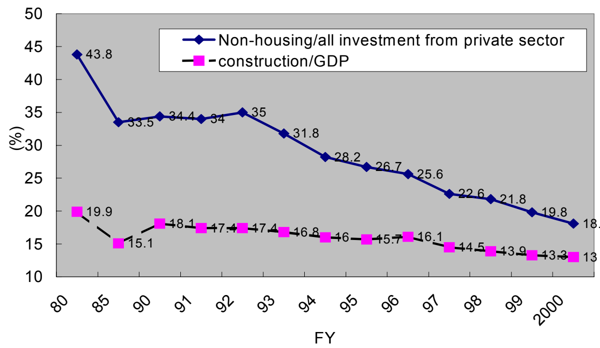

Figure 2: Construction Output (Japan)

2 Characteristics of KAMPO Facilities

Postal Life Insurance Welfare Corporation (KAMPO in Japanese), a subsidiary company of the Japanese Postal Services Agency, has operated 115 hotels and health facilities in Japan since 1962 as public sector, with total floor area reaching 877,000 sq.m. with a total land area of over 3.5 million sq.m. (examples are shown in Figure 3). Total assets in terms of price are valued at 482 billion yen (=4 billion US dollars). These facilities are built to improve health and welfare for the people who join postal life insurance by government management. KAMPO has many facilities for the aged, a medical-examination institution, a recreation institution, etc (Figure 4). We also have a huge number of customers (13 million people in a year) which is equivalent to 24.1 sq.m. per person per day (Figure 5). Half of the customers are over sixty years old.

Figure 3: Postal Life Insurance (KAMPO) Facilities

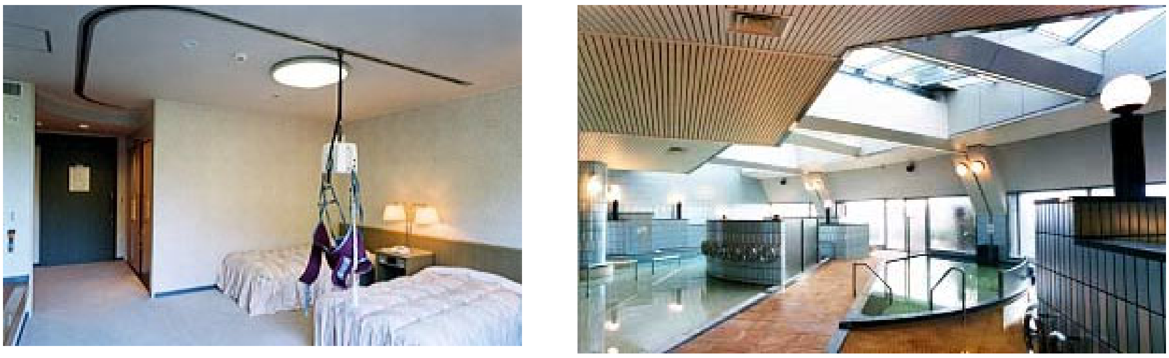

Figure 4: Facilities for elderly and handicapped customers

Therefore, KAMPO has a tendency to have many repair works to hot spring or barrier-free facilities. For example, a handrail is installed in every floor's corridor, and the drawing room for the handicapped is equipped with a toilet and bathroom for wheelchair users. Moreover, the bed in the sitting room is arranged with substantial equipment, such as attachment to the ceiling of a run lift for moving to a toilet or a bathtub from a bed. In addition to this, installation of the handrail with no difference in level anywhere is promoted. R&M works apply to not only one institution but also to all 115 KAMPO facilities. Thus, new facilities and new items for customers produce a higher annual construction cost that has reached approximately 24 billion yen. It is necessary to reduce this construction cost, especially R&M component of the cost, for KAMPO to remain a viable business. About half of construction cost is R&M works; the other is for new building.

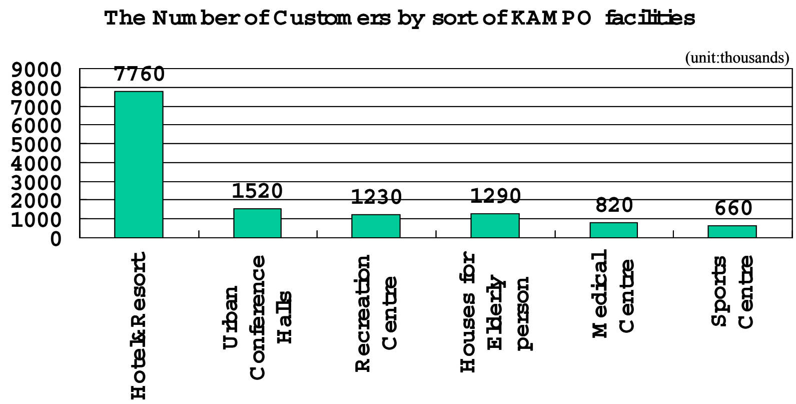

Figure 5: The number of customers by KAMPO facilities

3 Concentration of R&M works

3.1 Problems of Traditional R&M works

Since construction has been carried out when needed, there are many problems:
- The rise of the annual construction costs,
- Every facilities carrying out construction works every year,
- Construction works to decrease facility's function with reducing customer services, and
- The fluctuations in the construction budget.

3.2 Concentration method of R&M works

We introduced centralization of construction works, which raised efficiency for maintaining all KAMPO facilities. An important subject for KAMPO is how to control the maintenance budget to keep a standard level in all group facilities. For that purpose, it is necessary to judge the priority of repair by evaluation and comparison of each facility's present condition.

The cycle, which repairs degradation of a building, is made at a standard time according to former actual results. If construction does not coincide with this repair cycle, in accordance with degradation for every part of a building, you have to provide symptomatic treatment in each time. In order to promote coincidence intentionally, a cycle of ten years is set up, the component work with a halfway cycle extends its construction cycle, and what conversely has only a degree of degradation can be brought back to the fixed cycle, if the standard time is shortened (Figure 6). This not only extends repair time and continues dissatisfied state for function if work is not carried out.

A component in good state would extend beyond the common cycle time and the degree of degradation is shortened. It is important to consider whether such an operation is Value for Money (VFM) or not. Consequently, the R&M works accompanying degradation can be collected, and it becomes possible to lessen the tight budget burden.

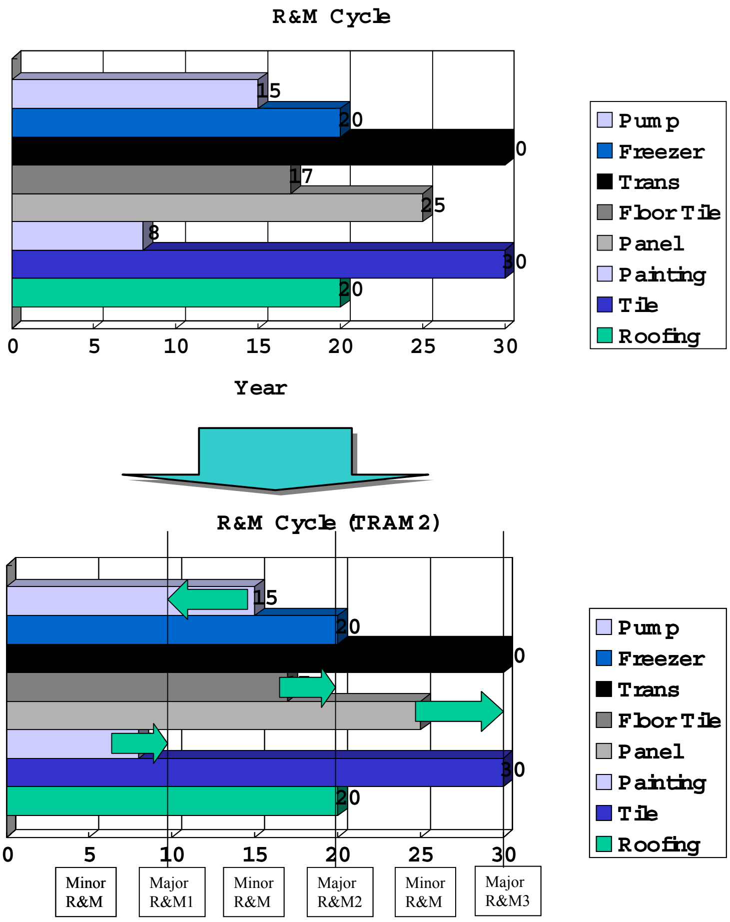

Figure 6: Concentration of R&M Cycle in KAMPO facilities

4 Theory of TRAM2

Traditional R&M works has been done by ad hoc user requirements and social needs, with a lot of construction expenditure. Consequently, the whole LCC has been dramatically increased with rising R&M expense.
KAMPO Total Repair and Maintenance Management (TRAM2) is able to cut down R&M cost, combining concentration of R&M works, building diagnostic system and R&M control system by database.

4.1 Constitution of TRAM2

TRAM2 is constituted as follows.
(1) Concentration necessary R&M works in every 10 years not every year
- The most important element of TRAM2 is concentration of R&M works. The LCC curtailment effect is large, combining with planned R&M works that can attain smoothing of expenditure.

(2) ALL KAMPO facilities are surveyed by specialists, architects and surveyors, in every year
- Only ten facilities were examined by the traditional system for the maintenance preservation of all KAMPO facilities, because it investigated one building

intensively from every detail point, and the building diagnosis has been drawn up. The budget was determined based on it and R&M works have been carried out. However, This method brings the last information of each institution in every ten years (115facilities/10facilities=11.5cycle/year), and exact building data cannot come to hand when needed. Now, customer needs have to be changed dramatically, so we have to respond to their needs as soon as possible. Then, TRAM2 is necessary to introduce the system in order to pick up our customer requirements for facilities. The core system is that specialists, such as architects and surveyors, visit all facilities for a half-day building check once a year, and make improvement report for facility's R&M works. Consequently, Customer satisfaction has been dramatically improved, and we can decide the improvement ranking numerically, based on the up-dated last data.

(3) Database for all KAMPO facilities is created.

- In the conventional R&M, finer correspondence, for example, adjustment of air-conditioning and a measure against leak in the roof, etc. is called for. Moreover, although construction is carried out in many cases as urgent matter in routine R&M, judging exactly whether it can be managed with concentration R&M works or urgency construction works. Then, the demand was arranged for every facility by created the database that R&M corresponding to needs should be carried out.

4.2 Change of LCC by TRAM2

Traditional R&M works has the tendency to increase R&M cost gradually as time goes on, because is had constructed according to repair needs or company facility policy such as providing barrier-free functions for all KAMPO facilities (Figure 7). Especially, there are a lot of urgent R&M works such as painting, fittings, etc. The peak in figure 7 shows intensive R&M works. It turns out that some peaks existed in the figure not only 10 and 20 years but 5, 7, 15 and 25 years. This shows R&M works has been done by requests from facilities without control and management. It also turns out that construction works continued in several years depending on the case.

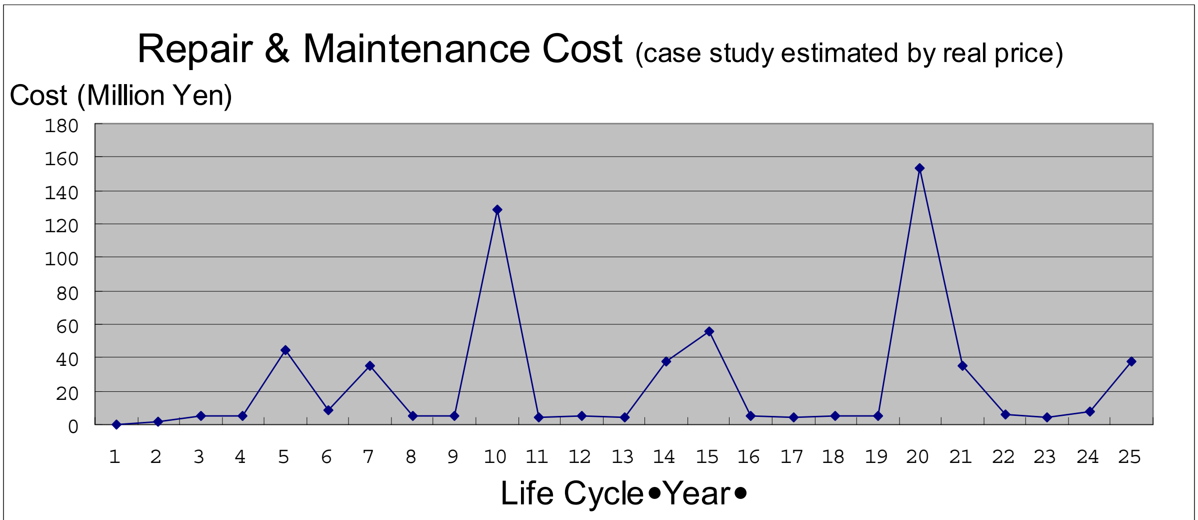

Figure 7: Life Cycle Cost (Source: KAMPO)

Moreover, the construction related cost that removes gas and electricity charges, etc. is examined by some examples of KAMPO facilities. When LCC is calculated as 60 years, initial investment (construction cost) is half of LCC cost. R&M cost is ranked second as about 20%, and, subsequently to initial cost. It is indispensable to cut down R&M cost from a viewpoint of LCC curtailment.

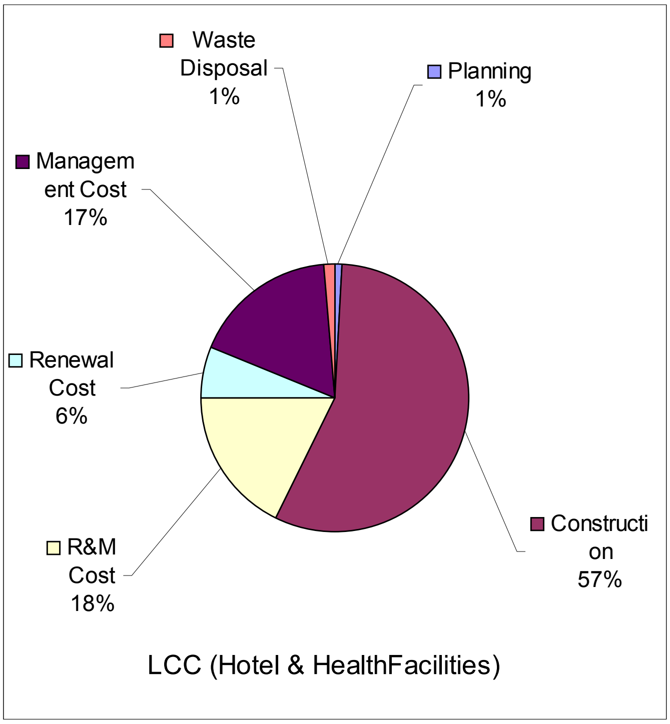

Figure 8: Life Cycle Cost by construction works (Source: KAMPO)

4.3 TRAM2 vs. Traditional RM

Figure 9 shows accumulation for every construction works based on large-scale office building's repair cost by BELCA (Building and Equipment Life Cycle Association of Japan) "The life cycle cost of a building (1999)". Since construction is carried out continuously, it turns out that the fixed amount of money is needed every year. Moreover, R&M cost in Traditional R&M tends to increase year by year. It is also increasing exponentially (Figure 9). On the other hand, TRAM2 is applied to this figure and concentration of R&M works is carried out. Then, in TRAM2, since concentration R&M works are carried out every ten years, the construction cost at the beginning of TRAM2 becomes higher than Traditional R&M. However, after 14 years later, the peak of TRAM2 is cheaper than Traditional R&M as total cost clearly. Moreover, since planned preservation construction is carried out, it has not led to increase the amount of money. A peak can be brought in 10th and 20th year, and it becomes easy to form a budget plan. Theoretically, 25 years later, curtailment of R&M cost will be attained about 57% of Traditional R&M by introduction of TRAM2.

Consequently, TRAM2 can be quite useful method for R&M, such as large-scale facilities and hotels.

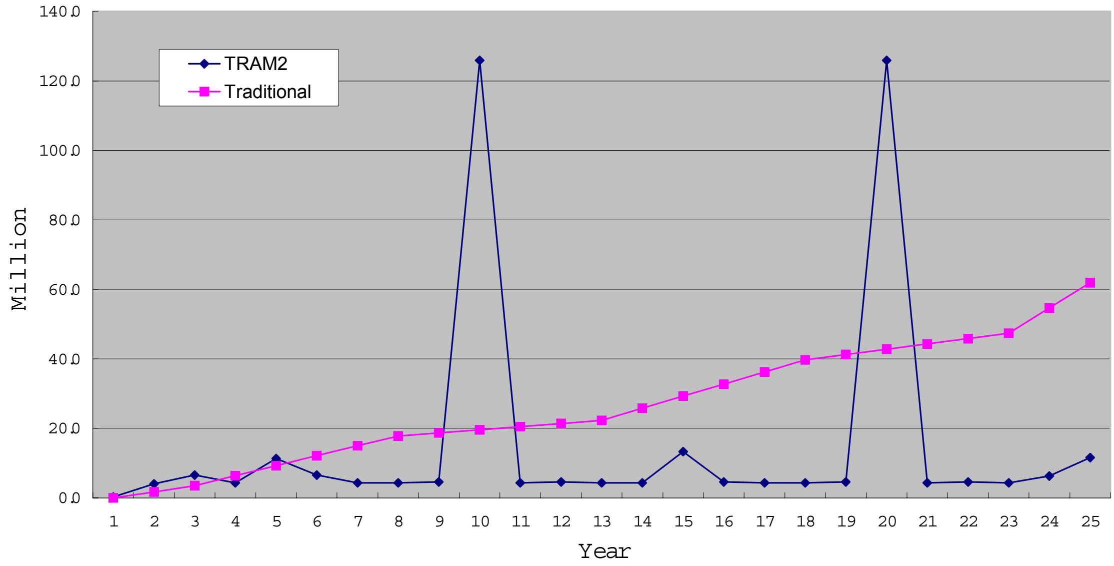

Figure 9: *TRAM2 vs. Traditional R&M by construction cost*

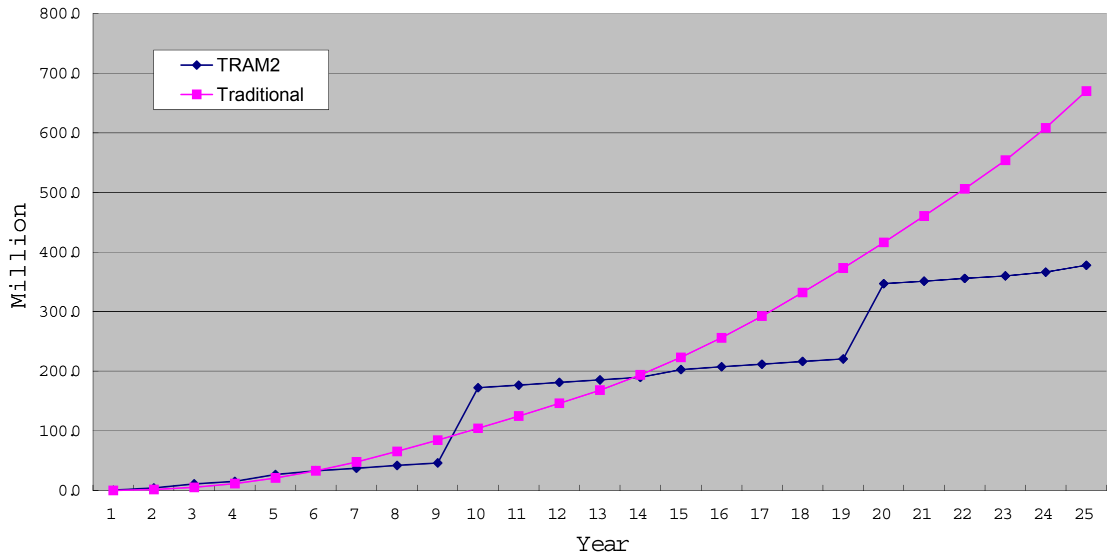

Figure 10: TRAM2 vs. Traditional R&M by LCC accumulation

4.4 The effect of TRAM2

Figure 7: Energy saving equipments (KAMPO new facility policy for environment)

In KAMPO, facility policy may be changed by change of service environment. As mentioned in previous chapter, we have to improve our facility as institution's preservation-request, such as, improvement of the barrier-free building method (in Japan, a duty of barrier-free construction is imposed about the building beyond some scale by law), anti-earthquake retrofit construction, energy-saving correspondence construction, etc. However, if R&M works has been done without necessary arrangement, a certain amount of construction will always be carried out. Then, it is necessary to adjust so that it may finish within a fiscal year with concentration of R&M works overlapping as much as possible at once. Thus, planned R&M works is attained by managing the maintenance preservation construction method with remarkably improvement of preservation works. It is TRAM2 to carry out intensively R&M works.

The following merits are created by TRAM2.

(1) Reduce Repair & Maintenance (R&M) cost dramatically (57% in R&M cost)
- The withdrawal cost and restoration cost are reducible with concentration of construction works.
- Curtailment of on-site cost (Overhead) can be performed by package of separated special contractors' R&M works.
- Curtailment of temporary work expense (expense concerning a scaffold, health & safety, etc.) can be performed.

(2) Value added for customers increasing renewal effectiveness (Customer Satisfaction (CS) growing up)
- Shrinking the period that cannot perform sufficient service to our customers by shortening construction time.
- Customer services have been attained by the improvement building function.

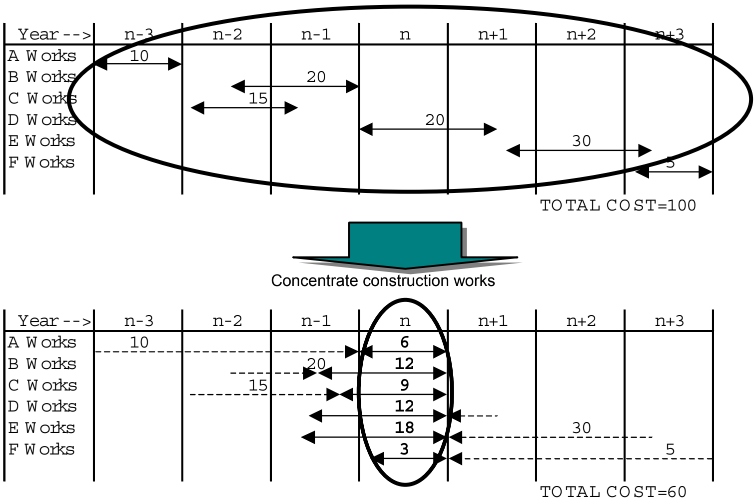

Figure 11: Concentration of R&M works

(3) Dramatic renewal effect for customers
- Customer does not care little improvement of facilities when construction works has been done continuously. In continuous construction works, the renewal effect is not realizable. However, the effectiveness between before and after construction becomes clear by introducing TRAM2, concentration construction works, to it.
- Customers are able to be provided with perfect service and lead to the improvement in service.

(4) Balancing the budget (Good timing for R&M creates most adequate R&M cost)
- Planned budget allotment is attained by TRAM2.

(5) Long Life for facilities (R&M is effective for total renewal)
- By constructing intensively, required improvement can carry out completely. Therefore, it becomes possible to lengthen the whole building life.
- In order to concentrate during a fixed period and to carry out required construction, a construction supervisor works by in-house engineers has been reduced.
- Although there were problems by safety control for customers etc. in order that a construction contractor might work each location of a building in Traditional R&M works, TRAM2 management increases safety standard for our customers and in-site works by concentration of construction works.

(6) Reduce construction time (Shrinking lead time)
- Compared with the total of the construction period that constructed separately as Traditional R&M works, TRAM2 can be smoothly carried out by centralizing adjustment during R&M works.

TRAM2 produces a plenty of merits for R&M works as mentioned.

4.5 The example of TRAM2

Concentration of R&M works by TRAM2 are mainly planned by big R&M works as a core work, such as air conditioning plant, accompanying renewal of electrical equipment, etc with related building works to one fiscal year.

It follows to collect R&M works as much as possible to each facility, and to carry it out about once ten years as a guide. Among those, big amount of R&M works is called "comprehensive preservation construction works (CPCW)."

KAMPO selects five facilities as examples of CPCW. The core of CPCW in this case is exchanging of air conditioning apparatus, piping, etc. with some minor R&M works such as some functional improvement, electrical equipment, and air-conditioning. After finishing these construction works, we examined the effectiveness of TRAM2 on theses case studies.

Consequently, as compared with Traditional R&M works, total construction cost was able to reduce about 3 - 7%. Moreover, when the ceiling was removed by exchanging the duct of air conditioning equipment, the light was simultaneously renewed to the energy-saving type with bright illumination. The scaffold has been used not only outer wall repair but also waterproofing construction, which reduces temporary construction cost. Consequently, it succeeded in cost reduction. Furthermore, it succeeded in inducing many effects, such as shortening of construction time and reduction of environmental load.

5 Conclusion

TRAM2 has become the greatest curtailment effect of R&M cost for KAMPO facilities as total asset management. Moreover, construction period and the amount of construction works could be reduced by TRAM2, and also TRAM2 has the strength for the environment accounting by reduction of materials. Furthermore, TRAM2 has some possibility of extracting LCC of a building, and it is a useful technique for Sustainable Design. However, TRAM2 has still begun since last two years. A long-term result will be asked for improvement in order to achieve more effective TRAM2.

We extend our trying to adopt TRAM2 to all KAMPO facilities and collect detail data of effectiveness of TRAM2. In near future, we would like to introduce further results of TRAM2.

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The application of performance-based maintenance contracts in The Netherlands

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Abstract:
In the Dutch building industry a shift occurs from new development to maintenance. Property managers in the housing sector as well as the commercial and the public buildings' sector concentrate on their core business. The execution of maintenance work and preceding steps to specify maintenance work are contracted out. Clients just want to formulate the desired performance of buildings and construction elements. A performance approach in maintenance provides opportunities to influence costs, financial risks and quality of the properties in the long-term.

OTB Research Institute is doing research on the state-of-the art of performance-based maintenance contracts with the focus on the clients, especially housing associations. The development of performance-based maintenance contracts is relatively new. They promise the optimal use of know-how of parties involved. However, benefits compared to traditional work are uncertain. Often definitions of performance-based maintenance are inconsistent. Moreover there seems to be a lot of misunderstanding amongst clients and contractors about a performance-based approach of maintenance work, performance criteria and requirements, contract periods and control on agreed performances. The application of performance-based maintenance contracts implies a condition-dependent approach to maintenance.

Keywords: Maintenance contracts; Performance requirements; Condition assessment; Defects

Introduction

In the Dutch building industry a shift occurs from new development to maintenance. Property managers in the housing sector as well as the commercial and the public buildings' sector concentrate on their core business. A similar development as design & construct in the case of new building takes place in maintenance work. Preceding steps to specify maintenance work, e.g. condition assessment, maintenance planning and specification of materials and workmanship are contracted out. Performance-based contracting or so-called 'co-makership' integrate the specification of maintenance work and the execution based on performance requirements. A principle of risk sharing amongst the building owner and the maintenance contractor takes place. Long-term maintenance performance contracts often shift condition assessment and planning to the contractor side. Finally contractors will also determine the years of maintenance work.

The share of housing associations on the Dutch professional maintenance market is about 25% (EIB, 1998). They contract out approximately 85% of the total sum of €2,5 billion. Housing associations adopt a business-like behaviour in their asset management and property management. They are willing to take new initiatives in technical management of their properties. Almost all housing associations carry out planned maintenance on the basis of a long-term maintenance program. A condition-dependent approach of planned maintenance is common used. The number of housing associations who set different maintenance performance levels in their planned maintenance increases. Those performance levels mostly involve technical, aesthetic and environmental performance of construction elements and decoration. Nowadays performance-based maintenance contracts attract attention of housing associations. They just want to formulate the desired performance of buildings and construction elements and consider the introduction of long-term maintenance contracts and performance-based contracts, as the means by which maintenance costs and quality can be managed in the longer term. But there seems to be a lot of misunderstanding amongst clients and contractors about a performance-based approach of maintenance work, performance criteria and requirements, contract periods and control on agreed performances.

Research project

Performance-based maintenance contracts are still in their infancy. Recently branch-organisations of housing associations and contractors have developed some models for performance-based contracts. Those contracts have been developed for one group of maintenance work or specific elements, for instance painting work (Bedrijfschap Schildersbedrijf, 1997), central heating installations (Aedes, 1998) and flat roofs (Berlee, 2001). A performance-based model contract for lift installations, designed by housing associations, lift manufacturers and contractors, will be finished this year. Dutch housing associations express high expectations of this new way of maintenance contracting.

The OTB Research Institute for Housing, Urban and Mobility Studies is doing research to the application of performance-based maintenance contracts by Dutch housing associations. This research project succeeds from research to the application of methods and instruments to measure performance loss of construction elements in an unambiguous way and the design of a model relationship between asset management and technical management by housing associations in The Netherlands (Straub, 2001). On the basis of available literature, case studies and expert meetings with clients, maintenance contractors and others, best practises, bottlenecks for a broader use and future research topics will be indicated. Five big housing associations owning together over 200.000 dwellings and the Dutch organisation for Building Research (Stichting Bouwresearch) sponsor this project.

Maintenance work by Dutch housing associations

On 1 January 2000, Dutch housing associations had almost 2.4 million dwellings in their possession, almost half of which were single family dwellings. Over 90% of the current social housing stock is post second World War. The ageing of the housing stock has increased the need for maintenance for all types of dwellings. The share of the total business costs of housing associations devoted to maintenance costs is 19%. The average annual maintenance and improvement expenditure in the social-rented sector amounts to about €1,100 per dwelling, a third of which involves refurbishment. Most housing associations execute responsive and re-let maintenance work by direct labour. Planned (preventive) maintenance, especially painting work, plumbing work and other maintenance of building services is contracted out by 70% of the housing associations (Straub, 2001). Apparently, the execution of maintenance work does not belong to their core business. Other main reasons for contracting out of maintenance work are insufficient capacity of direct labour connected to efficiency and flexibility and the need for specialist work.

Table 1 shows the ways in which housing associations contracted out different maintenance types in 1997. In this table we distinguish between offers from contractors and tenders. In most cases one or more contractors are directly invited to offer for a specialist work, e.g. painting work or roofing work, on the basis of project specifications ('work orders'). Open and restricted tenders that allow either every contractor or a small selective number of candidates, which meets the capability criteria to make a bid on the basis of building specifications are rare for housing associations. Most of the work is offered from one or several contractors. The differences between the maintenance types are small. Regular contracts are especially important for maintenance of building services. A regular contract means that a contractor executes recurring maintenance work for a specified period of time. In The Netherlands called 'contract work'. In the case of a regular relationship a contractor is available on call. One can compare this contract type to a measured term contract (Chanter and Swallow, 1996). In general it appears that client and contractors know each other well. That may encourage kinds of co-operation between housing associations and contractors.

	Fabric mainten.	Painting work	Plaster work	Stony materials	Plumbing work	Services Otherwise
Offer from one contractor	21	17	18	20	21	19
Offer from several contractors	66	54	44	49	50	45
Tender	17	10	6	8	9	7
Regular contract	11	12	10	8	15	35
Regular relationship	24	23	30	25	30	21
Differently	1	2	1	1	1	1
Total	100	100	100	100	100	100

Source: EIB, 1998.

Table 1 Ways of contracting by Dutch housing associations by maintenance type in 1997, in percentages

Ways of assignment

Table 2 shows the ways Dutch housing associations order the maintenance work. Traditional maintenance contracts are based upon a specified assignment. The contract focuses on prescribing items of work to be carried out over a given period. The building owner primarily carries the risks, and the contractor is paid on a schedule of rates or fee basis for maintaining the building. Normally the contractor agrees to execute the whole of the work for a stated ‘lump sum’, which is based on firm quantities, specifications and drawings (‘fixed price contract’). Specified assignments are most popular for all maintenance types. Second measure and value contracts are used a lot by housing associations. The contractor agrees to execute the work, at prices fixed in advance, fur units of work to be measured later.

In 1997 the share of performance-based contracts were small, except for painting work and maintenance work to building services, mainly lift installations and central heating installations; together responsible for over half of the total maintenance expenditures. We make some reservations about the used definitions of performance-based assignments. Other research indicate that respondents tend to name maintenance contract performance-based if they guarantee life span of used materials in the longer-term or involve repair of services failures within a certain time period (Straub, 2001). Those requirements might be used in performance-based contracts, but we think are not sufficient. On the other hand we think that the number of performance-based assignments has been considerably increased since 1997.

	Fabric mainten.	Painting work	Plaster work	Stony materials	Plumbing work	Services Otherwise
Specified assignment	61	52	41	52	48	43
Performance-based	3	12	4	4	6	18
Measure and value contract	30	27	34	31	33	26
Cost reimbursement contract	5	8	19	11	12	11
Differently	1	1	2	2	1	1
Total	100	100	100	100	100	100

Source: EIB, 1998.

Table 2 Ways of assignment contractors by Dutch housing associations by maintenance type in 1997, in percentages

Performance-based maintenance co-operation

The division between responsibilities and execution of the maintenance work seems to be one of the most important hindrances for essential innovations in new building. Contractors should be made responsible for design, materials, construction methods, standards of workmanship and the execution of the work. Property managers can focus on their core business and the planning and control of the technical management process. A performance-based approach could make this real.

The pros and cons

Advantages of a performance-based approach in maintenance work are evident. Clients mention the following (Berlee, 2001; Huizing and Scholte, 1997; Pries, 1997):

- minor needs for specialist knowledge;
- reducing of financial risks at the longer term;
- significant cost savings;
- improvement of performance and service;

- stimulants for innovations;
- steering processes on main points;
- reducing of paperwork.

Contractors often mention the benefits of having continuity in orders, the advantages of direct and sustainable relationships with clients that leads to a reduction of transaction costs, better understanding and service, efficient organisation and planning, and innovations of the whole maintenance process. However, performance-based (long-term) maintenance contracts will not just give benefits and profits for both parties. Clients fear disturbance of price competition and loss of knowledge about their own properties by long-term contracts. The Dutch construction industry is characterised by many small firms and some large companies, by heterogeneity in the types of firm and by strong prices competition in local markets (Bremer and Kok, 2000). Long-term contracts lead to a one-to-one relationship with contractors. We think competition can take place in requests for quotations by a selective number of candidates. Besides, price benefits are gained through good negotiations, independent of traditional or performance-based offers. Client will get enough management information, if they agree with contractors about contractors' reports over actual condition states of construction elements and executed maintenance work.

Conditions for a performance-based approach

A performance-based approach is bound by strict conditions. Pries (1997) names the following for new building:

- clients should formulate their desired performance requirements without technical specifications;
- there should be a relationship based on mutual trust between clients and contractors;
- contractors should really aim for integration of specialities;
- based on performance requirements, contractors should offer competitively with small costs margins;
- offers should not only be assessed on minimum prices;
- juridical implementations of performance-based contracts should be clear for all parties.

Although those conditions concern the performance approach and innovations in new buildings, most conditions also apply to maintenance and refurbishment. For contractors a performance-based approach means major changes in working processes, methods and need for information. Especially contractors need other skills and knowledge. In performance contracts the contractor takes the majority of the risk to supply an agreed performance level. In co-operation with suppliers and manufacturers, e.g. for paints and roofing systems, they have to guarantee life span of (new) materials and construction elements. A lot of small firms will not be able to adopt other ways of working and to take risks.

Performance requirements and condition assessment

According to the system of performance requirements of the Dutch Building Decree performance requirements consist of a functional description, a determination method and a limit value. A functional description without a determination method and a limit value is not sufficient for maintenance work.

Performance requirements and performance loss

The international standard ISO 6241 (ISO, 1984) classifies 14 categories of performance of building components. In reference to this standard, we distinguish between technical performance, fire safety, utility safety, social safety, health and the interior environment, functionality and availability, maintainability, aesthetic performance, energy performance, water performance, and sustainable use of materials. We apply those performance categories also to maintenance activities (Straub, 2001). As stated before, used maintenance performance levels mostly involve technical, aesthetic and environmental performance.

Figure 1 gives an overview of the type of requirements linked to performance-based and traditional maintenance contracts. Performance requirements in maintenance contracts regard to performance of construction elements (in the case of preventive and planned maintenance) and the execution of maintenance work (especially in the case of response and emergency maintenance).

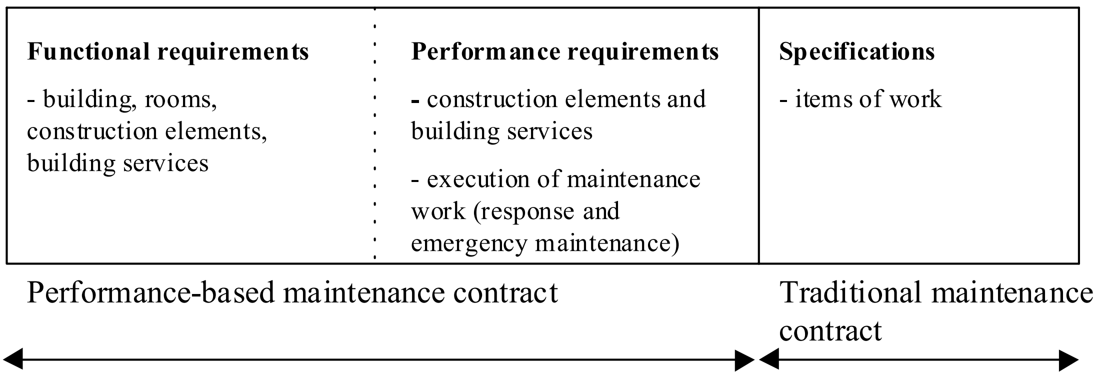

Figure 1 Type of requirements

Figure 2 shows some examples of the different type of requirements. Generally, we hold functional requirements qualitative and performance requirements quantitative. However, the difference between the kind of requirements is sometimes indistinct. We consider e.g. efficiency of central heating boilers as a performance requirement. A comparing functional requirement will be minimal required temperatures for the rooms of a building. The performance of construction elements can be determined by assessing defects. All construction elements have to contend with performance loss through ageing, use, and external causes.

Functional requirements	Performance requirements	Specifications
- fire safety, social safety, aesthetic performance, energy performance, etc.	- extent of defects, failures, efficiency, etc. - response time, production time, etc.	- materials to be used, methods of construction, standards of workmanship

Performance-based co-operation ◄──────► ◄──► Specified assignment

Figure 2 Examples of requirements

Condition-dependent approach

A condition-dependent approach to planned maintenance leads to a decoupling of quality assessment from the determination of maintenance activities (Straub, 2001). The inspector registers the actual state of the maintenance of the construction elements. Maintenance activities can be planned on the basis of this data and the desired performance level. The registration of the actual state of the maintenance takes place by listing the defects in the construction elements. A visual inspection is often sufficient. For a matter of fact, when a material or element degrades, there are some measurable properties, which vary with time and thus indicated degradation. That means that besides the inspectors' eyes, advanced instruments could sometimes be used to indicate and measure degradation. As a result of several research projects and the use of the method in the Dutch House Condition Survey, the process of condition assessment using standard lists of defects and a six-point scale has become popular by property managers, consultants and contractors in the Netherlands. The condition categories are of a chronological order that describe possibly occurring defects without references to remedial work, but just describe occurring defects. In a Brite Euram research project condition assessment is based upon functional, technical and aesthetic criteria (Damen Consultants et al, 1996). Those criteria have been related to most common defects, which may affect the element. Defects are classified in minor, serious and critical defects.

Implementation of performance-based maintenance contracts and especially variable performance levels requires the standardisation of performance loss and defects of maintenance cost elements. The essence of the matter is the difference in performance loss of construction elements before and after maintenance; that is to say, the defects present before and after maintenance work has been executed. Either the client, the contractor or a third party could assess the actual condition state of the construction elements. Budgets and maintenance performance levels can be calculated using the six-point condition scale as a measuring instrument (Straub, 2000).

New process

Traditionally processes for planned maintenance successively involves an inventory, condition assessment, planning, work specification, tendering, contract letting and execution of maintenance work. The principal does all tasks and subdivided processes. Contractors are just responsible for the realisation of maintenance work on the basis of technical specifications. The principal or an independent third party supervises the work. See figure 3. Obviously variants on this standard process exist. For instance the annual or short-term maintenance plan can be derived in several ways from the long-term planning.

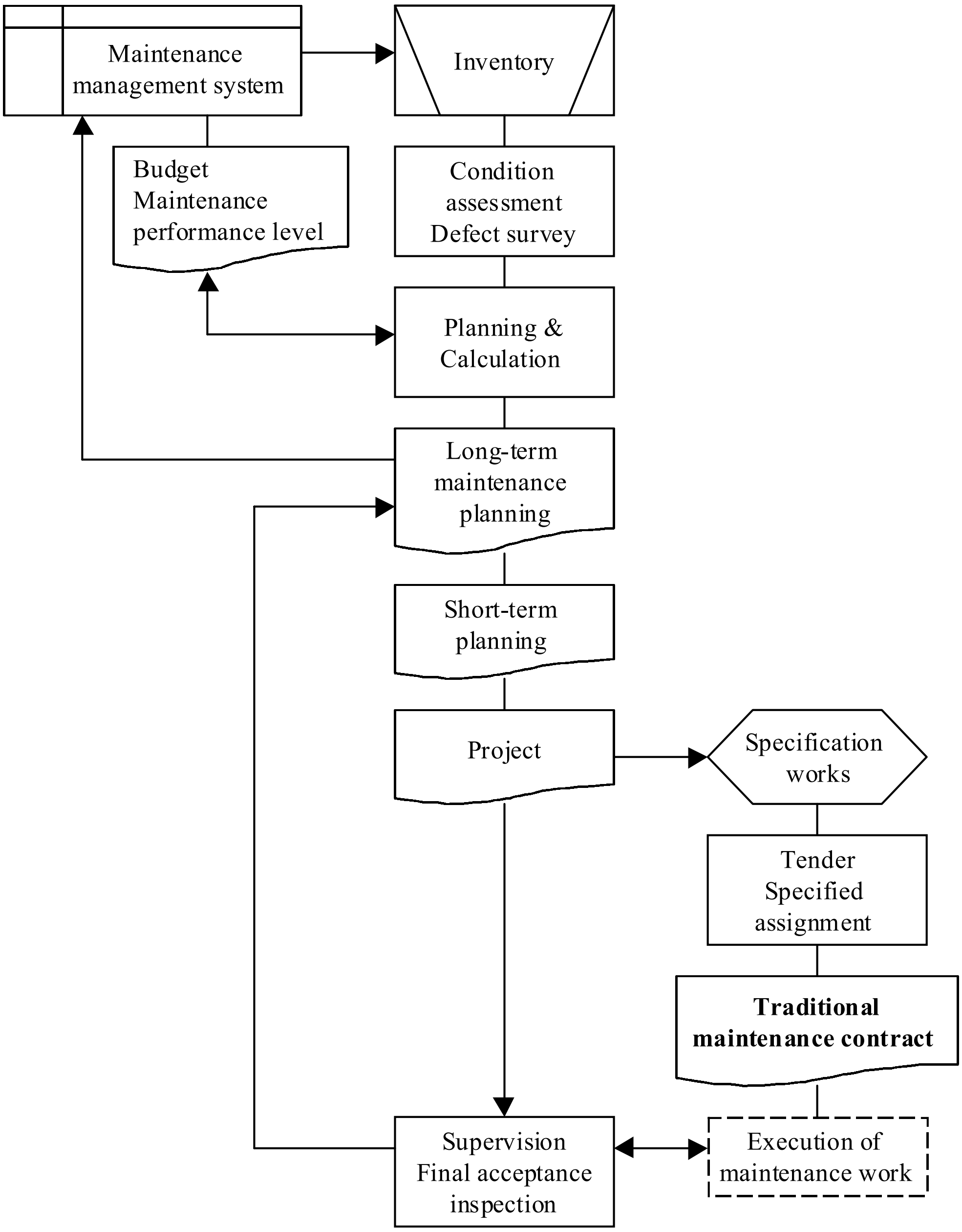

Figure 3 Traditional process planned maintenance

Contractors can be made responsible for preceding steps to specify the maintenance work. In so-called ‘intentions contracts’ intentions to co-operate with each other for a certain period are expressed. A contract is taken out yearly. Yearly maintenance work and costs are determined in consultation between the property manager and the maintenance contractor. The contractor is responsible for the long-term maintenance planning and annual plans by performing condition assessments. The contractor makes an offer for needed maintenance work, often using standard specifications. The property manager has to approve the tender. The benefit for the contractor is the planning and estimation of the work for a succession of years. The contractor takes no risks.

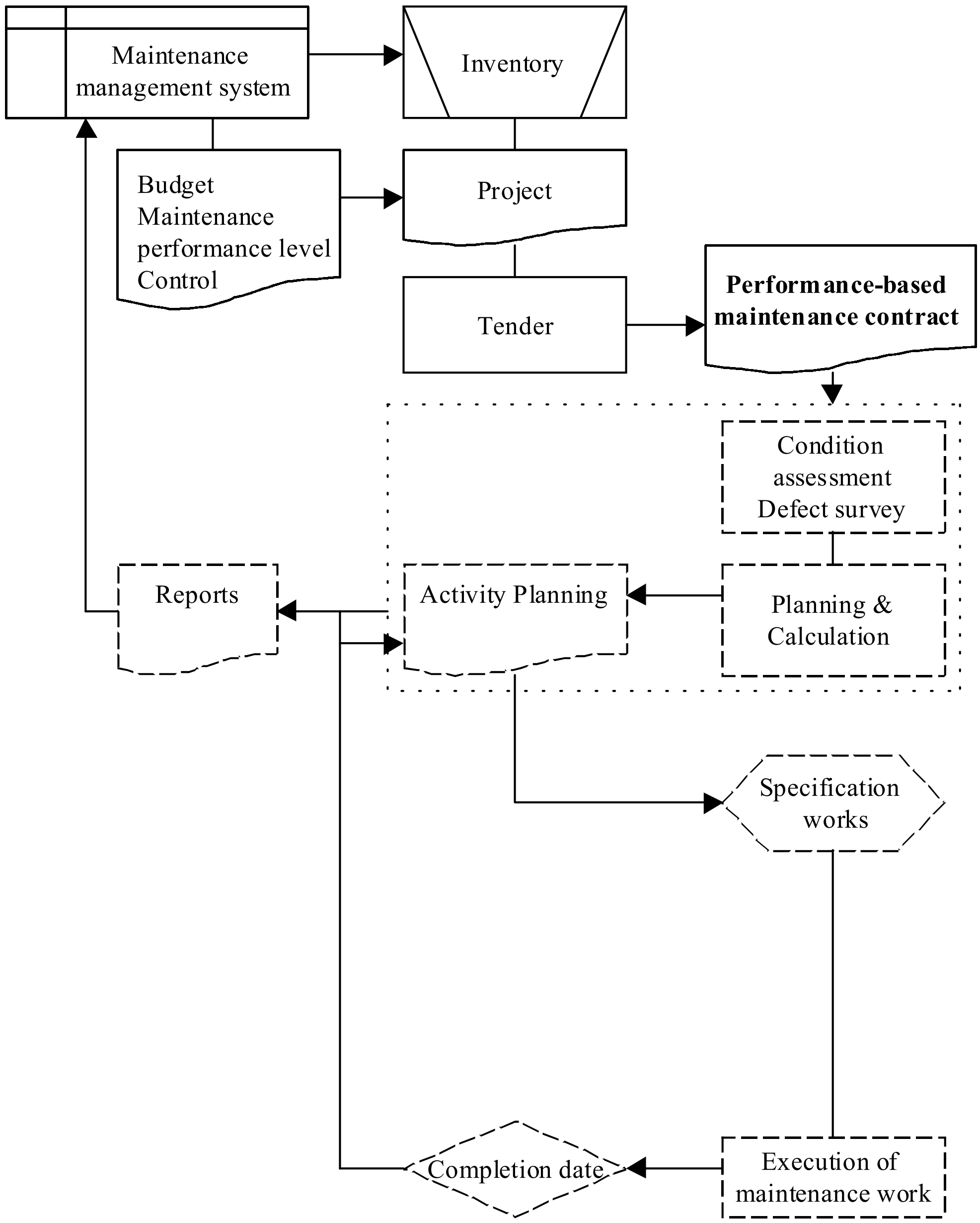

Figure 4 Process performance-based maintenance contract

The introduction of long-term performance-based maintenance contracts may change the traditional process radically. The contractor is responsible for the long-term maintenance plan and annual plan – often called activity planning - based upon performance requirements and a condition assessment. It implies that contractors determine the optimal years of maintenance work. They take responsibilities for the project specification and execution of the work. Contractors report about activity plans and executed maintenance work to the client. Supervision, final acceptance and inspection are replaced by another kind of performance control. The research model adopted in this study is shown in figure 4.

It appears that most performance-based contracts are evolved forms of 'intention contracts'. Standard procedures and working methods of both parties are written down and agreed in contracts. Those contracts are based upon performance requirements. Possibly the contractor formulates different maintenance strategies. Clients assign the execution of annual maintenance activity plans made by the contractor. The contractor is compensated for rate increases. Client and contractor will deliberate about the roundly dotted activities in figure 4.

Main issues of performance-based contracts

In the ongoing research project we concentrate on some main issues of performance-based maintenance contracts:

- starting point;
- performance criteria and requirements;
- control on agreed performances;
- contract period;
- financial risks and payment.

Starting point

For the starting point of a long-term maintenance contract several options exist: new build, refurbishment of buildings, major elements renewals - e.g. window renewal, central heating installations, flat (and pitch) roof renewals – and during maintenance planning. Performance-based maintenance contracting next to new build and refurbishment seems attractive. New Dutch uniform administrative conditions for the execution of building works (CROW, 2000) makes this possible by giving a framework for design, execution and maintenance work. Possibilities for all-in maintenance contracting of buildings increase. It appears housing associations opt for contracts following element renewals. Guarantees on performances and life spans of new materials and elements by manufacturers can be part of the contract.

Performance criteria and requirements

Specifications in facilities services contracts are often described as Service Level Agreements (SLA). One may use them also in case of maintenance contracts (Straub and Bais, 1999). A traditional maintenance contract can be based upon the maximum required performance of construction elements. A performance-based maintenance contract should be based upon the minimal performance of construction elements. In long-term contracts also the performance at the end of the contract should be agreed. The contractor is made responsible for maintaining or bringing the elements up to this standard.

Not all possibly occurring defects have to be used in performance contracts. For instance the branch of painting businesses names 17 defects which have to do with the workmanship of paintwork and 24 defects that involve the ageing of paints to woodwork. For all defects a classification in six degrees has been set up (Bedrijfschap Schildersbedrijf, 1997). A well-known painting research and consulting firm names 9 defects in wooden substrates and 7 defects of applied painting work in their condition manual (COT, 1998). All defects are visual shown and should be measured for intensity (1 to 4 classes) and extent (3 classes). For assessing some of the defects both organisations refer to official international standards, e.g. ISO 4628 Paint and varnishes.

Control on agreed performances

The primary purpose of control is to review the performance achievements and to identify problems with the necessary action. An independent control party could be appointed for this task. Anyhow client and contractor should be involved. A consultant monitors the agreed performance criteria and requirements between Staedion, a Dutch housing association, and painting businesses. Table 3 names the performance criteria of paints to woodwork. All shaded performance criteria are inspected. The final acceptance inspection includes also defects related to the workmanship of the contractor. Table 4 gives an example of some requirements.

Performance criteria	**Final acceptance inspection**	**Periodical inspection**	**Final inspection**
Cracking substrate			
Fissures substrate			
Jammed movable parts			
Open joints/ capillarity and moisture penetration			
Decay of wood/ Rotting			
Moisture content of wood			
Ageing sealants			
Ageing gaskets			
Chalking paint			
Loss of gloss paint			
Discoloration paint			
Blistering paint			
Delimitation paint			
Mat			
Bad intersection lines/ Unpainted spots			
Non-coated parts			
Pinholes			
Runs			
Discoloration through bad coating			

Source: Staedion Vastgoed, 2001.

Table 3 Performance criteria, paints to woodwork

Performance criteria	Standard	Percentage of measurements	
		Final acceptance inspection	Periodical and Final inspection
Open joints, capillarity and moisture penetration	Five degrees, from all joints closed to > 3 mm open joints	100% degree 0	95% degree 0 5% degree 5
Chalking paint	ISO 4628-6	100% degree 0	80% degree 0 through 3 20% degree 4 through 5
Loss of gloss paint	ISO 2813	90% degree 0 10% degree 1	yearly loss 25% of original
Delimitation paint	ISO 2409	90% degree 0 through 2 10% degree 3 through 5	85% degree 0 through 2 15% degree 3 through 5
Runs	Five degrees, from none to very obvious and widespread	90% degree 0 10% degree 5	not applicable

Source: Staedion Vastgoed, 2001.

Table 4 Example performance requirements, paints to woodwork

Contract period

A major decision the property manager needs to make is the optimal length of the contract. Jashapara and Kisters (2000) say that the optimal length balance between the competitive impetus of short-term contracts and the stability, continuity and potentially lower-cost of longer-term contracts. De Valence (2000) point out the use of varying expenditure limits (the contracts' risk limits) across building elements. We approve this. The life span of the elements and the difference between cleaning, painting work, repair and renewal ('normative activities') seems crucial to conclude contracts and to determine the contract periods. Asset management should indicate clear strategies over a long time for buildings and housing complexes continuing exploitation. The desired final performance together with the point in time by which this final performance must be attained, determines the opportunities for a long-term maintenance strategy and long-term maintenance contracts.

Financial risks and payment

The predominant options for payment of contracts range from lump-sum to variable contracts. Lump-sum contracts refer to contracts where the total service is tendered at an all-inclusive charge for the first year of the contract. This charge may be adjusted annually for inflation in subsequent years. The risk sharing of maintenance costs is a key component in performance-based maintenance contracts. Contractors take the majority of the risk to supply an agreed performance level. Examples exist of so-called no-claims bonus systems. In above mentioned example housing association Staedion is compensated for additional costs for bringing forward maintenance work, if the contractor can not meet the performance criteria.

Discussion

In the Netherlands performance-based service contracts are at the centre of attention of property managers and maintenance contractors, especially for preventive and planned painting work and woodwork in facades. Performance-based maintenance contracting means that preceding steps to specify maintenance work are contracted out. By adopting a condition-dependent approach to maintenance, housing associations are able keeping control over the desired maintenance performance levels, budgets, and risks. The shift to performance-based maintenance agreements is helpful in making the maintenance process more transparent. The development of sound contracts takes a lot of time. To make performance-based maintenance agreements a reliable and useful management tool need transfer of knowledge between clients and contractors. However, an optimal use of know-how of all parties involved in maintenance need other forms of co-operation. Not just clients and contractors should be involved, but also suppliers and manufacturers of construction elements, research institutes, control parties, etc. That requires high levels of goodwill on all sides. Contractors need other skills and knowledge and have to take more risks. Clearly a lot of small maintenance contractors, that applies especially for Dutch painting businesses, will not be able to alter their working processes. Differences in types of maintenance firms will increase between those who are able to co-operate with clients and take risks and those how just will execute specified assigned maintenance work.

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A Case Study: A Strategic Approach to Effectively Managing a Large Building Portfolio

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Abstract: *Utilizing the Massachusetts Institute of Technology (MIT) as a case study, this paper outlines the issues that led to the management of their large portfolio of real property with the same strategic approach used in managing their financial and human resources. After 9 years of research and development, MIT consciously adopted this approach in 1976 before nearly double its building portfolio to over 1 million gross square meters of academic space in the next 21 years during the Author's tenure as the first Director of MIT's Office of Facilities Management Systems.*

The paper overviews current IT strategies for managing corporate finance and HR activities, then provides MIT's rationale and approach to developing an enterprise-wide system for managing their real property portfolio. The concept of "space accounting" is introduced and explained in the context of responding to three critical questions about one's facilities. A business approach to effectively and efficiently provide strategic responses to those questions follows.

The paper concludes with two topics. The first is an overview of the design and application of MIT's multi-million dollar, enterprise-wide system (INSITE™) developed specifically for managing their large building portfolio. The second is a review of the international consortium established by MIT in 1973 and its evolution to:

- *transfer the INSITE™ technology;*
- *provide the training and expertise to appropriately and efficiently apply the technology from a business process perspective;*
- *gather ideas and knowledge from others with similar environments and concerns.*

Keywords: Real property, business process, facilities management; CAFM

Applying Information Technology to Corporate Resources

Background

In 1966, MIT's late Provost, Dr. Jerome Wiesner (Nobel Laureate; former Science Advisor to President John F. Kennedy; and later, President of MIT) ask the Director of the MIT Planning Office to eliminate the increasing dilemma facing the Provost when carrying out his space allocation duties as Chair of MIT's Space Committee. Meeting with a faculty member requesting additional space, the Provost's inevitable question of, "What space did you have in mind?" resulted in a finger pointing exercise between the requestor and the unaware "Donator" of the space. Dr. Wiesner inevitably invited both parties to a second meeting that he described to the author this way: "Most 60 minute Space Committee meetings result in a 50 minute argument about the data and only 10 minutes discussing the strategic space implications for both parties as well as the Institute." Dr. Wiesner's solution to reversing that trend was the authorization of funding to supplement the MIT Planning Office budget with a "temporary", MIS-trained staff member to "develop a computer-based space inventory on MIT's main frame computer, and then move on."

While the concept of developing software within a non-IT department was novel at that time, Dr. Wiesner's reasoning was simple. MIS staffs were seen then as taking but a few days to understand a client's needs, while months were then spent in developing the end product, generally in isolation from the client. The results often found client disappointment at the best; or seriously flawed functionality, at the worst. Dr. Wiesner insisted that this pattern could be minimized, if not eliminated, by forcing the IT developer and client to work in the same office. (That modus operandi in now quite common.)

From late 1966 to late 1970 at MIT, several iterations of the space inventory system were developed before a reasonable working model and data maintenance process was in place. Each iteration improved upon the lessons learned from the last. Those primary lessons, while simple in concept, proved time-consuming and costly to implement. Some key examples were:

- organizations in constant change needed a systems architecture that could be changed as rapidly as the environment within which it had to operate;
- the data analyses methods of the planning world had to be duplicated. This meant that the interpretive results of one's first query of the data leads then, and only then, to the formulation of a next query, and so on, until the planner or manager's decisions are reasonably supported by the analyses. This pre-empted the possibility of hard coding 'standard output' from the system;
- having a database filled with data has no value unless that data can be converted into information, and that the business processes in place allow that information to be transformed into knowledge.

The Birth of a Consortium

From the first fully successful use of the information system in late 1970, until mid-1973, the MIT Planning Office was able to build its knowledge of the growing MIT campus, using their information system as an important planning and decision-support tool. The system's functionalities, designed for the MIT planners to aide their upcoming master planning efforts for a major growth of the MIT campus, drew attention from several sister universities via word-of-mouth. Just as MIT was presenting its findings of this multi-million U. S. dollar development effort at several regional conferences, the system was put to its severest test in the fall of 1973 with the advent of the 1973-1974 energy crisis.

This now historic crisis found universities, medical centers, government agencies and corporations alike coping with the financial, human, and facilities issues surrounding the lack of oil to operate many of their facilities. While many developed nations such as the United Kingdom, Japan, and the United States were impacted severely by the oil shortages, the New England region of the U.S. within which MIT resides, was especially vulnerable as the region was nearly 90% oil dependant for its energy needs at that time. Shortly after the outset of the energy crisis, New England-based organizations were struggling to keep open their buildings, as their energy supplies increased in cost and decreased in availability. Non-profit organizations such as universities and hospitals were hardest hit.

The need for campuses to prioritize their facilities for closing decisions increased daily. This led to a call to MIT from several universities to form a Consortium through which the MIT space information technology and expertise to effectively implement it could be shared, along with an informal sharing of vital energy use data amongst Consortium members. While the latter had great appeal to MIT, it had no interest in suggestions to sell or lease the nearly 550,000 lines of programming code of which the system consisted in its early days.

After several proposals from Brown University, the initiator of the idea, MIT Provost Wiesner agreed to a 2-year pilot study with Brown University, Syracuse University, Harvard University's Medical School, and MIT. While Dr. Wiesner maintained a cautious approach to being involved in any activity that had even the slightest chance of mediocrity in its application, he agreed to these terms for the study:

1. MIT would freely install the system's object code, i.e. the binary interpretation of the code itself, on each participant's mainframe, with the commitment that if MIT could duplicate a user's system anomaly, MIT would fix it with new code;
2. In turn, each participant would reimburse the time and travel expense of the author to train their staff in the ongoing use and effective application of the system, and to provide both application and system support to the users;
3. Additionally, each participant had to agree to informally share data and information with each other as a means to more rapidly achieve the necessary knowledge for better managing their campus portfolio. (Consortium Members reasoned that the shared knowledge would allow for more informed decision-making about their facilities than they individually could achieve.)

After two years, the pilot study results were re-visited by Provost Wiesner with his counterpart from each of the Consortium Members. While positive overall for the continuation of the Consortium, the participants asked MIT for a guarantee that it would not abandon the continued development and support of the system. Rejecting that proposal, Dr. Wiesner countered with a US $1,900 budget to have the author report on the pilot study findings at several regional conferences. The purpose was to listen to the questions and comments of the audiences as a means to determine if the idea of giving away a multi-million dollar system for the sake of sharing knowledge of one's building management practices, made sense to others. The results were that nine other universities and medical centers asked to join the Consortium. With this, MIT officially recognized the existing of the Consortium, and pledged its long-term support.

The Birth of MIT's Office of Facilities Management Systems (OFMS)

As MIT pledged its support of the Consortium, it also recognized the need to have an MIT office focused on FM. Thus in mid-1976, MIT created the Office of Facilities Management Systems (OFMS), placing the author as the department's first Director, reporting directly to MIT's Senior Vice President. Within OFMS's mission statement, these groups were included:

1. a system development group to continue to enhance, improve and otherwise maintain a technology edge in MIT's space management systems;
2. a small, self-funding group to provided continuous support to Consortium Members using the MIT space management system; and,
3. MIT's own space management system operations group.

In 1979, OFMS was asked to create two other capabilities for MIT. The first was a Property Management Group to focus on tracking and controlling MIT's fixed and movable equipment. The second was a “Space Accounting” capability to respond to new U.S. Federal Government laws that provided reimbursement to universities for a prorata share of their reasonable and auditable operating and maintenance costs expended while performing government sponsored research, and to medical centers for similar purposes associated with their patient care delivery costs. As these costs were based upon a time and effort proration of the laboratory, healthcare, and ancillary areas used by Faculty and Doctors to carry out their activities, the element of building operating costs was added to the MIT space management system. As these efforts ultimately led to the annual recovery of millions of U.S. dollars to individual Consortium Members, the MIT space management system was referred to as a “Space Accounting” system. Along with this new-found income stream came the existence of Government audit specialists that insisted on seeing and testing business processes at institutions to insure an accurate and timely accounting of all research, teaching, and healthcare space.

Facilities Management (FM)

Shortly after the energy crisis in the United States, a new management concept was introduced, called Facilities Management, or FM, for short. Some suggest that this was a direct result of the energy crisis. Whatever the case, FM was introduced by the Facilities Management Institute (FMI) created by Herman Miller, one of the United State’s prominent furniture manufacturers. Of the many concepts developed by FMI’s excellent staff, the key was their focus on corporate physical assets as being equally important in meeting corporate business plans as were the corporation’s financial and human resources. Heretofore, the physical assets of a corporation were long excluded as being no more than a necessary item on one’s balance sheet, and worthy of little Board Room attention.

Unfortunately, as some would suggest, FM as a bone fide management concept that truly needed corporate attention, coincided with the advent of the Personal Computer. The result was the rapid appearance of profit-seeking corporations that offered the newly-recognized breed of Facilities Managers (FM’ers) the concept of CAFM, or Computer-Aided Facilities Management. These CAFM developers offered a plethora of PC-based tools, or COTS (Commercial-Off-The-Shelf) packages, that included Project Management; Computerized Maintenance Management; Building Control, Wire and Cable Management; Space Inventory; and Computer-Aided Design systems, to name a few.

Real Property Portfolio Management

Real Property Portfolio Management can be defined as the systematic activity to plan, manage, and utilize an organization’s physical assets and workplace environments from a strategic management and capital preservation viewpoint. It is a concept far more strategic in nature than the well-touted business of FM, and has a far greater impact on an organization’s financial well-being.

The concept of treating a collection, or portfolio, of buildings as a strategic management issue, versus the age-old practice of managing individual building as entities unto themselves was introduced at the Massachusetts Institute of Technology (MIT) in the late 1980’s. At that time, MIT’s senior management adopted a real property portfolio management perspective for managing MIT's large campus after enlisting the assistance of Dr. Ranko Bon of MIT's School of Architecture and Planning (now a distinguished faculty member at Reading University). His seminal research work on building economics, coupled with supportive research developed by his colleague, Mr. Michael Joroff, Senior Researcher and Lecturer in the same MIT School, convinced MIT's Senior Vice President responsible for all of the Institute's physical assets, to adopt this new approach.

The Need for Enterprise Solutions to Effectively Manage Real Property Portfolios

When MIT adopted the concept of strategically managing their physical assets based upon an economic portfolio perspective, they simultaneously recognized that the application of a COTS package to respond to their space management and accounting needs would not be adequate. With the emerging technology of minicomputers in the 1980's and the advances in Client/Server technology of the 1990's, MIT's decision to further develop their space management system as an enterprise-wide system was without question. Senior management insisted that MIT's space accounting system be similar in capability, robustness, data handling, and information distribution to their existing 'buy-pay' financial systems and their newly adopted HR and student records enterprise systems. With an annual income stream to MIT amounting to over U.S. $70 million from indirect cost recovery of operating and maintenance costs for carrying out government-sponsored research, and one that relied solely on a timely, accurate and auditable space accounting capability, an enterprise solution had no reasonable alternatives.

The Foundation of a Real Property Portfolio Management System

While simple in concept and mundane in some aspects of its execution, the foundation of a real property portfolio management system is a space accounting approach. This approach asks the followers to put in place the capability to respond to these three basic issues:

1. *Inventory*: This requires an accurate and timely response to the space –related questions of, "What do we have?", and "Where is it?"
2. *Utilization*: Next is the thoughtful and analytical approach to developing the answer to the question, "How well is it being used?"
3. *Panning and Costing*: This should be the end game of all space-related inquiries, the answers of which are both strategic in their development, and financially devastating in the erroneous resolution. The key questions to be answered by this effort are, "When do we need more or less?", and "What are the hidden, or indirect, costs, of these decisions?"

It is from these space accounting techniques that MIT eventually came to name their space accounting system as INSITE™ (<u>IN</u>stitutional <u>S</u>pace <u>I</u>nventory <u>TE</u>chniques).

The Basic Steps to be Taken

There are seven basic steps needed to be taken in order to manage any portfolio of real property. They are:

1. Inventory all of the facilities in one's portfolio with just these four basic elements, at the outset:
    a. A unique space identification for every space encountered on a floor, e.g. building-floor-room number. This includes both the assignable areas such as offices, labs, and the like, as well as the non-assignable areas. These include building service areas (e.g. janitorial supply closets), circulation areas (e.g. stairwells, corridors and elevator shafts at each floor penetration), and mechanical areas (e.g. utility rooms/closets, inaccessible utility shaft penetration on each floor).
    b. Area. Record both the inside-of-wall and the centerline of wall areas. The former is for space allocation purposes; the latter, for space reconfiguration purposes.
    c. Architectural room use. A caution here is to avoid the temptation to record a room use by the architectural function for which it was designed rather than the function to which it is being used. Such anomalies should be recorded elsewhere.
    d. Organizational assignment. The task here is to record the specific organizational unit to which the occupant of the room is assigned, or in the case of multiple occupants, the organizational unit of each.
2. Become "database-centric" versus "CAD-centric" in you approach. That is, do not cloud the vision of your goal with the colorful pictures presented by CAD-oriented COTS vendors. It sells systems, but it is the traditional 'cart leading the horse' approach to FM. While linking floor plans to a database is a capability that will provide added rewards on the output side of one's IT endeavors in space management, the data identification, collection, input, and analyses activities – all database focused activities – must be ones primary focus.
3. Identify and measure each building's indirect costs of their operation, maintenance, and repair. Pay close attention to the quality of this data, and the specific building areas to which it is related.
4. Distribute these indirect costs to their applicable building, first; then distribute those 'per-square-meter' costs to the occupying tenants of the building, or "cost centers".
5. Measure each building's utilization. While each industry may have their own unique measures, it is imperative to understand two things about this exercise. The first is that there are no magic utilization ratios that are guaranteed to work for your purpose. The second is that this process is simply one of ratio analyses. That is, an approach to measuring utilization is to analize a number of ratios of which the numerator denotes some measure of the organization's resource; the denominator, some measure of productivity from the use of that resource. While 'square meters per person' is often the measure of choice, there are numerous cases in which that has little or no meaning. One easy example is a measure of square meters per rank occupying the space – a far more realistic understanding of the space required by the differing ranks of occupants, recognizing that each rank may well have a different productivity

mission (e.g. teaching, research, doctoral candidate mentoring, etc) , and therefore different rates of space utilization.
6. Factor into each space both the indirect costs of occupancy as identified and distributed in steps #3 and #4 above, and the percent of that space's use by the occupant/occupants as described in step #5 above. A simply reminder of the significance of this step is this: if the indirect costs of operating and maintaining a laboratory equals "X", and if that laboratory is in use only 50% of the time, the actual cost to the organization for having that laboratory is "2X".
7. One can now transform data into information. The institutional database of real property used to meet the business goals of that institution is now able to be used as a Decision Support System providing senior managers with the ability to make more informed decision about their portfolio, based upon accurate and timely data, complete space costs, and true space use data.

Summary

A strategic approach to effectively managing a large building portfolio requires the same level of expertise, commitment, and focus as given the institution's financial and human resources. The benefits reaped from such an approach are enormous, as proven by some of the global corporate giants that utilize these technique. On the other hand, the implementation costs for such an approach is surprisingly small, but requiring these often difficult commitments:

- adoption and maintenance of a solid business process that assures a consistent and timely data capture process;
- implementation of a rigorous process of quality control in obtaining that data;
- a commitment to creativeness in converting the harvested data into information; and,
- a willingness to challenge yesterday's paradigms in order to enhance the knowledge we need to prepare successfully to meet the inevitable changes that occur constantly in our real property portfolios, whether those change are to the portfolio's value, quantity, quality, or any combination thereof.

As an epilogue of this case, MIT has since spun-off the international Consortium of INSITE™ users as a non-profit entity to share more effectively the technology and the expertise for its application. Naming this new entity OFMS, Inc. for its MIT benefactor, the MIT Office of Facilities Management Systems, a royalty-free license was provided OFMS, Inc. with the mission to:

- continue to support the existing Consortium Members – now located in 7 countries;
- allow for the growth of Consortium members to better serve all involved through a wider base of benchmark data and portfolio management experience; and
- utilize the broad base of users to continue with the enhancement of the existing INSITE™ system, and the further development of new, related tools and systems.

Last year's growth of Consortium membership allowed OFMS to establish an office in England to better support the growing membership of EU-based universities. The Consortium is leading the way to sharing the richness of benchmarking and planning data from the ever-expanding base of university participants, reap the benefits of economies of scale in development of tomorrow's latest IT technology, and link the brightest academic and administrative minds of university colleagues to manage the world's leading institutional portfolios of academic buildings.

In closing, I am reminded by the prophetic words of Dr. John Hinks in his presentation at the CIB W70 Symposium of 2000; "*We need facilities management… we don't need facilities*." This might serve well as our mantra for this century.

Development of an Integrated Building Information System – The Queensland Experience

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Abstract: *Many Government jurisdictions have recognised the importance of having information on their built assets as a first step in addressing the problems of under-funded maintenance and deteriorating assets as well as reaching out for better asset management to improve business performance. Having many departments and agencies, each keeping their own records of assets in a variety of formats is not conducive to information sharing. In 1995, the Government of the State of Queensland, Australia undertook the development of a single, Government-wide asset register of buildings across all departments in an effort to overcome these problems and provide a platform for improved asset management.*

This paper traces the developments to date that have led to the system being a spatial information system with potential for use on a variety of asset management and other applications including disaster management and commercial development of communications networks. The paper also discusses some key issues in relation to data collection and custodianship, connectivity of building data across Government departments and the use of data for building asset performance indicators across the various asset-owning departments.

Key Words*: information, building assets, Government, asset management*

Introduction

Buildings and other infrastructure like roads, rail, airports and ports are part of the asset base supporting the economic activity of most developing and developed countries. Buildings are used by Government to conduct its business in serving the needs of the community. They are part of the inventory of assets or resources supporting the delivery of policy objectives and services like education, health, justice and others. They are also enduring physical assets, often lasting up to 50 years or more (indefinitely if heritage-listed) and involving significant investments of public funds to acquire and ongoing recurrent outlays to operate and maintain. There are also risks associated with the ownership and use of buildings. Some of the risks include:

- Failing to derive the optimal benefits from the assets through ineffective deployment, operation and use;
- Suffering cost penalties and service quality degradation through poorly performing assets; and
- Exposure to legal, political, financial and other risks due to lack of maintenance, ineffective management or disregard for due process.

Obviously, most buildings (except for the simplest structures) would be well above the financial threshold for the recording of physical assets in the accounting books of most Government bodies. They would also be subject to valuation and depreciation treatment and the results reflected in statements of financial performance. It is also to be expected that an accurate inventory of buildings owned by Government bodies would be needed for effective management. While inventories of individual portfolios may exist, a Government-wide inventory is probably not so common.

As recently as in January 2002, the Audit Office of New South Wales was critical of the New South Wales Government for failing to establish a building asset register despite the need for one having been identified in 1988. In the UK, the Audit Commission indicated in its 2000 report, *Hot Property – getting the best from local authority assets*, that the UK central government was only just beginning to establish such a register. In Queensland, the Queensland Government commenced the development of such a Government-wide register in 1995. Since then the register has had a rather interesting journey. This paper describes some of the issues associated with it, in the broader context of asset management.

The need for a Government-wide building information system

There is growing recognition in various countries that building and other infrastructure assets have been neglected in terms of maintenance and that Governments could be facing the prospect of significant financial outlays to bring them up to the necessary standards to meet service requirements. There is also increasing recognition that buildings are a cost-intensive resource, have a significant impact on operating costs and need to be used effectively to provide the best possible value. In this regard, having a close overview of factors such as whether the assets are fully and effectively used, adequately maintained and in the right location and functionality to meet service requirements, is becoming increasingly important. While individual departments or agencies may have such a focus, the relative importance and commitment placed by individual departments on such key asset management aspects may vary considerably.

Potential problems that could arise as a result of such differential treatment include:

- A concurrent surplus of assets in some departments and a scarcity of space in others;
- Continuing investment in asset acquisition while existing assets are inadequately maintained and cared for;
- Lack of sharing and co-location among departments to reduce the demand for space and improve services to the community;
- An undetected growth in assets reaching the end of their useful/economic lives and requiring disposal, replacement or refurbishment;
- An undetected growth across all departments of a deferred maintenance backlog;
- Lack of coordination in asset disposal and acquisition within the same market; and
- Variances in the quality of Government facilities inter-departmentally and regionally.

In a de-centralised model where departments have a degree of autonomy in managing their own assets subject to Government policy directions, the above risks cannot be avoided completely. Having a Government-wide building information system would also not eliminate them either. However, a Government-wide system would provide Government with an efficient means of monitoring the risks effectively and intervening as the need arises. Such a system could be integrated with on-line access to policies, guidelines and other useful applications to become an Integrated Building Information System.

Figure 1 illustrates the data sources of a building information system based on a de-centralized ownership model.

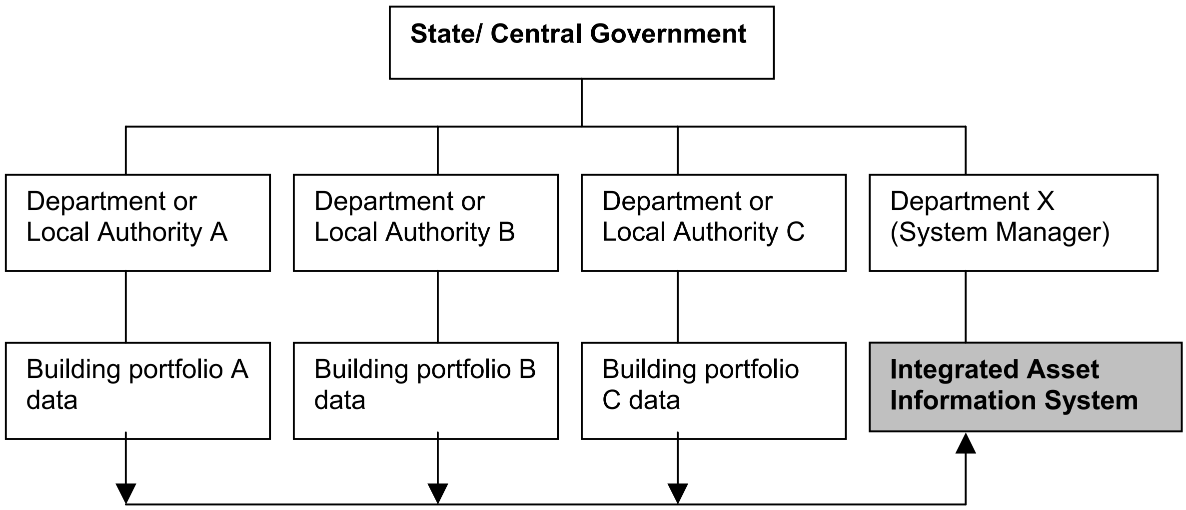

Figure 1: Data sources for a de-centralised asset ownership model

In the absence of a Government-wide building information system, such a model would mean that Government is reliant on individual departments or agencies to each maintain a register and collectively provide it with a consolidated overview of Government assets as required. This could be problematic if the necessary policies, systems and processes for data requirements, definition, collection, storage and retrieval have not been established to enable efficient consolidation into a Government-wide view. Problems could include:

- Variances in data definitions and meaning;
- Gaps in data availability;
- Incompatibility in data format for processing and consolidation;
- Variances in data quality (accuracy and reliability); and
- Difficulties in coordinating the supply of data from multiple sources.

The difficulty in collecting data from multiple sources should not be underestimated since these sources could present barriers arising from a sense of "ownership" protectiveness and innate suspicions regarding the purpose of data collection by an "external" party.

It should be noted however, that if the above model changed (for example, to a centralised one where a central agency owned all the assets and departments merely leased them from the central agency) the context and nature of a Government-wide building information system could change. In the centralised example mentioned, data collection and storage would be a single-agency responsibility but would include a wider variety of data required for portfolio management.

Figure 2 illustrates the data sources for a centralized model of asset ownership.

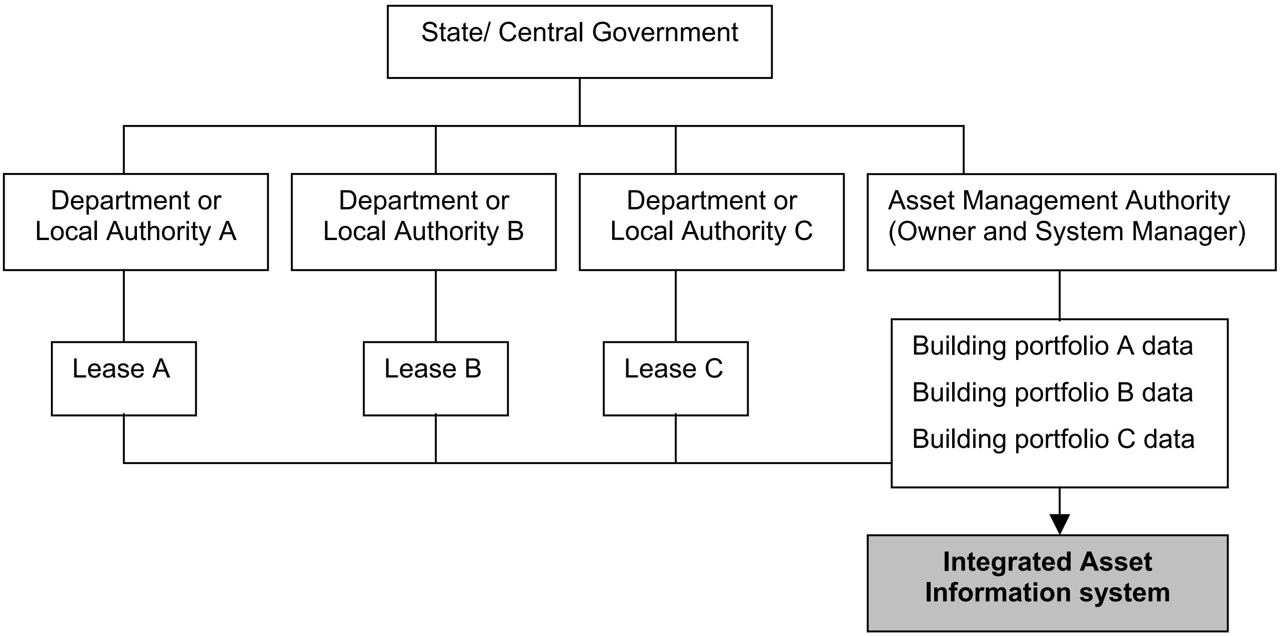

Figure 2: Data source for a centralised asset ownership model

The Queensland Experience

The asset ownership model that formed the backdrop to the development of a Government-wide building information system in Queensland is a de-centralised one where individual departments or agencies exercise control over their building assets but the State Government funds capital investment and operating and maintenance costs through the normal budget process. The Government also retains a policy and risk management role (through its central agencies like Treasury Department and the Public Works Department).

The challenge was in defining the decision-making, reporting and data requirements that would result in a system that:

- Achieves a minimal duplication of departmental systems;
- Contains the essential data for reporting and decision-making;
- Provides value-added functionality to users in return for their contribution of data;
- Enables efficient collection and updating of data;
- Meets Government requirements for risk management monitoring; and
- Is supported by an asset registration policy and protocol applicable across Government.

The early development consisted of building up a database to accommodate a number of fields of data on sites, buildings and other related information. A manual was produced containing some basic information on the system and some data definitions. In the absence of data from individual departments that could be readily uploaded into the system, data from the Department of Public Works maintenance management system was used to initially populate the system. This was not entirely satisfactory since some of the information was incomplete or inaccurate. There were few applications of the system apart from some reports. There was no clear articulation of the purpose of the system apart from it being an asset register of all Government buildings.

The second stage of development was precipitated by the recognition that it could be given mapping capabilities and become a spatial information system. At this stage, the issue of its actual application and benefit to users was still unclear although the development of performance indicators (in parallel with system development) was seen as a potential solution. There was still a lack of focus on its potential role in risk monitoring and management by Government and providing value-adding applications to the data contributors (departments). As a result, user support and the willingness by data contributors to contribute and update data waned somewhat, due to the perceived lack of benefits.
To overcome this apparent indifference, the system was re-developed to include map layers and thus transforming it into a spatial information system. Data could now be displayed on location maps and the system equipped with all the capabilities of a spatial system. This improvement was driven by a persistent (but perhaps undefined) view that the system still had the potential to be of value for asset management.

The data was also cleaned up considerably through desktop and site audits but the issue of transferring updated data from departments continued to haunt the system. A duplicate asset register of each department's assets was created together with a mechanism for an automatic upload to overcome the problem. However, the motivation for departments to update their data and upload them into the system continued to be problematic through a lack of incentives, competing priorities and technical issues. Management commitment to the system (in terms of committing resources to really resolve the problem) changed as priorities shifted.

The introduction of mapping capabilities did, however, achieve some small victories. Asset managers and other personnel began to see the potential for such a system and became more supportive of the concept. An unlikely champion of the system emerged from one of the departments involved in assisting the private sector in the development of communication networks across the State. By overlaying their network grids on the system, their clients could assess their network location relative to Government facilities (a key factor in their business decision-making).

The value of the system as a database was also demonstrated in late 2001 and early 2002. As a result of a review of Government operations across all departments, the Department of Public Works was called upon to prepare a report on a review of building asset maintenance. The report was focused on Government liabilities in deferred maintenance and the development of policy solutions to prevent future problems.

The system was able to provide the data for the report within the stipulated datelines, despite the intervening Christmas holiday period taking a significant portion of time out of contention. It would have been impossible to meet the requirements on time if each department had to be approached individually to provide data out of their systems to be collated and processed. A number of key asset management reforms are now being developed for endorsement as a result of the report.

The current System

The system currently contains data on 36,000 buildings valued at approximately Australian $12 billion. Some of the main data fields include:

Stable or "tombstone" data such as:

- Site addresses and identifiers
- Facility Name and type
- Building details
- Building-related assets/improvements

Variable data such as:

- Maintenance expenditure
- Condition

- Valuation
- Replacement value
- Valuation date and method

Reports that can be produced from the system include:

- Number of buildings by department/region/type
- Value of buildings by department/region/type
- Age profile of buildings
- Remaining useful life
- Maintenance expenditure

An example of the analysis that can be done using the data in the system is trending the benchmark of maintenance expenditure as a percentage of asset value over a number of years as shown in Figure 3 below. In conjunction with other information such as asset condition, the value of capital investment in buildings and overall maintenance expenditure over the same period, the analysis could provide an indication of the adequacy of maintenance funding.

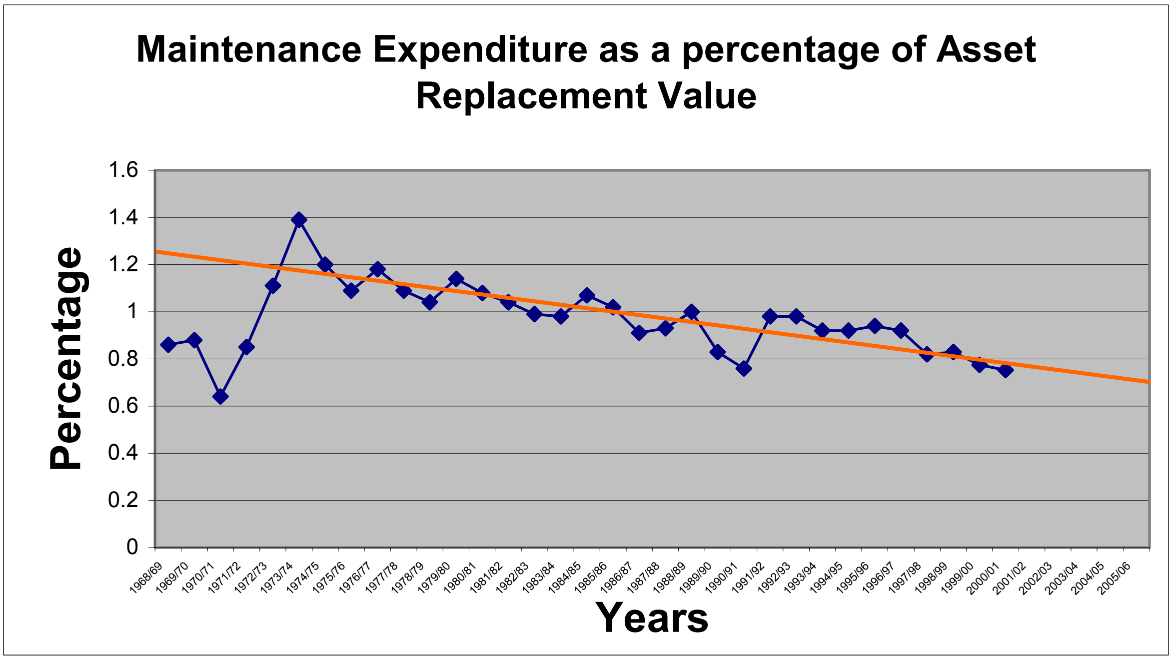

Figure 3 Example of system output

New potential applications have emerged as a result of recognising a wider application for the system. These include:

- Adding maps of flood levels for use by disaster management agencies;
- Adding data to assist in the management and removal of asbestos containing materials in buildings;
- Providing access to security agencies protecting Government buildings;

- Providing access to fire and ambulance services;
- Providing access to specific agencies requiring a knowledge of Government facilities for planning purposes;
- Providing links to other asset management information such as policies and guidelines; and
- Providing application tools such maintenance works planning and possibly, links to electronic drawings.

At the time of writing, the system is undergoing yet another stage of re-development. Web technology and a re-thinking of the system and its applications is driving development towards system maturity in terms of securing user and data donor support.

This re-development will focus on:

- Meeting the needs of the primary stakeholders in terms of strategic asset management (Government represented by Treasury and other central agencies);
- Meeting the needs of the secondary stakeholders in terms of system functionality for operational asset management and data contribution (departments and agencies);
- Value-adding data applications that benefit all users (asset and non-asset related);
- Adoption of new web technology for improved access, functionality and data management.

Data Quality

As noted above, there are problems with data collected by individual departments and agencies in the absence of policies and protocols governing data definitions, asset identifiers, asset definitions and other consistency issues. An asset registration policy is being developed to address these issues and help improve data quality.

Currently there are a number of data quality issues that need improvement.

Data needs to be up to date. Reports that contain out of date information are quickly discredited and affect the credibility of the whole system. Such errors could include storing superceded data on:

- Buildings that have been sold or no longer exist;
- Buildings under new ownership or use;
- Asset values that have been superceded by new valuations;
- Buildings still in old electoral boundaries that have been altered; etc.

If there are no incentives for those responsible for the data to update the data, or if the process and system of updating is cumbersome and time-consuming, it is unlikely that the data would be kept up to date.

Data consistency

Data consistency is particularly important for performance measurement and benchmarking. For example, *costs per square metre* type of measurements would be difficult to compare effectively if there is no consistency in using either gross floor area, net usable area or total covered area. Condition ratings of "good", "fair" and "poor" would be difficult to compare with numerical ratings from 1 through 5.

Data completeness

There could be gaps in the data fields for individual records. For example, a school facility record could be missing a building altogether or the data on one or two buildings could be missing information on floor areas or condition.

Data uniqueness

Duplication of records could easily occur if data protocols are not established and implemented. The same facility called by different names or listed by different street frontages could appear as two separate facilities. If unique identifiers are used, controls need to be in place to ensure that the same facility or building is not issued with more than one identifier.

Data accuracy

The accuracy of data such as asset value, maintenance expenditure, floor areas, etc. would impact on the reliability of reports produced. The credibility of the system itself is at risk when reports are found to be inaccurate due to poor data.

Unique building identifiers

A reliable and simple system of unique identifiers is essential to uniquely identify buildings and link them with sites and any site improvements or building "attachments" that need to be tracked against buildings. An example of an "attachment" could be works of art located in buildings as a Government initiative to promote art in the community.

The system of identifiers needs to be able to deal effectively with various situations of building and site ownership. For example a site could be owned by one department with multiple buildings on it belonging to other departments. It should also be capable of tracking buildings as departments re-structure and transfers occur between departments.

Feeder Systems

The issues of data quality identified above are largely related to the "feeder" systems in agencies since the System draws the data from the asset management systems in agencies. An alternative approach (technically feasible) would be for the System to be partitioned for individual agencies to enter, view and update their data with appropriate security provisions. This would enable some consistency in data entry but would not eliminate human error and bad data in the first instance.

Performance Measurement

One of the applications that have remained the focus of system functionality has been that of performance measurement based on the data stored. From a Government perspective, a combination of a select number of key performance indicators with good analysis of trends and other information would arguably be more useful than a wide range of detailed operational indicators. Some suggested initial key performance indicators that could form the basis for reporting to Government in conjunction with other information would include:

- Condition (actual against standard)
- Utilisation
- Operating costs per unit area
- Maintenance costs per unit area

Part of the current re-development process will include functionality for performance indicators to be measured and displayed for on-line users.

Conclusion

The development of a Government-wide integrated building information system is a major challenge. There are good reasons for taking up the challenge and providing Government with a system to manage the risks of building ownership and use. The experience in Queensland shows that the benefits of such a system may take time to be appreciated and there are a number of issues to be dealt with along the way.

Ultimately, the aim is good service to the community and not just good buildings. However, having the means to manage buildings as a resource to deliver services to the community will go a long way towards improving the quality of those services.

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Decision Support Systems for Infrastructure Asset Management: Prospects and Challenges

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Abstract: *The concept of asset management has drawn much attention from those responsible for and interested in civil infrastructure systems. Motivated by rising public expectation and changing capital allocation requirements, many public agencies and associations in the United States have begun promoting and coordinating efforts to develop frameworks and decision support systems for infrastructure asset management. Most efforts are in their infancy, so the opportunity to take account of the prospects and challenges of development is palpable. Accordingly, this paper briefly reviews the state of infrastructure asset management developments within several international agencies and assesses significant obstacles and decision factors. While the technical challenges of developing cross communication between information system components and platforms are noteworthy, a principal conclusion of our research to date is that these challenges must be balanced by equal attention to elements which are salient to construction and analysis of alternative scenarios for investment and operation. These factors include: (a) identification of key performance and service indicators, (b) definition of comparative baselines, (c) alignment of operating and financial management systems with capital programming processes, (d) integration of functional and condition requirements, (e) consideration of public and private sector roles, and (f) incorporation of flexibility. In addition, developers must carefully consider the scale and scope of these systems as well as their institutional implications. Initiatives that neglect these factors are likely to produce decision support systems for infrastructure asset management that fall short of fulfilling expectations.*

Keywords: infrastructure asset management, decision support systems, infrastructure management

Introduction

Numerous studies and publications have cataloged the deterioration of American infrastructure systems (Choate and Walter, 1981; National Council on Public Works Improvement, 1988; ASCE, 2001). Regardless of the merit given to various estimates of need, a prolonged effort to renew and replace components and sub-systems of infrastructure systems nation-wide is a logical expectation. Further, this cycle is perpetual; today's challenges will be replicated by similar challenges in the future. Essentially, the century old systems in many of America's urban centers are approaching the end of their first lifecycle, and similar circumstances are found worldwide. The future includes second, third and fourth cycles. Identifying system priorities and allocating scarce capital resources among competing requirements shall remain a constant challenge.

Motivated by these circumstances along with rising public expectations and competitive pressures, many public agencies and enterprises in the United States have begun promoting and coordinating efforts to develop frameworks and decision support systems for infrastructure asset management. Most efforts, however, are in their infancy, so the opportunity to take account of the prospects and challenges of development is palpable. Advances in information technology are making it possible to integrate disciplinary information systems to support decision-making like never before. Beyond the obvious technical issues of cross communication between data and software platforms, however, a number of salient challenges are forthcoming if asset management is to realize its promise.

The intent of this paper is to explore developing asset management concepts and practices while incorporating lessons learned from past and ongoing research efforts at MIT and Columbia University. Over the past several years, the authors have been engaged in the development of case studies about and decision support systems for infrastructure. In the course of these efforts, we have identified several challenges when implementing decision support systems designed to improve capital and operational planning as well as performance. This paper serves as a forum for: (a) reviewing U.S. and international experience with infrastructure asset management, in effect taking a “pulse” of developments worldwide, (b) considering asset management prospects and challenges, and (c) highlighting critical issues that might preclude asset management practices from fulfilling expectations.

U.S. Experience

Federal Highway Administration & AASHTO

In 1998, the US Federal Highway Administration (FHWA) completed a reorganization effort that established the Office of Asset Management as one of its core business units. Its establishment was the result of increasing pressures and constraints upon FHWA to make efficient use of scarce resources. One of the Office’s first efforts was the publication of an asset management primer in response to repeated questions of “what is asset management?” (FHWA, 1999). As the primer emphasized, many transportation agencies across the United States already make regular use of both pavement and bridge management systems to monitor their condition and performance and to analyze and recommend sustainment and improvement projects. However, many agencies do not fully utilize the capabilities of these systems, and the two sub-systems are generally managed independent of one another (FHWA, 1999). The new emphasis upon a more holistic and formal approach to managing assets was underscored in FHWA’s “working definition” of asset management, which is listed in Table 1. Recent activities by FHWA include the organization and execution of several seminars and workshops designed to educate decision-makers and practitioners about asset management.

Concurrently, the American Association of State Highway and Transportation Officials (AASHTO) adopted transportation asset management as a priority initiative. Recognizing that the transition to such a posture would not come easily, AASHTO formed a task force to develop a strategic plan to guide this transition. One of the tasks identified by the plan was the development of a *transportation asset management guide* for use by transportation agencies. Subsequently, the National

Cooperative Highway Research Program (NCHRP)[1] incorporated this objective into one of its solicited research projects. The project is currently underway, and its first phase was completed in the fall of 2001. The objectives of the initial phase were to gather information about current practice, to develop a framework that would serve as the basis for the guide, and to recommend a program of research in asset management. The initial efforts identified several characteristics of the current transportation environment in the United States that might complicate the practice of asset management (Cambridge Systematics, 2001):

- Responsibility for different modes or segments of the transportation system is fragmented across several agencies
- Funding is often constrained by mode and function
- Within highway transportation organizations, organizational units such as pavement, bridge or maintenance are not integrated
- Information management systems and databases are often stand-alone and of different vintages or platforms
- Senior managers do not have access to sufficient quality information for analysis and decision-making

These findings suggest that overcoming institutional challenges will comprise the majority of the effort necessary to implement such an approach. Development of the guide continues in the project's second phase.

American Public Works Association

In the late 1990's, the American Public Works Association (APWA) assembled a task force to study asset management and its implications upon public works organizations throughout the United States. The task force delivered a report describing the concept and issues surrounding its development and adoption within public works agencies in the late summer of 1998. Their definition (also shown in Table 1) suggests that asset management is more an investment policy than a management tool since individual systems, such as pavement management systems, are adequate for managing each class of asset (Danylo and Lemer, 1998). As such, asset management becomes an integration methodology. In addition, the report identified legal, financial and accountability issues which motivated the strategies recommended by the task force to further asset management development and practice. These strategies included coordinating the interested parties to promote a common strategy and allocating appropriate resources to insure that the concept is fully understood and documented. APWA's Leadership & Management Committee has assumed responsibility for coordinating further activities in this area, and they continue to develop concepts and tools that will assist and encourage public works agencies to embrace asset management practices within their organizations.

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[1] NCHRP is sponsored by AASHTO, in cooperation with FHWA, and is administered by the Transportation Research Board. Formed in 1962, its mission is to conduct research in acute problem areas that affect highway planning, design, construction, operation, and maintenance nationwide.

Source	Definition
American Public Works Association Asset Management Task Force	Assets management is a methodology to efficiently and equitably allocate resources amongst valid and competing goals and objectives. An assets management system is more an integrator, a system that can interact with and interpret the output coming from many dissimilar systems and provide deciders with reliable and tested data.
New Zealand National Asset Management Steering Group and Institute of Public Works Engineering of Australia	The goal of infrastructure asset management is to meet a required level of service in the most cost-effective way through the creation, acquisition, maintenance, operation, rehabilitation, and disposal of assets to provide for present and future customers. The key elements of infrastructure asset management are: taking a lifecycle approach; developing cost-effective management strategies for the long term; providing a defined level of service and monitoring performance; managing risks associated with asset failures; sustainable use of physical resources; continuous improvement in asset management practices.
Transportation Association of Canada	Managing highway assets is not a new concept; highway agencies have been using pavement, bridge and maintenance management systems for decades. What sets asset management apart today is the move to merge single-asset management systems into an integrated whole. Asset management is a comprehensive process that allocates funds effectively and efficiently among competing pavement, structure and infrastructure needs.
U.S. Federal Highway Administration	Asset management is a systematic process of maintaining, upgrading, and operating physical assets cost-effectively. It combines engineering principles with sound business practices and economic theory, and it provides tools to facilitate a more organized, logical approach to decision-making. Thus, asset management provides a framework for handling both short- and long-range planning.

Table 1 - Definitions of Asset Management

International Experience

Transportation Association of Canada

Early in 1999, the Transportation Association of Canada (TAC) released a primer to introduce the concept and to outline the benefits of asset management to its constituents (see TAC's definition in Table 1). Soon after the release of the primer, TAC initiated a follow-up study to examine a range of issues associated with asset management. In the fall of 2001, TAC released a report that focused upon three areas: determining highway asset value, measuring system performance and integrating data into executive information systems (TAC, 2001). The report provides an overview of several approaches for valuing assets, but emphasizes two: depreciated historical cost and written down replacement cost. In addition, deterioration functions applicable to varying assets are cataloged. Key steps identified in the valuation process include completion of an asset inventory, determination of asset status, and application of an appropriate valuation method.

The report reviews a range of proposed performance indicators and recommends a two-tiered system of performance measures. The first tier focuses upon a macro-level view of highway system performance while the second tier targets detailed indicators of service quality, productivity & efficiency, sectoral effectiveness and institutional effectiveness. Five areas of key consideration for development and utilization of performance measures are also highlighted: (1) stakeholder involvement, (2) balanced view, (3) efficiency and effectiveness, (4) transportation values and (5) objectivity. The final focus of the report is upon executive information systems (EIS). Included as potential users of the EIS are individuals or groups outside a transportation agency, such as the general public and elected officials. The report suggests that the aggregation of data will increase and the accuracy of data will decrease as information moves upward from technical users to the general public. Two forms of EIS are also described and typical reports are illustrated.

New Zealand & Australia

In 2000, the New Zealand National Asset Management Steering Group (NAMS) joined with the Institute of Public Works Engineering of Australia (IPWEA) to release the *International Infrastructure Management Manual* which built upon previous manuals developed by each organization in 1996 and 1994 respectively. The manual describes its purpose as “to promote best management practices for infrastructure assets regardless of ownership (public/private sector) and country location”. It focuses upon four general areas of asset management: (1) basic concepts, (2) implementation, (3) techniques and (4) information systems. Without question, the publication provides some of the most comprehensive treatment of the subject available. Interestingly, the authors differentiate between *basic asset management* and *advanced asset management*. As described, *basic asset management* relies primarily upon an asset register, maintenance & resource management, condition assessment and defined levels of service to establish alternative treatment options and long-term cash flow predictions. *Advanced asset management* goes beyond this to employ predictive modeling, risk management and optimized decision-making techniques to establish asset lifecycle treatment options and related long-term cash flow predictions.

Both New Zealand and Australia have become leaders in developing and practicing asset management. In fact, a 2000 World Bank report described the two countries as representative of current world best practice (Worley Intl., 2001). The report identified three conditions that have contributed to New Zealand’s and Australia’s success. First, legislative reforms requiring prudent and sustainable long-term financial planning led to explicit accounting standards and reporting requirements. Second, support systems such as computerized asset registers and decision-making tools were developed for improving the ability of organizations to quantify long-term benefits. Finally, regular monitoring of asset management performance has occurred to insure that the benefits and improvement expected have in fact been achieved.

Defining Infrastructure Asset Management

This brief survey indicates that the interest in this subject is pronounced, and the organizations highlighted are in varying stages of development and practice. In addition, a general consensus exists about the concept. While the definitions of asset management offered by these organizations are somewhat unique, several common themes are discernible. Foremost, asset management is a *methodology* for programming infrastructure *capital investments* and adjusting infrastructure *service provision* to fulfill established *performance and service objectives*. In addition, the methodology takes a *systemic and lifecycle perspective* of infrastructure, and its application is *systematic*. Finally, the methodology's decision process is *scenario-driven* and founded upon principles of *engineering economy* and *management science*.

As defined, asset management represents a noteworthy shift in infrastructure delivery and management. First, its emphasis upon systems and the long-term, not components and the short-term, changes the focus and analytic basis of the programming process. Whereas decisions may have centered upon *projects for asset classes* such as bridges in the past, decisions must consider the *lifecycle of asset collections* such as transportation corridors in the future. Second, the construction and evaluation of alternatives is central to the approach. While decision-making about public capital projects has routinely developed and considered design and construction options, the inclusion of operations & maintenance, capital renewal & replacement, and abandonment as decision parameters adds new dimensions to the analytic process. In addition, integrated facility delivery and contracted operations & maintenance have become viable alternatives for evaluation. Third, the approach is systematic, so input and feedback are instrumental. Effectiveness depends upon dynamic and reliable metrics or indicators. Otherwise, decisions are under or uninformed. Finally, implicit within such a framework is the substantive use of information technology to facilitate the collection, management and analysis of data to support decision-making processes. Recent advances make it possible to integrate information systems to support decision-making like never before.

Decision Support System Prospects & Challenges

Asset management is a data-driven, decision-making process that evaluates various capital and operating scenarios to improve infrastructure service and performance. As such, tools and information systems designed to support this process are vital components of this emerging concept. Certainly, the use of decision support systems in infrastructure management is not new. They have been and will continue to be an instrumental part of the process. What is new is the challenge of developing such systems to support a more holistic and formal approach toward investment and operational decisions. Still, the prospects of such systems are quite exciting. One can envision an information system that collects routine data about an infrastructure system or enterprise and transforms this data into meaningful and reliable information while also providing linkages with system models and GIS to forecast performance and cash flow and to map spatial data and trends. Common strategies for achieving this end place an integrating platform amongst existing data analysis and management systems to filter, transfigure and distribute data according to user needs. Certainly, other structures are possible, and if history provides any indication, the technical challenges of integrating disparate data management systems will precede institutional capacity for their utilization. This reality tempers the general enthusiasm for the concept of asset management. Accordingly, equal attention to other important elements is necessary if the promise of asset management is to be fulfilled. Those interested in developing systems to aid in the construction and evaluation of alternative scenarios must think broadly about a range of issues. Simply building the information infrastructure to provide access to system data is not enough. We have identified several challenges for those thinking strategically about decision support systems for asset management to consider. The observations presented are underpinned by our own experiences in creating and deploying decision support tools, and they were reinforced by the literature surveyed.

Performance Measurement

Performance measurement is central to asset management; feedback about an infrastructure system or enterprise will drive the construction of investment and operational alternatives. Within the United States, the discussion about performance measurement has been ongoing since the 1980's (National Council on Public Works Improvement, 1988; GASB, 1994; National Research Council, 1995). Within this literature, metrics are typically categorized as either measures of output or outcomes where output metrics are simply measures of workload and outcome metrics are indicators of program results such as timeliness or effectiveness. Indicators that relate service efforts to accomplishments can also be labeled "efficiency" indicators that are ratios of input to output or input to outcome. Defining appropriate performance measures which adequately reflect objectives is one of the first difficulties encountered. Incorporating the range of values present in society about the built environment is no simple task, but it is critical to the subsequent indicators selected. Burton and Hall (1999) describe the utilization of serviceability matrices within the UK water industry and its irrigation sectors as a means for integrating objectives and indicators.

A second, more pragmatic challenge is establishing comparative baselines. Without benchmarks, performance measures are less meaningful. More importantly, they are essential for supporting the accountability and transparency principles that are integral to the asset management philosophy. Cross-sectional comparisons, however, can be problematic, and concerns about data uniformity, availability and reliability are significant and warrant consideration. For example, the metric *per capita consumption* is popular amongst the water supply community to illustrate water use characteristics. A significantly higher value for one system when compared to a similar system might suggest a variety of issues worthy of analysis such as pricing arrangements, distribution efficiency and conservation measures. Defining the metric as *volume of water sold/population served* will obviously differ from defining it as *volume of water delivered/population served*. Each definition can convey meaningful information about water use, but can complicate its deployment as a basis of comparison. In addition, the denominator *population served* is more difficult to quantify consistently than commonly recognized. Issues such as these introduce real issues for cross-sectional performance evaluation. Over time, however, ongoing efforts by international and professional organizations to normalize industry practices, standards, reporting and accounting will somewhat reduce these concerns. Meanwhile, performance indicators should allow an independent enterprise to internally assess its system since indicator states should change over time as management implements various programs or activities. Still, some of the quantification and data issues remain.

The problems described above have become the fodder of those willing to shy away from performance measurement. Recognizing that performance indicators are only intended to provide a reasonable representation of different aspects of an infrastructure system can diffuse debates about their adequacy. Independent analysis and judgment are still required. The most apt analogy for performance indicators is triage. They serve as a decision-maker's first-line of diagnosis and suggest areas of strength and weakness. A starting point can be the use of financial data. Financial information is often the most tangible factor in any decision-making environment, and it is already collected as part of the annual accounting and budgeting process. For instance, an organization operating as an enterprise account can make use of standard financial ratios such as *average collection period* to monitor organizational performance. In addition, data drawn from financial statements have a degree of consistency and reliability that may not be found in other data sources since the reporting of financial information follows generally accepted accounting principles. Garvin (2001) effectively applied similar metrics to characterize large water systems in the United States. At a minimum, such metrics can be applied until the consistency issues that challenge the use of a broader set of metrics are, at least partially, resolved.

Data Analysis & Management

Undoubtedly, information systems will play a fundamental role in asset management, and this notion was reinforced by the emphasis placed upon them in the literature surveyed. Current domain specific systems are routinely employed in decision-making processes to identify needs and allocate resources, but evidence suggests that available features are underutilized. For example, many bridge management systems have predictive models of future maintenance requirements, but this aspect of the system is rarely exploited (FHWA, 1999). Understanding this condition is but one challenge facing those interested in the development of decision tools.

Additional challenges abound. Foremost, a data-driven decision approach starts with data input. Data collection processes should occur naturally during routine activities, and the potential of technology to support this function is tremendous. Hand-helds or similar devices could easily replace paper-based record keeping. A second issue is data access and security. Deciding what information is available to different actors is not a trivial decision, particularly since the value that this information might hold to each group is not necessarily understood at this point. In addition, infrastructure data security, understandably, has become a subject of tremendous, recent attention. Safeguarding potentially sensitive information while trying to maintain transparency to system managers, operators, users and investors is no simple task. Data maintenance is another nagging problem, and identifying the right mix of data to support necessary decisions is critical. One of the authors has experience with cleverly designed and intellectually appealing military data management systems that became too cumbersome to maintain and were thus underutilized. Simply put, the benefits of collecting and evaluating data should outweigh the costs. Not surprisingly, systems with extensive data requirements remain suspect. A related concern is data accuracy and reliability. Amekudzi and McNeil (2000) discuss how uncertainty in data can incorrectly influence decisions and describe an approach for handling this uncertainty. Finally, data will undoubtedly be used as a tool for prediction, but caution is warranted. Events over a lifecycle are uncertain, so programming analyses must incorporate flexibility to preclude ill-advised technological or capital commitments. Methods for recognizing and providing this flexibility in decision models and procurement processes need further development.

Aligning Capital & Condition

Currently, the processes of functional planning and condition assessment are segregated. Functional requirements are commonly identified during master planning efforts, which generally focus upon capital requirements generated by functional demands that are manifested in new development and/or retrofit projects with little consideration of existing asset condition. Similarly, approaches to condition assessment typically focus exclusively upon existing asset deficiencies without reflection upon functional needs. As a result, owners frequently possess separate lists of capital projects and deficiencies backlog that are undoubtedly somewhat redundant. A more holistic approach demands the integration of these two dimensions. Intuitively, consideration of capital needs and condition simultaneously will permit the identification of a more robust set of owner requirements.

To some degree, this situation is a by-product of decoupled capital and operational decisions. Just as asset classes are generally managed independent of one another so are capital and operations. Maintenance, repair and minor rehabilitation are typically funded from operating budgets while development or improvement investments are funded from capital accounts. Integrating capital with operations is fundamental to a lifecycle perspective. To properly evaluate a lifecycle decision, these two dimensions must become partners. Lifecycle decisions must routinely evaluate the effects of capital decisions upon operations while the existing state of assets and operations can and should affect the choices made during programming. This is especially true for owners considering an integrated facility delivery or an O&M service contract where understanding these conditions is important to structuring capital and maintenance contract provisions and evaluating proposals against historical or projected costs.

Roles of Public & Private Sectors

Debates about infrastructure and the private sector often diverge to increasing the use of private sector capital or transferring assets into private hands, but these discussions miss the point. Undoubtedly, a solvent, tax-exempt public agency can borrow at more competitive rates than a private entity, and the public sector need not, nor should it, abdicate its oversight of public infrastructure. In fact, the environment demands better public sector leadership. When constraints are present, balancing social and economic goals such as equity and efficiency is no simple task, but to do so requires full consideration of available alternatives and their benefits and costs. Public agencies need to view the private sector as a partner or a tool to improve public services; their competencies are developed and honed in competitive markets, and the private sector is an ally and not an adversary in the struggle to fulfill the demand for infrastructure services. Integrated facility delivery and service contracts are two mechanisms that can possibly leverage the competencies of both sectors.

Very few public owners in the United States have elected to utilize integrated service contracts for the delivery or upgrade of facilities or O&M contracts for existing facilities or system-wide operations despite anecdotal and growing empirical evidence of the cost reductions offered by such arrangements. Notable examples include Seattle Public Utilities' delivery of its Tolt River and Cedar River Water Treatment Plants using 25-year design-build-operate contracts and the City of Atlanta's 20-year O&M contract with United Water.[2] Seattle expects to save approximately $70 million over the 25-year concession period for the design, construction and operation of the Tolt Water Treatment Plant (Seattle Public Utilities 1999). Atlanta's decision was based upon their expectation that a system-wide O&M contract would substantially reduce operations costs in the near-term to allow stabilization of water rates and implementation of a significant capital improvement program (Salo et al. 1998).

The consideration of these arrangements needs to become a routine part of the programming process. The possible advantages are too great to ignore. Certainly, these approaches also have drawbacks, but the important point is their inclusion in the portfolio of options considered by infrastructure managers. A key step toward achieving this end, particularly within the United States, is opening up procurement processes. Current procurement statutes and practices either restrict or limit their use. A second, more practical challenge, is improving the structuring of these procurements. “Experiments” with such arrangements over the past decade have met with varying degrees of success, but unfortunately more often than not public procurements of integrated or O&M services have been flawed.[3] Properly packaging and procuring these services is critical to the long-term viability of alternative arrangements and the possible advantages that they might present. The response of likely private sector bidders and, more broadly, the development of the market are at stake. If private participants are to add value to the procurement process, then public owners must treat them in a stable and predictable fashion. Otherwise, potential participants are likely to pursue market alternatives that are more attractive elsewhere.

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[2] The contract includes operation and maintenance of: (1) a city-owned 100 million gallon per day (MGD) treatment facility and (2) the city's distribution system.

[3] See case studies in Miller's *Principles of Public and Private Infrastructure Delivery* and *Case Studies in Infrastructure Delivery*.

Conclusion

Certainly, this paper has raised a number of questions rather than providing many answers, but we see these questions as critical to the success of infrastructure asset management. We hope that they might spark dialog and research into important areas. Challenges to asset management presented in this paper generally fall into five categories:

- **Strategic:** opening procurement processes and defining system objectives
- **Integration:** desegregating functional & condition-driven requirements and asset classes & sectors; linking independent management information systems
- **Measurement:** identifying appropriate indicators and establishing comparative baselines
- **Analytic:** improving data collection, analysis & management and incorporating flexibility
- **Institutional:** defining public & private sector roles and affecting coordination between or reconfiguration of "stove-pipe" infrastructure divisions

The transition to an asset management posture within public sector enterprises and agencies has intuitive appeal since its potential to improve investment decisions and infrastructure performance appears considerable. Perhaps the most concise argument for asset management is provided below:

> *A formal approach to the management of infrastructure assets is essential in order to provide services in the most cost-effective manner, and to demonstrate this to customers, investors and other stakeholders (NAMS & IPWEA, 2000).*

Asset management is a promising concept where sustainable solutions are sought, better resource allocation decisions are possible, and management accountability is increased. Efforts are already underway to resolve current technical difficulties of integrating disparate databases, management and decision support systems. These problems are likely to be solved, probably sooner than expected, so data integration barriers will disappear. The unanswered question is whether or not public institutions and participating professionals will be prepared to follow suit.

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Asset Management in a Best Value context: A typology of interactions

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Abstract: *'Best Value', is a recent program in local government in the United Kingdom and Victoria (Australia). The Best Value framework has principles that are the hurdle requirements for success. These principles emphasise process as much as the outcomes or any quantitative performance measurement. As such, additional performance is required from local government asset managers. Best practice now includes accountability for process.*

Best Value's consultative interaction is only one of several possible ways of asset managers interacting with their municipal stakeholders. The literature identifies several different forms of interaction that, on consolidation, provide a generalised typology of interactions. Possible interactions range from those of the technocratic expert to those of the deliberative practitioner. There are qualitative differences in the aims of the interactions. Each type has differences as to what constitutes best practice.

The typology proposed in this paper provides a means for local government asset management to identify the value context through practitioner identification. This achieves the requirement that best practice be context dependent.

The Best Value framework points a way forward for future research into asset management processes as a precursor for identifying process's best practice.

Keywords: Best Value; corporate real estate; local government; performance; practices; property.

Introduction

Organisations in many fields are searching for best practices to improve organisational performance (Australian Manufacturing Council 1994, Lyne 1998). Local government has not been immune to the influence of this search for best practice (O'Neill 1995, Beattie 1994). The recent introduction of 'Best Value' into local government, initially in the United Kingdom and subsequently in Victoria (Australia), is the latest example of efforts to improve the performance of local government.

Recent years have seen a number of reform processes implemented in local government management. The rise of New Public Management (NPM) (Aulich et al. 2001), the use of Compulsory Competitive Tendering (CCT) mechanisms, council amalgamations and consequential changes in property and asset portfolios, and the introduction of new accounting standards (accrual accounting) (Bishop 1997) are just some of the changes. Changes in the operating environment of local government have changed what is required of management including asset management. The introduction of Best Value and considerations of Best Practice in local government raises not only issues of performance, but also issues of process. Issues of process are also a specific consequence of considering the local government environment.

This paper, specifically directed towards asset management while being couched in terms relevant to local government, reviews Best Practice and Best Value concepts before suggesting a typology for understanding the processes of community interaction.

Objectives & Method

Process is important in Best Value. This paper's objective is to examine the local government Best Value literature for process performance criteria and practices, of which interaction practices are a key process. The literature was reviewed from the perspective that Best Value represents the present high water mark for best practice in local government. This leads on to an examination of other literature to locate Best Value's practices within a general typology of interactions that identifies the qualitative differences and applicable practices as key points of distinction between types.

To form a typology, a diverse literature must be reviewed. In addition to the Best Value literature, urban planning practice literature is useful because of its heavy involvement in managing environmental change processes. A further body applies to asset and property managers, who are now encountering similar kinds of experience due to recent changes to local government management. Further, general public administration and professional practice literature provide sources of interaction practices.

Four possible groups for interaction have been identified – community, elected officials, employed officials, and other vested interests[1]. This paper concentrates on the interactions between employed officials and the community. Discussion of interactions between all four groups is beyond scope of this paper.

Best Practice

Interest in Best Practice, as opposed to 'best practice,' is motivated by a desire to improve organisational performance. Best Practice is defined as 'the process of gathering and comparing data from internal or external sources to evaluate your own business costs, processes or outcomes' (Cameron & Raphaely 1997)[2]. General principles of Best Practice are: shared vision of world class performance; consultative strategic planning; organisation-wide commitment to change; high level commitment; flatter organisational structures; continuous improvement and learning; focus of

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[1] Within the four groups identified further separable groups exist. Groups within community; within employed officials (functional departments and service providers); within elected officials (depending on the political situation there may be an elected mayor that claims a different mandate from other elected officials); and between non-resident vested interest groups like users of services, visitors and the media.

[2] This paper distinguishes between Best Practice and best practice. The former is the management philosophy widely discussed from the 1990s onwards, whereas the latter is the application of practice to achieve the best outcome.

customers (internal and external); pursuit of innovation; and use of performance measurement systems (Australian Best Practice Demonstration Program 1995).

Best Practice is commonly linked with the need to benchmark and other performance measurement practices (Beattie 1994). Benchmarking, however, relies on historical data while best practice is a constantly moving target (O'Neill 1995).

Best Practice is usually couched as being a generalised ‘pursuit of world-class performance’ (O'Neill 1995). However, best practice is context specific. Practices applicable to a profit-generating organisation may not apply to local government. For instance, the application of customer or consumer centred service models (Battaini 1993) to local government, while widely emphasised in New Public Management models, is problematic due to conflict with other concepts of citizenship (Black 1997).

In addition, several possible value contexts apply for local government. Firstly, there is its’ normative conditions and historical antecedents. For example, recent experience of providing local government expertise assistance to formerly Communist European countries shows this. Practices that worked within the normative traditions of mature democracies required reworking for the different norms of these transitional democracies (Straussman 2001). Secondly, the political environment contains expectations and experience of democratic processes that provide various models representing different philosophical views of democracy, such as participatory democracy, deliberative democracy (Bohman & Rheg 1997) and discursive democracy (Dryzek 2000). Thirdly, legislative requirements create contexts. For instance the legislative changes as has been experienced in the past decade in Victoria and the UK.

Best Value – conceptual and practical differences between the UK & Victoria.

There is a distinct difference between ‘best value’ and Best Value. The former has connotations of aspirations to, and achievement of, higher good. The latter is a legislated performance management framework implemented in local government in the UK and Victoria. Each manifestation of the framework has principles that encapsulate its objectives and provide hurdle requirements for measuring success.

In the UK the principles are:

- A ‘corporate’ view, including:
  - Whole of organisation approach;
  - Performance measures; and
  - Local aspirations.
- A program of performance reviews;
- Performance reviews to challenge the status quo;
- Targets for improvement (continuous improvement);
- Auditing (external review); and
- Intervention (in worst case scenarios) (Department of the Environment Transport and the Regions (UK) 1997).

For the UK, Best Value is a performance management system, or framework (DETR 1997), that is one element of an overall reform (modernising) program for local government that includes:

- Democratic renewal (redefining roles and organisational structures);
- An ethical framework (redefining roles and organisational structures again);
- Financial system changes;
- Improving service delivery and cost ; and
- Still accountable to central government (DETR 1997).

The rhetoric surrounding Best Value's introduction in the UK embeds the performance management framework within government that is founded on the '4Cs' – challenging performance, comparing performance, consultation, and competition.

In Victoria the principles are:

- Specification and Measurement of performance, including:
    - Service provision specification;
    - Performance outcomes;
    - Service specific measures are permitted;
    - Assessment of value for money;
    - Community expectations;
    - Balance of affordability and accessibility;
    - Opportunities for employment growth and retention;
    - Partnerships with other bodies; and
    - Environmental advantages[3].
- Responsiveness to communities;
- Accessibility and affordability;
- Continuous improvement;
- Community consultation; and
- Reporting (Department of Infrastructure 2000a).

The rhetoric surrounding Best Value's introduction there emphasises community, consultation, responsiveness and reporting (Department of Infrastructure 2000b).

In Victoria, Best Value is being implemented as a 5-year rolling program of testing council services starting in 2001. Services may be market tested in a manner similar to Compulsory Competitive Tendering (CCT), or other comparisons may be made. Benchmarking with other councils is likely to become an important comparison method.

Victoria has adopted the performance management framework, primarily as a replacement for a despised CCT program. The political framework is implied, or still under development through further changes to the *Local Government Act*, or silently relies on the reforms of the previous government[4]. Nevertheless, Best Value was introduced there as a way of restoring faith in local government democracy, by

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[3] The last two of these are guidelines only; the remainder are legislated requirements *Local Government (Best Principles) Act 1999,* ss208B, 208C and 208D.

[4] CCT, along with amalgamations of councils and many other local government reforms, was introduced by the Kennett Liberal government; Best Value by the Bracks Labor government.

making local government more responsive following a period where reform was imposed centrally. An imposition which saw non-elected commissioners appointed to oversee amalgamations[5], and a shift towards corporatised models of governance.

The process of implementation differs between the two jurisdictions. In the UK, Green and White Paper consultations preceded legislation, followed by pilot programs and further Green and White paper consultations on other aspects of the modernising program. Victoria introduced Best Value's legislative changes two months after a change of State government, and then conducted a consultation process on its implementation. Undoubtedly, Victoria's Best Value program owes an intellectual debt to the UK process which may account for the different, and much truncated, implementation process.

Local government political structures also differ. The UK local government White Paper's model (DETR 1998a) may be described as an 'executive and parliament.'[6] Committee chairs are given executive power for their 'portfolios.' Victoria operates more on a 'board of directors' model with a Mayor more akin to a chairman of a board. The council provides strategic direction and overall leadership with delegation of power for day-to-day issues to the non-elected CEO and council officers (Tucker 1997). Committee work is usually limited to the whole of council meeting as a sub-committee. The differences may reflect the number of councillors and the sizes of constituency in each case (Collins 1996).

The two manifestations of Best Value share the objective of improving local government performance regardless of the differences in rhetorical emphasis, the mechanisms of Best Value's introduction, governance models and the detailed principles.

Best Value and its consultative interaction

Almost every Best Value principle, in either manifestation, involves issues of process as much as performance measurement. Asset management activities link the actual assets, political decision-making, other service delivery managers and the general public. Best Value invokes for asset managers questions of their interaction with the community and processes of consultation, reporting and being democratic (transparent and inclusive are optional readings for democratic).

The idea of Best Value contains a consultative interaction with the community as a key element. (DETR 1997, Lowndes et al. 2001, Martin 1998) Community is a contended term (Gibson & Cameron 2001). There are two main categories of community. Firstly, there is a 'community of place' that assumes a consensual harmonious view where differences are ignored through an emphasis on common territorial or spatial interests (Saunders 1979, Martin 1998, Lowndes et al. 2001). The

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[5] Amalgamations in 1994 saw the 210 local governments reduced to 78. Non-elected commissioners were appointed to manage councils during this process. Councils have subsequently reverted to elected bodies of, typically, between 7 and 12 councillors.

[6] The White Paper suggests 3 models of governance for adoption – directly elected mayor with a cabinet; cabinet with a leader; and directly elected mayor and council manager.

second is a 'community of interest' where a common stake creates a specific grouping (Martin 1998, Lowndes et al. 2001). Adopting Best Value raises questions as to the means asset managers use to interact with both these communities.

Consultation encompasses not only users, local businesses and the wider community, but also non-resident visitors, tourists, non-users of services, 'communities' of place and of interest (DETR 1997, Martin 1998). This paper concentrates on interactions with that contended community.

A number of authors (Martin 1998, Lowndes et al. 2001, Bishop 1999, Arnstein 1969 & 1973, Burns et al. 1994, Marshall & Sproats 2000, and Conner, 1985) have identified engagement with the community as a spectrum of possible interactions relying on Arnstein's 8 tier hierarchical model (1969 & 1973). Martin (1998) proposes a simpler 4 level hierarchical model of community engagement.[7] Consultation occupies a middle position within both Arnstein's and Martin's classifications where it involves 'asking people what they think of what you do' (Martin 1998). In practice Best Value interactions may also include 'Involvement' where priorities are elicited from the consultees (Martin 1998).

The consultative interactions understood in Best Value do not exhaust the kinds of interactions that might be desirable in best practice. Rather a range of types exists that provide a typology of interactions that may be adopted to suit circumstances.

A Typology of Interactions

Rather than a hierarchy, this paper proposes a typology of interactions. A classification by type avoids, to some extent, the hierarchical problem identified by Martin (1998) who criticises the hierarchy as implying activities further up the hierarchy are better. There is an implied assumption as to idealised forms of interaction, and even democracy. The implication is that giving people more direct control and empowering them as a consequence is a 'good' thing of itself (Osborne 1994).

The literature identifies several different forms of interaction – suggesting a generic typology of interactions. There exist qualitative differences in the aims of each interaction type, and what constitutes best practice differs across types.

The hierarchical models noted identified above raised issues of blurred boundaries between categories with some approaches falling in more than one category (Martin 1998). Categories may be defined by specifying boundary conditions, or by defining central tendencies. The second form of category is one of type and is more useful where boundaries are indistinct and subtle distinctions exist due to the nomenclature used, and where some characteristics may be shared by several types without being the distinguishing feature of the type.

[7] Martin's (1998) hierarchy consists of Information provision, Consultation, Involvement and Delegation

This paper's typology proposes a classification system of possible ways for local government managers to interact with their community based on the following types of interactions:

- Consultative/ Participatory;
- Technocratic;
- Reflective;
- Communicative;
- Deliberative;
- Representative; and
- Facilitative.

Consultative/ participatory

There are differences between Consultation and Participation. A definition of consultation that involves 'asking people what they think of what you do' is sufficiently narrow to be useful for classification purposes (Martin 1998). Participation may be conceptually closer to Martin's 'Involvement' which may also include elements of a further category of 'Delegation.' Definition of participation as referring to 'public involvement in the process of formulation, passage and implementation of public policies' (Parry et al. 1992) represents the current distinction between the two interaction forms. Arnstein (1973) adopts a more cynical view bundling consultation with other token forms of interacting such as Informing and Placating. Vestiges of the bases of Arnstein's cynicism are still evident but current definitions appear to reflect a genuine valuing of community inputs.

Consultation implies an *a priori* formulation of proposals before discussion with other parties, whereas participation's inclusion of formulation within its definition indicates a much earlier engagement with conferees.

The impetus for Consultation is frequently a need for improved and more responsive decision-making. Elected and employed officials, through a consultative interaction, look to the community to articulate its position which is then incorporated in decision-making processes. The impetus for Participation is, frequently, to broaden the base of democratic processes and derive greater legitimacy for democracy as representing a wider range of views (DETR 1998b).

Local government consultative activities may range in level from whole of organisation to specific services (from a range of facilities) down to individual facilities.

Consultative/Participatory practices are many and varied having been in use for some time. They include public forums and consultative documents (Marshall & Sproats 2000, Martin 1998, Lowndes et al. 2001); interactive IT mechanisms, surveys, and citizen panels (Martin 1998, Lowndes et al. 2001); performance targets, community/area profiling and citizen juries (Martin 1998); referenda (Lowndes et al. 2001); and newsletters (Marshall & Sproats 2000). Some of these practices are attributed to other types of interactions, particularly citizen juries (Lowndes et al. 2001) and communicative interactions.

Technocratic

In this interaction mode, achieving ends are the key measure of performance. An interaction mode favoured by the 'Technical-Rational' practitioner (Schön 1983), a Technocratic approach relies on the solving of tractable problems which requires agreement about ends, and an ability to name the things attended to and frame the context. The application of 'expert' technical (scientific) methods achieves a decisive solution.

Interactions rely on a clearly defined 'need' (ie. problem to be solved) and boundaries to the problem for an 'expert' solution to be delivered to a 'grateful' recipient. Dissemination of information (Martin 1998, Lowndes et al. 2001) and solutions are forms of interaction consistent with this approach, together with needs definition.

Reflective

Reflective interactions are primarily a practitioner's internalised learning (Schön 1983). Reflective practices yield greater understanding of the complex phenomena encountered in interactions. Through consciously raising ways of knowing, thinking, and reflecting on problems adaptive forms of interaction are achieved. Ways of practice may entail opportunities for reviewing interactions through case study learning (Yin 1994) or research practices

Communicative

Communicative interactions are a key theme in the work of Forester (1989) and Healy (1996), among others, who rely on Habermas (1984) for their philosophical foundation. These authors operate from the principle that 'ourselves, our interests, and our values are socially constructed through our communication with others and the collaborative work this involves' (Healy 1996). Communication processes are crucial in this interaction, particularly 'inclusionary argumentation' where public discussion includes all members of a political community's ways of knowing, valuing, and giving meaning (Healy 1996).

The distinction between this and participation is difficult as communication is said to underpin conceptions of participatory democracy (Held 1987). Previous definitions of participation contained involvement and delegation, whereas communicative interactions emphasise communication processes and inclusiveness of various views.

Mapping stakeholders is an important part of communicative interactions. Deciding location and style of discussion are important practices as are developing strategies of discourse or argument now and ongoing (Healy 1996). Other practices not specifically attributed to this interaction type, are drawn from Consultative/Participatory interactions, particularly those that contain high levels of community involvement.

Deliberative

Forester (1999) has gone on to propose 'deliberative' interactions as involving debate, public consideration of issues and public learning in a two-way iterative process. Deliberative interactions involve more than evaluation of efficiency. Rather, searching for multiplicity of values is required, as no single 'vision' can be correct, or complete. The difference between Deliberative and Communicative interactions is also unclear but, based on Forester's definition, the Deliberative interaction highlights a multi-valency, that is, different methods at different times.

Deliberative interactions require attention to both substantive, technical issues and relationships between the parties who care about the issues (Forester 1999). Deliberation must, at different times, involve expert knowledge, listening, encouraging creative solutions, through a structured process of participation, discussion, intervention, and decision making (Forester 1999).

Focus groups, community plans, visioning exercises, user management, and citizens' juries are specifically identified as Deliberative type practices (Lowndes et al. 2001) along with other previously mentioned practices, implemented to permit the two-way iterative learning of Deliberative interactions.

Representative

This type of interaction is based on electoral processes. It is unusual within governments of the Westminster style for management to be elected.

A representative acts in the interest of the represented, but may also act independently with discretion and judgement. Representatives are vested with interim responsibility. Ultimate responsibility is with the electorate via the ballot box (Pitkin 1967). The ballot box is the supreme interaction.

Interaction practices may entail whatever is necessary to ensure representation – one-to-one meetings, attending public meetings, and media interactions, among others. Good interactions may provide an ethical dividend through claims of integrity based on reference to the constituency, a restoration of faith in the workings of representative democracy, and an enhancing of representative institutions by giving all parties a chance for voice (Bishop 1999).

Facilitative

The Facilitative interaction builds community through 'building political capacity – the capacity to make collective decisions amidst diverse and conflicting interests' (Nalbandian 1999). Community diversity is expressed at administration, representation and participation levels.

Interactions are process-orientated. Employed officials' technical knowledge is required in problem solving with the community. Negotiations involve practices such as public hearings, discussion, deliberation, anticipating and fostering participation, and building structures of participation considered legitimate by the community. How business is conducted is as important as what is done.

Discussion

Local government's context in Victoria and the UK is currently dominated by the Best Value framework. The idea of Best Value is to improve local government management. A key requirement is for consultation with the community. Differences in definitions of community ensure that different voices exist within a municipality. For Best Value's implementation to be successful these 'voices of difference' need to be incorporated in local government management practices. The means of this incorporation are particularly important where democratic renewal (UK) or the restoration of faith in local government (Victoria) is required.

Best Value makes a number of demands on local government management through legislated requirements of performance measurement, continuous improvement, consultation and reporting. As such, Best Value is the latest attempt to implement Best Practice in local government. Best Practice assumes a moving target of continuous improvement (a Best Value requirement) but does not acknowledge context implying an amorphous kind of Best Practice that is suitable to all organisations everywhere. For local government, value contexts - normative conditions and historical antecedents, the political environment and philosophical emphases, legislative requirements and the voices of difference are integral to their operating situations.

Typologies are useful for analysing practices in relation to organisational objectives and contexts. The previous hierarchical models, while helpful, are inadequate where multiple contexts apply, and where contexts are fluid. In this situation, best practice needs to respond to this pluralistic environment. The development of a non-hierarchical typology of interactions between local government employed officials and the community provides a more suitable classification method.

This typology will assist local government asset managers discern the value contexts they operate in and the practices (from those listed within the types) that begin to constitute ‘best practice’. The identification of context appropriate best practice is a basis for accountability for the processes that are embedded in those practices.

The typology also provides a basis for further empirical research in asset management into the actual practices and processes applicable to its types. Studying and categorisation of processes is difficult, as they are frequently qualitative and rely on the experience of practice. There is a role for further qualitative research into these experiences as a precursor to identification of best practices.

Conclusion

A typology of professional-community interactions provides local government managers with a means to identify their value contexts and best practices. The current Victorian and UK environment for operating local government asset management is the Best Value framework, which is the latest incarnation in the search for best practice in local government. While not precluding the possibility of achieving ‘best value’, Best Value requires more than measurement and improvement of performance. Issues of responsiveness to community are expressed in Best Value as Consultation. However, this does not exhaust the kinds of interactions that might be desirable in best practice, though it does point the way through the requirement for consultation. Having used considerations of process from Best Value, other interactions were examined to develop a typology that also includes process in their success. Where process dictates success, as in Best Value, considerations of best practice require that not only the process, but accountability for that process is considered.

This then is the flow-on effect from the introduction of Best Value. Best Practice now includes process and accountability for those processes which in turn requires means of identifying processes to ensure that accountability. The application of a typology to classify interactions is an aid in developing accountability for processes. This paper's non-hierarchical typology provides that a means that is more suitable to the plurality of contexts typical of modern local government.

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Relationships between building condition assessment and maintenance costs in the evaluation of real estates refurbishment programmes

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Abstract

Refurbishment of the existing real estate is a strategic objective of the Italian housing policy for the next years.
Condition assessment of the large public real estates is still the main problem for the development of the refurbishment strategies. On the other hand, the assessment procedures should give the information required to establish the feasibility of refurbishment works, considering the interdependencies between technological-commercial aspects and economic constraints.
This paper presents the methodological framework of a first stage research project funded by the Ministry of Scientific Research and carried out by the Polytechnic of Milano (co-ordinator), the University of Ferrara, the Polytechnic of Torino and the University of Napoli.
The research project will investigate the incidence of maintenance costs in the evaluation of real estates refurbishment programmes. The objective is to develop a methodological approach and the attendant procedural systems to support decisions on refurbishment programmes considering the relationships between buildings condition assessment and maintenance costs analysis
The paper explains the main steps that will be developed in the research project which consists of three work packages:
- *definition of a condition assessment procedure, based on "condition scores", to evaluate buildings decay and maintenance costs required to refurbish them;*
- *analysis of the interdependence between decay trends and maintenance cost rates to define "global cost evaluation" factors;*
- *development of the framework of a decision support system to evaluate feasibility and opportunity of refurbishment programmes.*

Keywords: Refurbishment, Condition assessment, Maintenance costs

Introduction

This paper presents the methodological framework and the actions developed in the first stage of the research project “Definition of indices for the development of building maintenance schedules and programs”. The project, funded by the Italian Ministry of Scientific Research, is co-ordinated by the Polytechnic of Milano and involves the University of Ferrara, the Polytechnic of Torino and the University of Napoli.

The Work Package which the Ferrara University research unit is involved in, concerns the “Assessment of building decay and maintenance costs for the evaluation of maintenance strategies”. The first tasks developed in this Work Package have been focused on the main relationships between maintenance costs, building subsystems and building types.

Data on maintenance costs have been estimated and processed analysing some case studies and then developed with the aim to evaluate the incidence of the main building components on the total amount of maintenance costs. The results of this task will be further developed to define “cost indexes” for the evaluation of refurbishment opportunity.

Research approach and methodology

In Italy there is still a lack of knowledge about methods to manage maintenance works and tools for a preliminary estimation of budgets required for these works.

The public organisations which have to manage large real estates generally do not have updated and detailed data about maintenance costs; these costs are generally split in different parts of the balance sheet depending on budget sources rather than type of works.

Thus it is very difficult to collect reliable and homogeneous data to be used to develop relationships between economic issues (repair, maintenance and refurbishment costs) and technical matters (quality and decay process of materials and building components).

The working groups involved in the research project are analysing the costs of maintenance works measuring the shares that can be referred to the main building subsystems and assessing how these rates change depending on the building categories.

The objective is to define maintenance cost indices which allow an estimation of the budget required to improve and maintain a real estate.

On the other hand to complete the estimation of maintenance costs it is important to schedule the budgets required; assessment of actual cost being depending on the time when the money will be spent.

Thus, the analysis of the maintenance cost rates will be deepened investigating, for each building subsystem, the changes of these rates due to the assessed conditions of materials and components (i.e. how the condition assessed, delaying or moving up a maintenance work, can increase or reduce the global cost of a maintenance programme).

The results of this analysis should provide the coefficients to be used to adjust the maintenance cost rates of each building subsystem considering its condition; with this aim the condition assessed will be scored using a “condition scales”.

The first tasks developed by the University of Ferrara research unit have been focused on the relationships between the results of real estates condition assessment procedures and the estimation of maintenance costs.

The objective is to develop a method of maintenance cost analysis to be related to the decay analysis; this method should satisfy two important requirements:
- to do not require much time, specialised surveyors, high-tech equipment, etc. (in other words to be fast and not expensive);
- to be based on a decisional support system able to reduce the subjectivity of evaluation.

Because the end is a forecast of costs required to refurbish and maintain the real estate object of the condition assessment, it is important to define:
- how the survey should be done (how many data to be recorded, how much detailed, etc.);
- the selection of building components more significant for a reliable forecast of refurbishment and maintenance costs.

The first aspect being important to optimise the procedures and to reduce the condition assessment costs, the second one to assure the quality of results.

Results to be reached by the University of Ferrara research unit regard:
- definition of maintenance cost rates for the main building subsystems;
- development of procedures for a condition assessment based on scores depending on a condition scales ;
- adjustment of cost rates using factors based on the condition assessment results.

Maintenance costs analysis: conceptual model

Research project aims to analyse maintenance costs considering the relationships with:
- building condition assessed and decay trends expected;
- technical performances required for building components and services.

The main result of this analysis is the definition of cost rates and indices to be used to focus the condition assessment procedures to a selection of building and service subsystems more relevant in the total amount of maintenance costs.

In other words, analysing the data on the different maintenance cost rates it is possible to reduce the number of elements to be analysed in a condition assessment of the buildings of a real estate. It means that the survey can be fast and not expensive.

On the other hand using the same maintenance cost rates it is possible to estimate the total amount of the maintenance cost required processing the data concerning the condition assessed for the selected subsystems.

The work on this task has been scheduled in three subtasks:
- collection of data on maintenance cost of the building and services subsystems;
- choice of parameters to be used for the definition of cost rates and indices;
- processing of data on maintenance costs applying the parameters developed in the previous subtask.

Reliable data on maintenance costs have been collected analysing in details some maintenance plans developed for different types of building.

The plans selected had been carried out estimating the actual cost (man-hours and consumables) of each maintenance work of each building component and service equipment scheduled for a standard period of three years.

On the other hand, to have homogeneous results, the buildings selected as case studies had to be new buildings or just refurbished buildings; thus the cost of maintenance works scheduled for the first three years were not altered in those buildings requiring substantial replacements or expensive repairs.

This approach allow to determine which subsystems can be considered as the main sources of maintenance costs and used as “indicators”.

The maintenance costs have been analysed computing all the maintenance works planned for a period of three years. The shares of costs for each subsystem have been estimated considering the rate referred to the building value.

Thus a first assessment of the following data has been reached:
- the share of maintenance costs for the building and services subsystems;
- the variation of these shares in the different categories of buildings;
- the rates of maintenance costs referred to the building value.

Obviously, the number of buildings monitored is not sufficient to consider the data recorded as the final ones. The actual end of this step was to define the main figures to be analysed in a second step of case studies including a more significant number of buildings.

Maintenance costs related to building types: case studies

Case-studies include four buildings selected from different categories:
- health centres
- industrial buildings
- office buildings
- houses

The case studies include one building for each category; the four buildings selected have been chosen considering the possibility to compare the results achieved investigating the detailed maintenance costs for a large number of building components and services components.

The buildings are new or just refurbished, then the forecast of the maintenance costs for the first three years do not include replacements or other expensive works. As defined in the methodological approach, this condition has been considered very important to analyse, in this first step, the share of maintenance costs to be assigned to each building and services subsystem without any "interference" due to different levels of decay.

The buildings analysed and presented in the case-study forms include:
- an hospital refurbished in Torino;
- an industrial area including several buildings in Bergamo;
- an new office building in a village close to Milano;
- a new block of flats in a small town close to Rome.

Case study n.1 – "Le Molinette" Hospital

This case study concerns the new building included into the refurbishment and enlargement project of the "Le Molinette" Hospital in the urban area of Torino.
The maintenance programme has been carried out with the building contractor which was requested to offer a maintenance service for the first three years.

Building value	Euro 15.750.000,00 (cost of the new building as indicated in the tender for building contract)

Charts

Fig. 1.1 Yearly Maintenance Costs Average for Sub-Systems

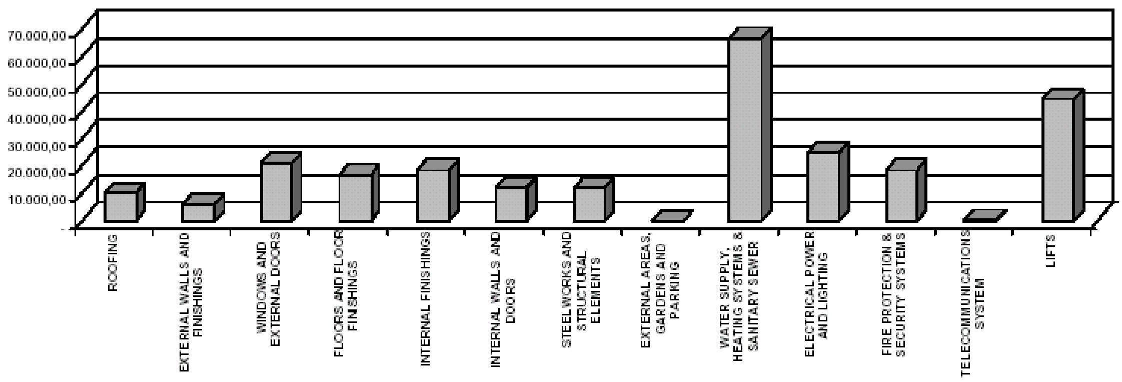
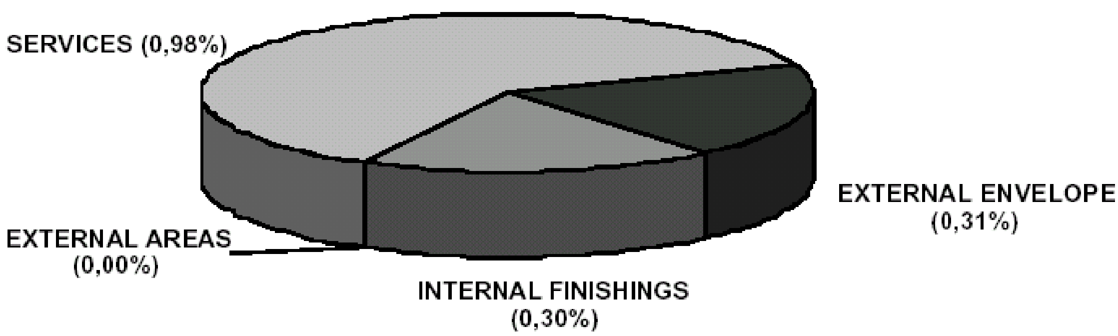


Fig. 1.2 Rate of Yearly Average Maintenance Costs on Building Value for main groups of works



Notes

The maintenance plan indicates high costs for inspections and checks of lifts (generally expensive in the hospitals because of the number of lifts required); it depends, in this case, on the concentration of vertical circulation in this new building.

Case study n.2 – “ABB” Industrial buildings

In this case the maintenance costs analysis concerns an industrial complex close to Bergamo owned and managed by the same organisation; the real estate includes six buildings (factories and offices).
The buildings have been built about 25/30 years ago and the condition assessed was good on the average. No significant replacements were required.

Building value Euro 21.000.000,00
(value estimated considering the average cost of industrial buildings in the same area)

Charts

Fig. 2.1 Yearly Maintenance Costs Average for Sub-Systems

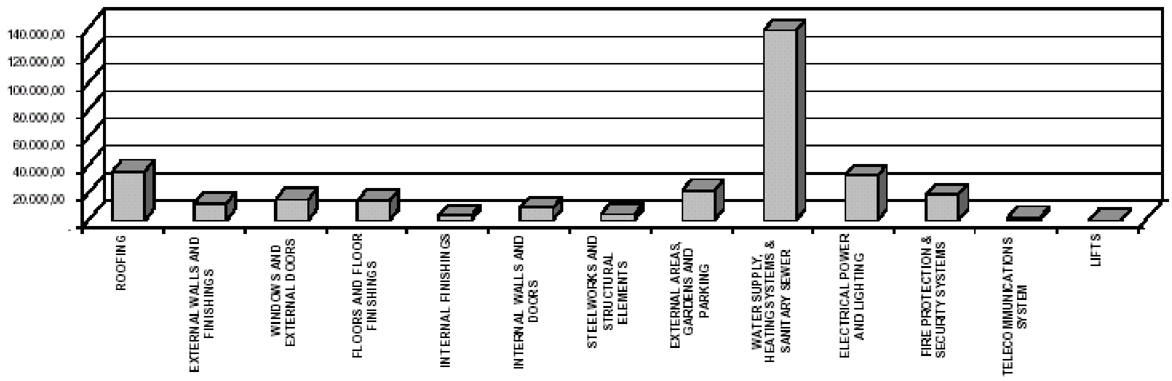
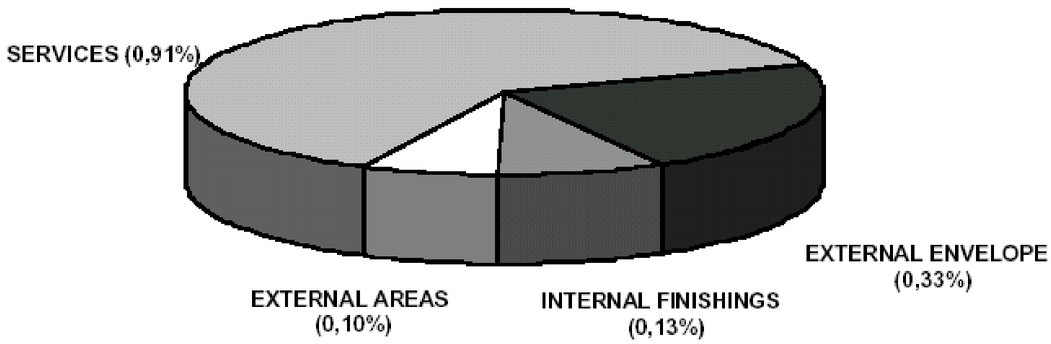


Fig. 2.2 Rate of Yearly Average Maintenance Costs on Building Value for main groups of works



Notes

The remarkable rate of maintenance costs for the external areas depends on the considerable dimension of parking areas and gardens. Analysing these data it has been also considered that the maintenance plan concerns a group of buildings (it can determine an increase of cost for some maintenance works)

Case study n.3 – "Triumph" Office Building

The building analysed is a new block for offices in a village close to Milano.
The maintenance plan and the cost estimation have been done during the construction design stage carrying out a detailed analysis of the technical solutions adopted for each building and service subsystems.

Building value	Euro 2.020.000,00 (cost of the building as indicated in the tender for building contract)

Charts

Fig. 3.1 Yearly Maintenance Costs Average for Sub-Systems

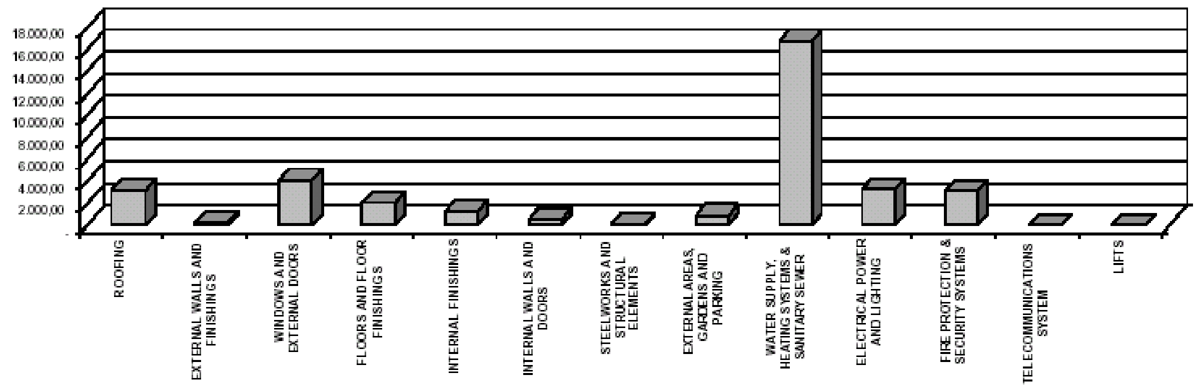
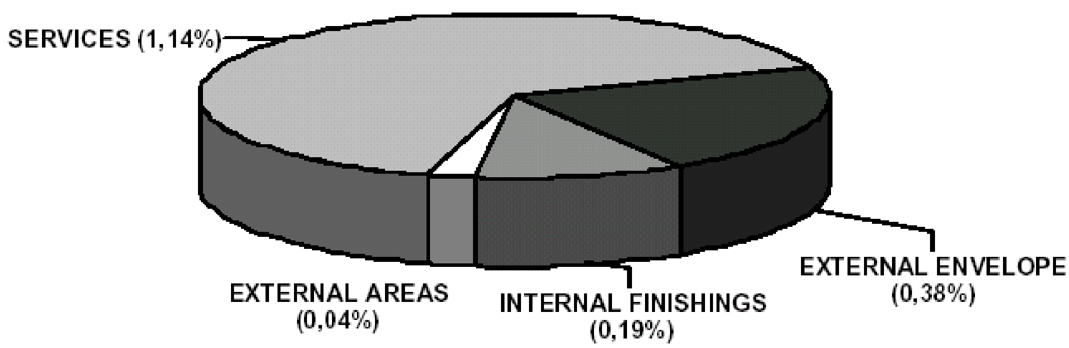


Fig. 3.2 Rate of Yearly Average Maintenance Costs on Building Value for main groups of works



Notes

The quality of finishing and the technical-functional-aesthetic performances requested determine frequent and expensive maintenance works. Levels of maintenance costs recorded are the highest in the majority of subsystems (this is a condition generally found in the office buildings).

Case study n.4 – "PA.L.MER." block of flats

The building is a multi-storey block for flats.
As in the previous case-study the maintenance plan and the cost estimation have been done during the construction design stage carrying out a detailed analysis of the technical solutions adopted for each building and service subsystems.

Building value Euro 1.150.000,00
(cost of the building as indicated in the tender for building contract)

Charts

Fig. 4.1 Yearly Maintenance Costs Average for Sub-Systems

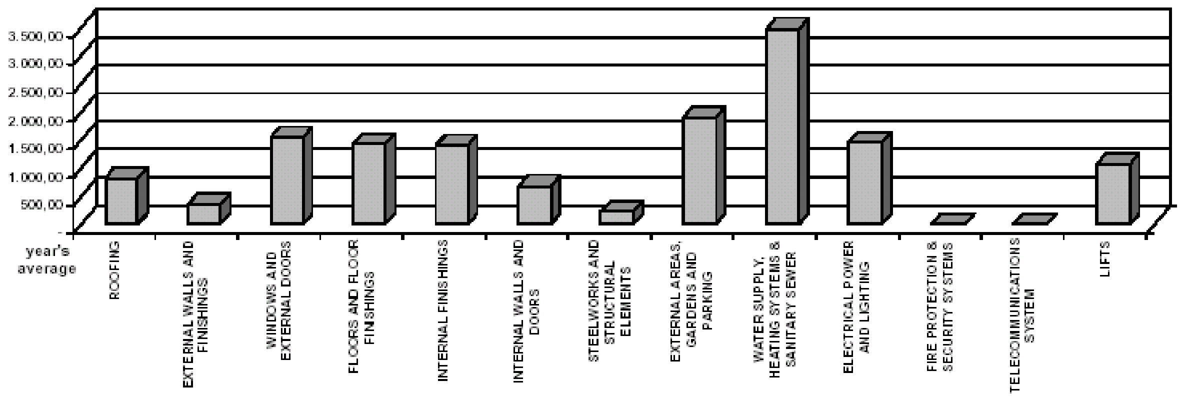
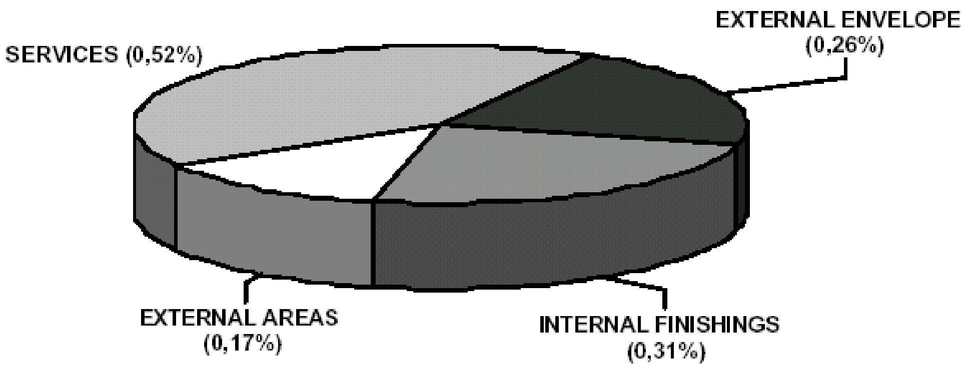


Fig. 4.2 Rate of Yearly Average Maintenance Costs on Building Value for main groups of works



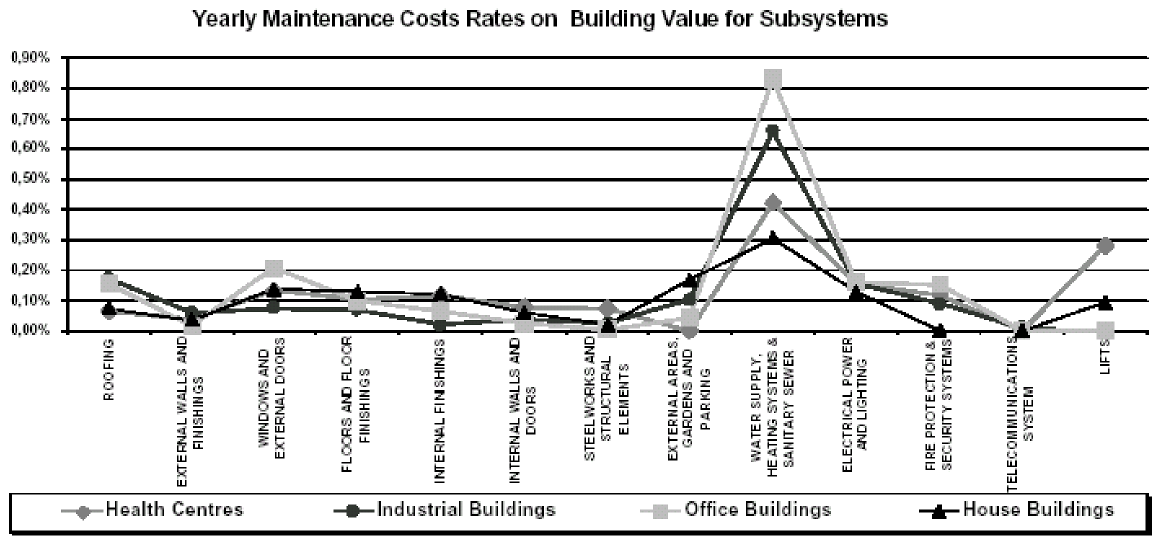
Notes

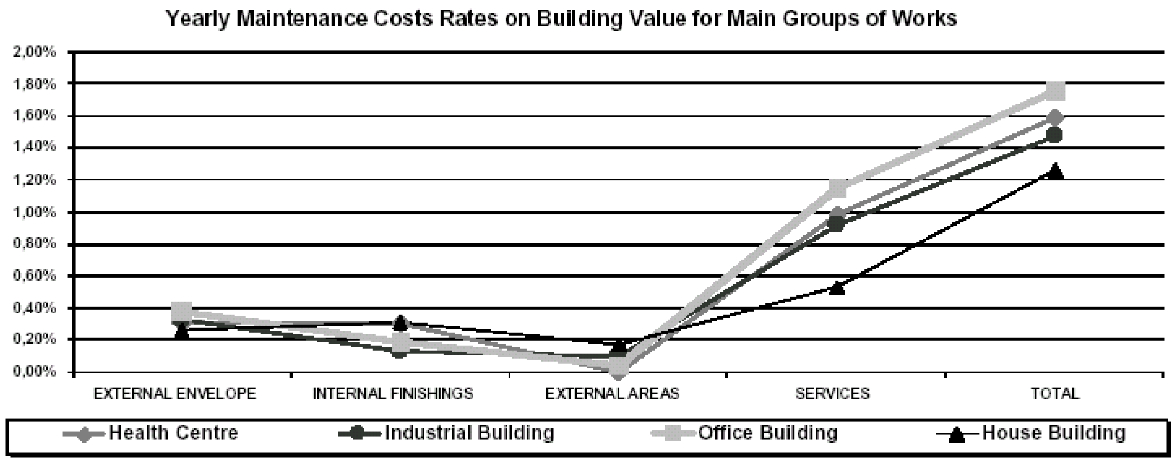
Contrary to the previous case study the maintenance costs of this building are the lowest for the majority of subsystems. In the house buildings the users are directly involved in the management of their flats doing some inspections and maintenance works by themselves; thus some works (and costs relating to) are not included in the maintenance plan.

Comparative Analysis

Data on maintenance costs recorded in the case studies have been processed and compared to estimate the trends of the rates referred to the subsystems and to some macro-groups of subsystems.

The following charts show the results obtained about the trends of maintenance cost rates for each subsystem and for some macro-groups of subsystems.





In the first chart it can be seen that there are some significant differences in the maintenance cost rates of some subsystems. The clearest one concerns the subsystem "Water Supply, Heating System & Sanitary Sewer": on one hand the differences are proportional to the high maintenance costs of this subsystem, on the other hand in the different types of building the characteristics of this subsystem change very much.

For the other subsystems the different rates can be referred to specific condition as well as: durability of materials and construction technologies, difficult execution of maintenance works due to the shape of buildings, etc.

In any case, as showed in the second chart, the trends seems to be more homogeneous if the rates are referred to the main macro-groups of subsystems.

The ranges of the maintenance cost rates analysed in the four case-studies show the following values that can be used for further analysis.

Rate of Yearly Average Maintenance Costs on Building Value

	External Envelope	Internal Finishings	External Areas	Services	**TOTAL**
Hospital	0,31%	0,30%	-	0,98%	**1,59%**
Industrial Buildings	0,33%	0,13%	0,10%	0,91%	**1,47%**
Office Building	0,38%	0,19%	0,04%	1,14%	**1,76%**
Block of Flats	0,26%	0,31%	0,17%	0,52%	**1,26%**

Conclusions and next actions

The comparative analysis has showed a substantial homogeneity of the maintenance costs rates in the different building categories. Thus this approach can be extended deepening the analysis on other buildings for more detailed and reliable values of the maintenance costs indices.

The reference to the building value as parameter to calculate the maintenance costs rates seems to be a reliable approach. It provides an “automatic adjustment” of the differences of maintenance costs depending on the technical and functional characteristics of different buildings included in the same real estate.

The further analysis, to be carried over investigating a larger selection on buildings, should define the subsystems that the main part of the maintenance costs depends on: these subsystems will be used as “indicators”.

These “indicators” can be different depending on the type of building; for example, the maintenance cost for building services is most important in a hospital rather than in a block of flats. In any case it will be possible to define a table indicating the different “weights” of each subsystem in the different building categories.

This approach will be applied in the condition assessment focusing the inspection only on those subsystems that can be identified as “indicators” (it reduces length and cost of survey procedures without affecting the reliability of results).

Next actions will aim to define the coefficients to adjust the “maintenance cost indices” considering the condition scores assessed after the building survey procedure; to achieve this objective the following steps will be developed:
- definition of building survey procedures based on a selection of elements more significant for the assessment of the real estate condition (indicators);
- adoption of a condition scale to categorise the building into a condition state;
- definition of a method to adjust the maintenance costs rates of each subsystem using the condition scores assessed;
- development of estimation procedures based on the maintenance costs rates.

The estimation procedures, based on reliable maintenance costs rates interfaced with the buildings condition, are the strategic objective for the development of the framework of a Decision Support System for:

- evaluation of refurbishment opportunity;
- feasibility analysis of refurbishment work considering the budget available;
- assessment of priority for a good schedule of maintenance works.

Study of Water Cooling Schemes for Commercial Air-Conditioning Applications

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Abstract: *For a number of years, the use of water-cooled air-conditioning systems was not encouraged for commercial applications in Hong Kong. This was mainly due to the scarcity in water supply. Central air-cooled air-conditioning systems with a relatively low coefficient of performance are thus widely applied in the city. With a raised concern about building sustainability and a surplus supply of potable water from the Mainland China, the local government policy has been revised recently and the possible use of various types of water-cooled air-conditioning systems is being actively considered. In many existing commercial buildings, a conversion of the air-cooled air-conditioning system by a suitable design of water-cooled system has to bring into a number of crucial considerations such as the availability of space, replacement cost, payback period, etc. This paper presents a case of investigating the performance of evaporative air-conditioning system under Hong Kong weather condition. The economic feasibility of modifying an existing air-cooled air-conditioning system to one using fresh-water cooling towers in an existing commercial building is discussed. The application of centralised condensing seawater supply and district cooling schemes, and the methodology and procedures leading to the final recommendation are addressed.*

Keywords: air-conditioning, cooling tower, district cooling scheme, life-cycle costing

Introduction

Comparing with an air-cooled air-conditioning (AC) system, a water-cooled AC system offers better coefficient of performance (COP) for the same application, i.e. less energy consumption for producing the same amount of cooling capacity (Goshayshi *et al* 1999). Some water-cooled AC systems use seawater as a means of condenser heat rejection; these include the once through seawater-cooled AC systems and the application of seawater cooling towers. Recent studies indicate that energy savings of around 20-30% are possible when compared with the air-cooled chiller schemes. In the past, potable water was a cherished resource in Hong Kong. For a number of years, one major source of potable water is from the Mainland China and the water from the Pearl River is delivered via lengthy pipelines across the territory to Hong Kong. The application of evaporative cooling by means of mechanical-draught fresh-water cooling tower in AC system had to be approved by the Water Supplies Department, since the device requires continuous supply of make-up water to compensate the evaporative loss. Only the applications to specific industrial processes were allowed with very stringent assessment criteria. According to the government statistics, there are only about one hundred numbers of evaporative-cooled AC systems in Hong Kong using the Government's main water supply. There are about another one hundred once-through seawater-cooled AC systems that serve public and commercial buildings. These are installed at buildings close to the seafront, and have dedicated seawater pumping stations and pipelines for AC heat rejection. In some other buildings near the seafront however, air-cooled heat-rejection systems are still used because the investments can be lowered. Hence the use of air-cooled AC systems has been dominating in the public and commercial sectors throughout the city.

With the growing concerns about energy saving, building sustainability and, at the same time, a record of over supply of potable water from the Mainland China, a wider use of evaporative-cooled and water-cooled AC systems has been called for. Building professionals urged the relaxation of using fresh-water cooling towers in newly designed AC systems. In 1999, a government study (HKSAR Government 1999) concluded that the economic and environmental benefits of adopting water-cooled AC systems on a wider basis in Hong Kong are substantial. Three different schemes of water-cooled AC systems with good potentials have been identified. These are:

1. Centralized piped seawater supply system that consists of a central supply of large quantity of seawater to a number of buildings via pumping station for condenser cooling.
2. Centralized piped supply system for cooling towers, that is a similar infrastructure arrangement to the above; however, this involves the supply of a much smaller amount of seawater or freshwater to the buildings.
3. District cooling scheme (DCS), that comprises a large central chiller plant located within close proximity of the buildings (or district) being served.

In a centralized piped seawater supply system, seawater is supplied to the air-conditioning plant of the individual building through an underground distribution piping network. It is a capital intensive infrastructure development. Energy and economic benefits must be justified before implementation. Other than the advantage of installing less number of seawater pumps because of the diversity factor, the economy of scale lies in the use of large seawater pumps. This is not so attractive as the use of huge chillers in DCS, of which the COP can be much higher than the medium-size chillers.

Technically speaking, the location, development and implementation of the above schemes will be largely dependent on the physical area or district where the scheme is to be employed. It will be much simple to implement these in new developing areas than in existing urban areas. In many existing commercial buildings, a conversion of the air-cooled AC system by a suitable design of water-cooled system has to bring into a number of crucial considerations such as the availability of space, replacement cost, payback period, etc. The methodology and procedures adopted to produce the final recommendation also have to be explored. In the role of a facilities manager, there is a need to study the technical feasibility and financial implication of modifying an existing air-cooled AC system, during the building retrofit work, to an evaporative AC system with cooling towers. In the following sections, a study of the said modification work based on real building data is first introduced. Then a methodology of evaluating DCS is discussed. Computer simulation has been found very useful in these analyses.

Modification of Existing Air-Cooled Air-Conditioning System

In this study, real data of an existing commercial building installed with an air-cooled air-conditioning plant was used. This is a 20-storey curtain wall commercial building with a window-to-wall ratio of 40%. There are ten nos. of chillers: two 100 TR, one 175 TR and seven 200 TR in the hydronic circuit with differential pressure bypass control. A building management system (BMS) is provided and recorded the operating data of the AC system, such as hourly chilled water flow rate, chilled water temperatures, electricity consumption of major equipment, etc.

A transient plant simulation program TRNSYS was used to model and simulate the operation of the AC system. The modelling flow chart is shown in Figure 1 below. A set of 8,760 measured hourly weather data for the year 1989 in Hong Kong was used for the simulations of respectively air-cooled and evaporative-cooled (with fresh-water cooling tower) AC plants. The year 1989 has been worked out to be the Test Reference Year (TRY) of Hong Kong, which represents the prevailing weather conditions regarding comparative energy study (Hui & Lam 1992). The evaporative-cooled AC plant configuration developed through TRNSYS is shown in Figure 2. With the hourly building cooling loads derived from the BMS recorded data, the monthly/annual electricity consumption of each AC plant was simulated. Economic analysis was then conducted. Life-cycle cost and pay back period were also determined.

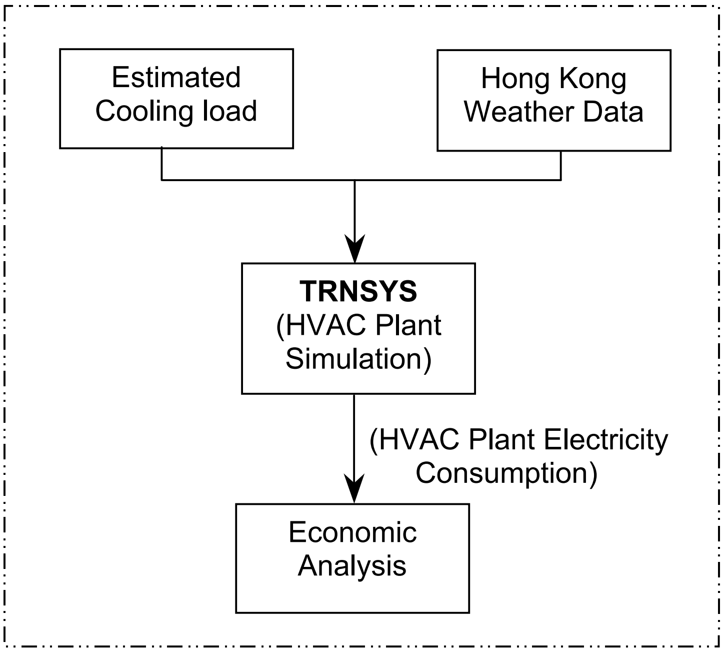

Figure 1 Modelling Flow Chart

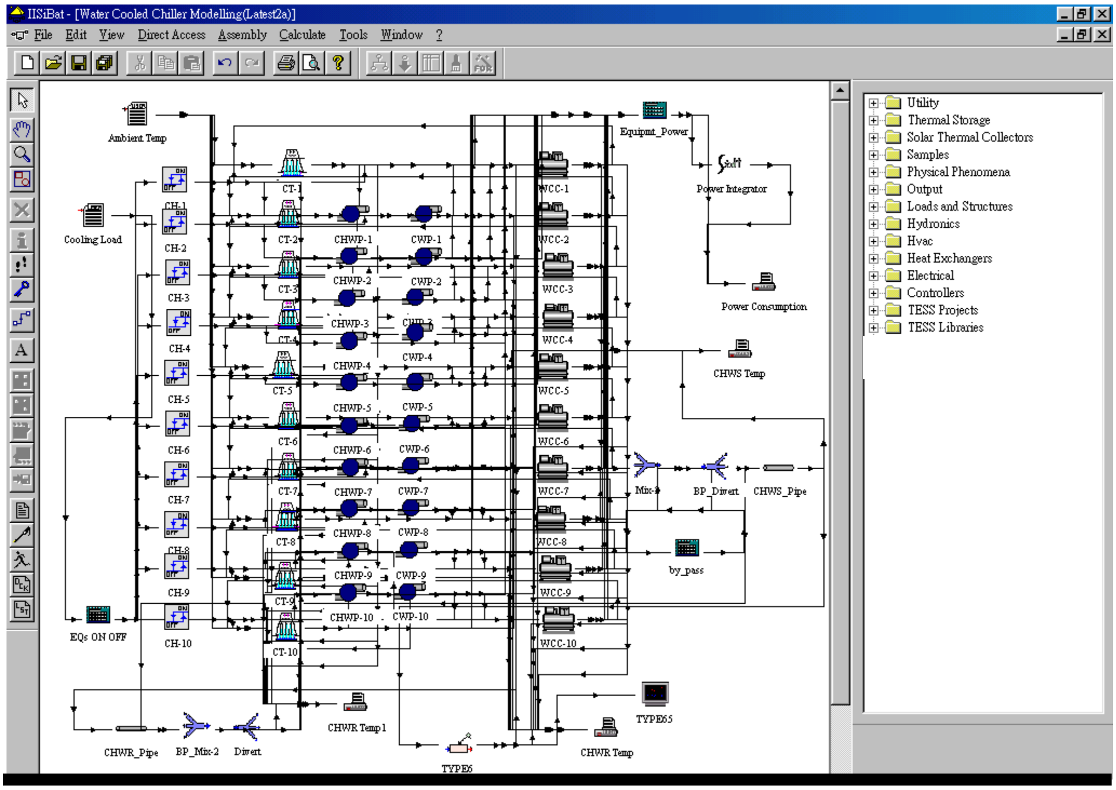

Figure 2 Air-Conditioning Plant Configuration in TRNSYS

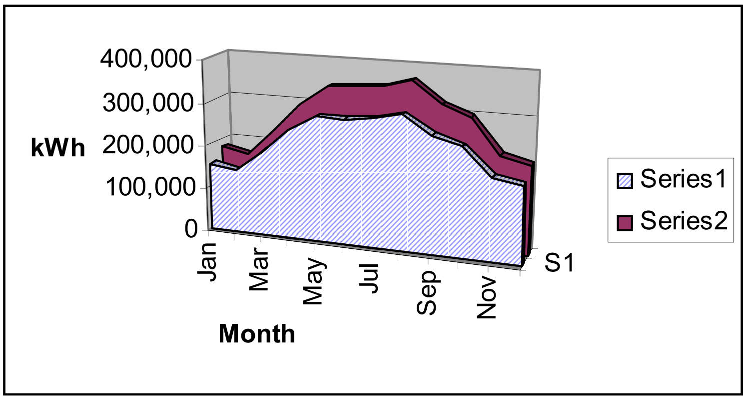

Figure 3 Simulated Monthly Electricity Consumptions of Air-Cooled and Water-Cooled Air-Conditioning Systems

Figure 3 shows the simulated monthly electricity consumptions of the two AC systems. Series 1 shows the electricity consumptions of the evaporative-cooled AC system and series 2 shows that of the air-cooled AC system. The evaporative-cooled AC is found more energy-efficient. The percentage in saving ranges from 12.35% in February to 17.1% in August. The annual saving is 15.6%.

Economic Feasibility Analysis

Life-cycle costing technique was used to investigate the economic feasibility of modifying an existing air-cooled air-conditioning system to an air-conditioning system with cooling tower in existing buildings (Charette 1980). Due to inflation and market discount rate, net present value (NPV) of the total electricity cost over the life cycle of the air-conditioning plant has to be calculated. This is expressed as:

$$\sum_{n=1}^{p}(EC)_n = EC\sum_{n=1}^{p}\left(\frac{1+i}{1+d}\right)^{n-1} \quad (1)$$

where

EC = electricity cost in the first year

i = escalation rate of electricity cost

d = market discount rate

$\left(\frac{1+i}{1+d}\right)^{n-1}$ = discounting factor

and the pay back period is calculated by:

$$P = \left\{\frac{\ln\left[\frac{1}{ID} - \frac{I\times(1/ID-1)}{EC_1 - EC_2}\right]}{\ln(ID)}\right\} + 1 \quad (2)$$

where

ID = $\left(\frac{1+i}{1+d}\right)$

I = investment for plant modification

An average escalation rate of electricity of 3.55% and a market discount rate of 5.69% (HKSAR Government 2000) were used. The electricity tariff in Hong Kong is about HK$0.95 per kWh (1 GBP = HK$12 approximately). Based on the simulated results, the annual saving in electricity cost was found HK$493,600 after the conversion. The life cycle of the modified plant is 25 years, and the corresponding cost is HK$3,800,000; these are provided by a licensed air-conditioning contractor firm. Based on the mentioned life-cycle model, the pay back period of the conversion is found about 8 years, and the net saving in electricity cost is HK$5,960,600 throughout its operating life. It can be seen that both the payback period and the net saving are reasonable, from the building owners point of view.

District Cooling Scheme

In a district cooling scheme, chilled water is circulating between a centralized chiller plant and a district comprising multiple buildings or facilities, through closed-loop underground piping network. The economical advantage of DCS mainly comes from the diversity factor in which the total installed cooling capacity at the centralised plant is smaller than the sum of individual plants at the consumer buildings based on conventional design. DCS thus offers massive and collective cooling energy production, which is higher in efficiency than individual cooling energy production. On the other hand, DCS consumers are not required to install their own chiller plants and thus can utilise building space more effectively. Moreover, operating cost advantage can be achieved by shifting power consumption of electric-type chillers from daytime to night by the use of thermal storage, hence cutting power consumption in the peak hours. A systematic approach to evaluate the feasibility of a DCS is illustrated below.

Thermal Load Modelling

The methodology for developing thermal load profiles, central plant design, and operation arrangements was introduced herewith, making reference to a new district in Hong Kong. The process is indicated in a flow chart shown in Figure 4.

In the process, the buildings to be served by the DCS are grouped into a number of categories, such as office, shopping arcade, hotel, hospital, etc. Of each category, model buildings are developed to represent the typical conditions within the district. These include the appropriate building materials, configuration, floor area, occupancy, operating schedule, etc. The hourly cooling load profiles of each model building during the whole year (or only the summer months for simplicity) are determined using a cooling load estimation tool, like the HEVACOMP or CARRIER software. The computation is based on the cooling load design weather data of Hong Kong. Three daily schedules are involved: weekday, weekend and holiday types. By these the normalized design load profiles of each category expressed in terms of cooling load intensity (*CLI*) in W/m^2 are determined. For a development site with n numbers of building categories, the hourly district cooling load profile, the *DCL* matrix (with elements in MW) can be determined as illustrated in Figure 5. A_1 to A_n in the equation represent the gross floor area of each building category. DCL_{max} is the peak value sorted from the *DCL* matrix elements and is the required cooling capacity of the DCS plant, i.e. the total installed capacity.

Figure 6 shows the weekday design cooling load profiles for different building types of the selected new district in Hong Kong. Based on the gross floor areas for each type of building, the peak cooling load without diversity is estimated as 261 MW, while the peak cooling load for the whole district is 193 MW when the DCS is applied. The corresponding diversity factor is 0.74.

Similarly, the 8,760 hourly thermal load profiles for various typical buildings in different categories during the Test Reference Year can be obtained through the use of a dynamic simulation program. In our case, the DOE-2 energy simulation software was used.

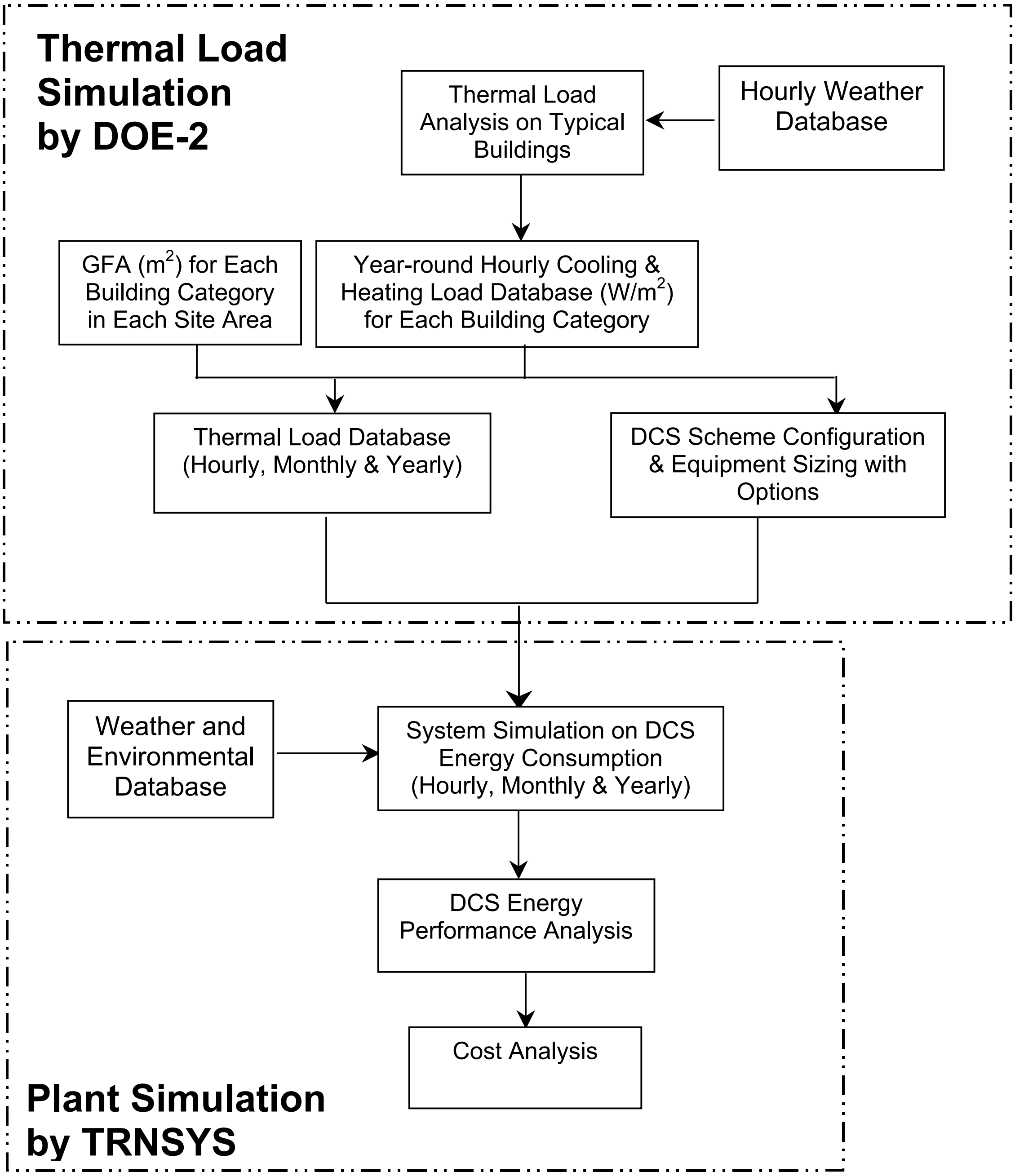

Figure 4 Thermal Load and Plant Simulation Modelling Flow Chart

$$\begin{bmatrix} CLI_{1,1} \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ CLI_{1,8760} \end{bmatrix} \times A_1 + \begin{bmatrix} CLI_{2,1} \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ CLI_{2,8760} \end{bmatrix} \times A_2 + \begin{bmatrix} CLI_{3,1} \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ CLI_{3,8760} \end{bmatrix} \times A_3 + \dots\dots\dots\dots + \begin{bmatrix} CLI_{n,1} \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ CLI_{n,8760} \end{bmatrix} \times A_n = \begin{bmatrix} DCL_{n,1} \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ DCL_{n,8760} \end{bmatrix} \Rightarrow DCL_{\max}$$

Figure 5 Determination of Hourly and Peak Cooling Loads in a District

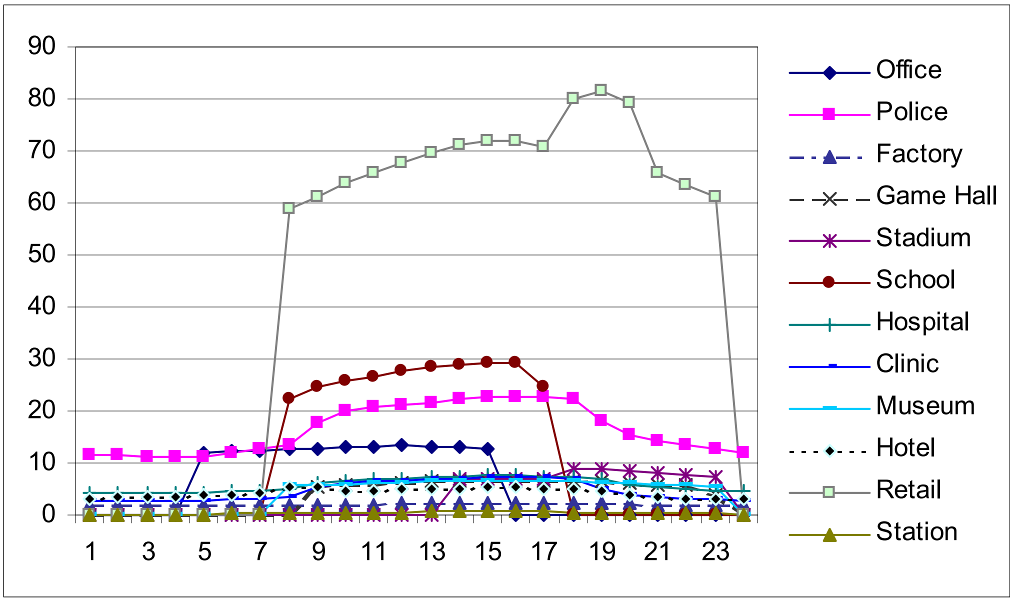

Figure 6 Weekday Cooling Load Profiles for Various Building Categories

Plant Modelling

In plant simulation, the TRNSYS software had been used for estimating the annual electricity consumption through a "quasi" steady-state simulation of discrete hourly data of the system operation. Figure 7 shows the proportion of the energy consumption at the four main system components, namely the chillers, the production pumps, the distribution pumps, and the seawater cooling pumps. In DCS, the chiller is the major power consumer and can consume up 70 to 80% of the total electric energy supply. The percentage shares of the distribution pumps and the seawater cooling pumps depend very much on the size of the distribution network as well as the seawater intake and discharge locations.

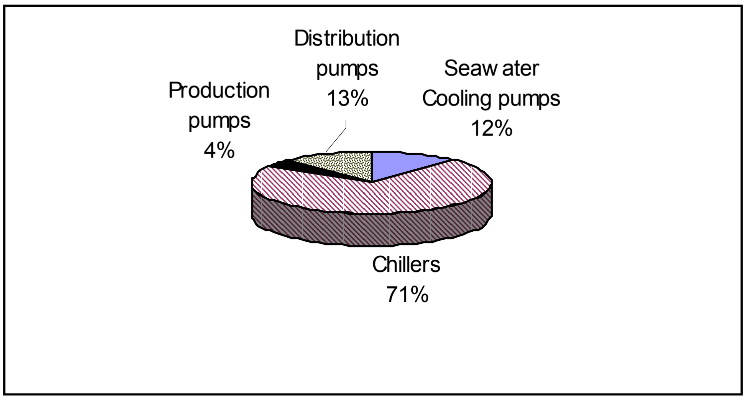

Figure 7 Percentage of Electricity Consumption in a DCS

System simulation exercises can be extended for a mix of central plant facilities and distribution loop configurations. The decision on potential DCS options must bring into consideration a series of plant operating strategies, as well as other physical constraints imposed by the civil work, the social, business and legal environment etc. The output of the energy model, i.e. year round hourly data of the electricity (and other fuels if any) consumption profiles, can be transferred to the cost model to analyse the annual operation costs under different tariff structure. The cost model thus needs to compare costs of each option with the revenue flows that could be expected by potential DCS operators. Costs and revenues are to be compared within the options for a regulatory framework to protect DCS customers.

Discussion and Conclusions

There is a global concern about energy conservation - the lesser we consume, the "greener" environment we can have due to lesser pollutants produced. Air-conditioning, the largest electricity-consuming item in commercial buildings, accounts for about 50 to 60% of the total building electricity consumption in Hong Kong (Chan 1994). In most commercial buildings in Hong Kong, air-cooled air-conditioning systems are installed. It is needed to look severely into the energy saving opportunities by applying the water-cooled technology in condenser heat rejection.

The possibility of a wider application of water-cooled air-conditioning systems had been discussed. The feasibility of modifying an existing air-cooled air-conditioning system to an evaporative-cooled air-conditioning system has been investigated. In the present study, it is found that the modification is both technically and economically viable. Issues including prevention of legionnaire disease, interruption to building operation during modification of air-conditioning plant, space required, etc. should be further investigated.

Also introduced is the methodology that can be used in the feasibility study of district cooling system. The process involves a sequence of building design load computation, building dynamic simulation, and plant energy consumption analyses. Identifying the optimum DCS plant configuration actually involves the determination of the optimum locations of the seawater intake and discharge, the locations of the central plant and main distribution pipes, etc. This should be further explored

(Babus'Haq *et al* 1987, Nagaiwa *et al* 1995). The task can be extended to study the various options which will optimise the cost effectiveness of the DCS scheme such as co-generation or tri-generation, thermal storage, low temperature chilled water distribution, the possible use of phase change materials, ice-water slurries, etc. Various optimisation techniques such as dynamic programming and genetic algorithm (Sakamoto *et al* 1998) can be used in the above studies.

Acknowledgement

The work here is supported by the Strategic Research Grant (Project No. 7001192) from the City University of Hong Kong.

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Facility Management as a Support Tool for Energy Conservation: A Case Study from Michigan State University.

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Michigan State University

Abstract
There is a broad understanding of the technical aspects of designing an energy efficient building but it is only in recent years that the importance of integrating technology and management has been appreciated. In the early 90's the Department of the Environment in the UK launched its Corporate Commitment initiative linking the Chief Executive Officer with energy management. In 1998 the Chartered Institute of Building Services (CIBSE) in its guide 'Energy efficiency in buildings' stated that 'the influence of management on energy consumption is commonly underestimated. Although improvements may be made to the fabric and services, the management of the building often has the biggest impact on the day-to-day energy consumption'. These views are in line with the 'whole building' concept that is familiar to the facility manager.

This paper outlines how a facility management oriented technical/management approach has been adopted at Michigan State University (MSU) in its endeavour to establish energy efficient strategies for the campus. It outlines how the survey of a major building resulted in the development of building and user 'profiles' that led to a three level strategy encompassing 1) behaviour (individual, no cost activities), 2) management (organizational, low cost activities), and 3) works to buildings and services (high cost). The research was carried out under the auspices of the University Committee for a Sustainable Campus and the Physical Plant Department of MSU. It is now being integrated into initiatives supported by the President of MSU, and the administration.

This case study illustrates the importance of viewing energy management as not simply a technologically driven activity but one that pervades the activities of the whole organization. It also offers a forum for considering how the facility manager can contribute to energy management programs.

Keywords: Energy Management, building and user profiles, sustainability, facility management.

An Overview of Michigan State University

MSU was founded in 1855. It is a Land Grand University (given land for its campus by the Federal Government and in receipt of partial State funding). There are about 43,000 students and 3,500 faculty and support staff occupying over 600 buildings amounting to some 21 million square feet of floor area. About 15,000 students live on campus on halls of residence. The campus covers some 3,500 acres with a further 3,000 acres of research farms adjacent.

MSU is provided with electricity (and steam for heating) by its own coal fired co-generation plant, the T B Simon power station. This however is reaching capacity as demand from new buildings comes on-line, the use of computers increases, and research expands. The power plant is the responsibility of the Assistant Vice President of Physical Plant.

The Assistant Vice President Physical Plant is responsible not only for power generation but also the upkeep of the MSU estate including management of works and cleaning.

The University Committee for a Sustainable Campus, established in 1998, is a voluntary cross-campus, multi-disciplined group. Its mission is 'to foster a collaborative learning culture that will lead the MSU community to a heightened awareness of its environmental impact; to conserve natural resources for future generations; and to establish MSU as a working model for creating a sustainable community.' Under its wing exist three subcommittees for the assessment of specific elements of the environmental foot print of the campus; solid waste, water, and energy.

This paper reports upon activities arising from research sponsored by the UCSC and the Physical Plant Department in respect of energy.

Research Project

Rather than immediately launch a funding drive for expansion of the power plant the University Committee for a Sustainable Campus (UCSC) proposed a research activity to establish if demands could be reduced within campus buildings. In 1999 the Physical Plant Division and the Energy Subcommittee of the UCSC sought proposals from relevant MSU departments to audit a campus building and to establish a methodology for energy assessment activity.

The response was a two phase proposal covering a) a building structure and its services and b) the building users. The intention was to develop what were termed a Building Profile and a User Profile. The building chosen was a large teaching block (150,000 square feet) built in the 1960s which had undergone little upgrade and was typical of a number of buildings both technically and in terms of use.

Methodology

The research was jointly administered by faculty of the Department of Construction Management and Department of Human Environment and Design. Tim Mrozowski led a team undertaking the technical investigation into the building envelop and services. David Lawrence was responsible for the user study. The intention from the outset was that it would constitute a learning process in energy awareness for students therefore undergraduates and graduates played active parts.

This paper will focus generally upon the facility management approach that integrated the work and how this developed into further activity involving other groups in the university. It is however appropriate to briefly outline how the Building and User Profiles were researched.

The approach to the design of the research activity and the inter-relationships of energy to the technical and user profiles is shown in Figure 1. [i] The technical team investigated Services, and Condition. The user team investigated Function and Management. The outcome of the Energy column, while predominantly a technical matter was heavily influenced by users and management thus reflecting the US Library of Congress definition of FM which is the practice of coordinating the physical workplace with the people and the work of the organization; integrates the principles of business administration, architecture, and the behavioural and engineering sciences.

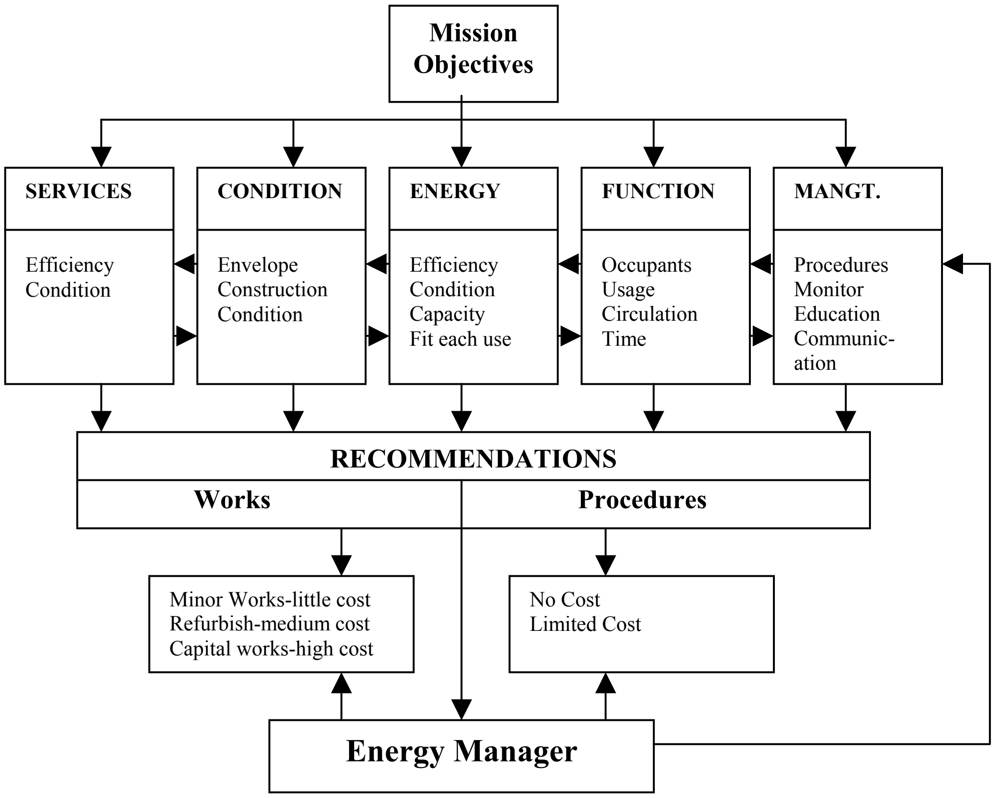

Figure 1: Energy Audit-Integrating Technical and User Profiles.

Recommendations Arising from the Audit

The findings of the investigation were presented in 2000.[ii] Specific recommendations for the college building included replacement of windows, upgrades to the HVAC, and installation of motion sensors for the major rooms. A number of management improvements were also proposed including the creation of a 'turn-off' reminder system for computers and lighting. This paper concentrates on the most prominent of the 26 recommendations in respect of policy and administration for MSU. These included:-

1. Establish a 'corporate commitment' to energy management.
2. Establish and publish a university wide energy policy or philosophy on reducing energy and encouraging sustainable practices.
3. Establish and articulate goals for saving energy—developed for all organizational levels
4. Establish a campus administrative staff position to oversee and lead a campus wide energy reduction effort
5. Communicate goals to administrators, faculty, staff, and students.
6. Develop a database of energy use and building data available for comparison between buildings of similar characteristics

7. Reports of energy consumption to be published in various forms
8. Consider establishing an energy budget for individual buildings to increase accountability
9. Develop incentive programs to reward energy reduction
10. Consideration be given to scheduling all evening classes into a few buildings to permit shut down of services in remaining buildings

Recommendations were also made to develop educational courses and for faculty members to let it be known to students that energy usage is important to the university and society.

An Energy Policy

Upon receipt of the report the Energy Subcommittee of the UCSC recognized the importance of the need for corporate support to achieve improvement. In line with the recommendations an Energy Policy was drafted and submitted to the university administration for endorsement by the President of MSU. The text of the proposed policy is set out below.

Introduction
MSU, in its mission of teaching, research, and outreach has a duty to use resources economically and with minimal environmental impact now and in the future. One element of this is energy.

Energy Commitment
MSU is committed to a Campus which is a model for a Sustainable Community where energy awareness and reliable, safe, and efficient practices are recognized as essential elements of teaching, learning, and campus management.

The Energy Principals
The Energy Commitment will be achieved through the following principals:

- Raise the awareness and practice of energy conservation management through teaching, research, outreach, and operational practices while recognizing the impact on the environment.
- Promote efficient technical and administrative management of buildings, infrastructure, and support services.
- Recognize the need to equate energy efficiency and conservation with life cycle economics and design functionality in new buildings and in the renovation of existing ones.

MSU Guiding Principals
The Energy Policy supports the MSU Guiding Principals through enhancement of the intellectual and moral culture of the university population.

Regular Reviews
The Provost, Vice President for Finance and Operations, and Vice President for Research and Graduate Studies, with the support of the Chair of the

UCSC, and the Assistant Vice President of Physical Plant, will establish a set of guidelines to implement this policy and periodically review progress.

While the policy was not published in the format proposed above, the concepts were embraced by the President. Public statements were made referring to a 'Campus Commitment' and information was requested from the UCSC as to what might be done.

An Energy Strategy

The Energy Subcommittee of the UCSC prepared a strategic document reflecting the 'Recommendations' section of Figure 1 which indicates that the outcomes of a technical/user energy audit will fall into the categories of both works and procedures. The objective was to indicate an incremental approach to energy efficiency. Entitled the 'MSU 5.5.20 Energy Reduction Strategy' it mirrored the time frame for the MSU infrastructural plan that is under development and covers needs up to the year 2020. The energy reduction strategy proposed three phases, the first of which could be put in place quickly and result in 5% savings, the second taking longer but providing a further 5% and a third leading to a total of 20%. An early draft of the text is shown below:

MSU 5.5.20 Energy Reduction Strategy

The Energy Subcommittee of the UCSC recommends the following 3-Phase strategy for a 20% reduction in demand over a period of 20 years.

Phase One: Behavioural 5% Reduction

Faculty, Students, and Staff turn off lights, computers, printers when not in use. This is with immediate effect. It will need regular reinforcement.

Phase Two: Management 5% Reduction

University and College Administrators optimise the use of accommodation. (Consider an Evening Class building if classes need to take place later in the day.)

Phase Three: Capital 10% Reduction

Condition and Energy Audits to integrate Capital and Deferred Maintenance Works to improve energy improvements. A five year time scale for audits, planning, funding, and procurement. This program will be long term and result in upgrade of existing (and future) buildings to new standards.

Resource: Energy Manager

The Energy Subcommittee recognized the need for proactive management but made no specific recommendations upon manning this process.

The energy reduction strategy reflects the 1) No Cost, 2) Limited Cost, 3) Minor Works-little cost, 4) Refurbish-medium cost, 5) Capital works-high cost regime that is depicted in Figure 1. Behavioural changes would represent items 1 and 2 where any expenses would be in training and reinforcement. Management instigated changes might fall under items 3 and 4 where zoning of lighting, HVAC might be appropriate to create evening class accommodation. Energy reduction through improvement to building fabric and installation of more efficient services would be contained under items 4 and 5.

MSU Energy Conservation Campaign Committee

Arising from these activities the Administration sponsored a cross-campus group, the Energy Conservation Campaign Committee, jointly chaired by the Chair of the UCSC and Assistant Vice President for Finance and Operations. Commencing in July 2001 it planned a number of activities

Campus Energy Summit

This was an all day scenario building event held in November 2001. Faculty, staff, administrators and students came together to look at potential scenarios that would affect potential energy consumption over the next 15 years. Scenarios developed at the summit will be used to open campus discussion on the future this coming Fall.

Logo Contest

Organized by a public relations students as a part of their student group's activity, it sought design ideas from the campus community for a logo for energy conservation. The winning entry was announced at the November 2001 Energy Summit and has been extensively since.

Articles in the Local Press

The Committee has worked with university Public Relations staff to have regular spots in the campus faculty/staff newspaper, and have contributed story ideas to the campus student newspaper. Energy saving tips, and events have been featured in both papers throughout the year.

Energy Awareness Week (March 2002)

The Committee organized a series of events to focus attention of the community on energy. Events included tours of the Power Plant and Cyclotron (huge energy consumer in the research field), display of alternative fuel vehicles, energy conservation vendor show, speakers, and a panel presentation by energy experts from industry in Michigan.

Web Page

Utilized the web page for UCSC www.ecofoot.msu.edu to publicize stories, events, tips, and leads to other pertinent information.

Developments

The recommendations arising from the research into energy usage, referred to at the opening of this paper, inspired a range of activities. The work of the UCSC has benefited from the corporate commitment resulting from the positive response of the President and the administration of MSU. Set out below are current activities which are under development. These are listed under the categories of Behaviour, Management, and Works/Capital.

Behavioural

Education: Development of Courses
In the past sustainability has been covered informally in some classes. Recently a forum has been convened by the UCSC to give faculty members the opportunity to discuss how to introduce sustainability more formally into the curriculum. The objective is to ensure that all students acquire a broad understanding of its concepts and are introduced to ways in which they might be practiced both during college life and after Commencement (graduation) in career and society.

In the Facility Management arena graduate students are exposed to the British CIBSE Guidelines for energy management[iii] and the New York City High Performance Guidelines which became available on the Internet in 2001. [iv] In the Forward to the NYC Guidelines, comment is made that they 'set out a range of best practices for planning, designing, constructing and operating healthier, more energy—and resource—efficient facilities'. These fit the behavioural, management, and works/capital framework outlined in this paper. (It is also likely that the Stamford University Guidelines to Sustainability, put onto the Internet in March 2002, will be studied since they reflect LEED and NYC Guidelines.[v]

Management

Centralized Evening Class Accommodation
The implications of Evening Class Buildings is being investigated. The objective is to centralize all evening activities in order to reduce lighting, HVAC, security services etc to campus buildings.

This is a complex subject since some buildings include not only classrooms but also research laboratories and offices that are used 24 hours a day throughout the year. Space management and shutting down all or part of a building is a scheduling/management activity which in some cases can only be achieved through works being undertaken to permit zoning of services. Transportation, security lighting and public safety implications for the campus as a whole also need review.

Raising of Summer Cooling Temperature
The MSU Energy Conservation Committee has proposed that the university adopt a 75F for a cooling set point for campus buildings rather than the 72F of the past.

Awareness Among Custodial Staff
An effort to raise the awareness and good practices of custodial staff has commenced. The staff has been responsible for placing energy conservation ('Why Waste?') stickers on light switches throughout the campus. They are also making more of and effort to look for lights left burning.

Capital/Works

LEED Comparative Study.
A study is being designed to establish the implications of aligning MSU standards for new construction and refurbishment with the LEED recommendations.

LEED (Leadership in Energy & Environmental Design) is an initiative with parallel objectives to the BREEAM energy rating system. Launched by the US Green Building Council [vi] it "evaluates environmental performance from a 'whole building' perspective over a building's life cycle, providing a definitive standard for what constitutes a 'green building'."

Wind Powered Generation
During MSU energy week in March 2002 a presentation was made by the first commercial organization in Michigan providing power by wind turbine generators. [vii] The renewable energy source provided by wind generators is delivered through the state supply grid. Generators have been erected in the north of the state in exposed positions overlooking Lake Michigan and the company seeks partnerships in expanding this alternative power source.

Subject to the economics of wind generation, MSU may have an interest in a partnership. Anemometers have been placed on the campus to establish if local winds could support on-site generation. The on-site presence of large generators would raise awareness but if an inland site is not viable then remote coastal sites may be necessary.

A proposal has been made for 3 generators on a coastal site capable of providing 5.4 million kwhr. This represents 2% of need for the main campus.

The US Department's 'wind powering America' initiative calls for 5000 MW of new wind power by 2005 therefore if MSU enters this field it would be providing leadership within its outreach mission.[viii]

Photo voltaics
MSU Physical Plant, in partnership with MSU Faculty have applied for a Federal grant to install a 10 kW photovoltaic demonstration project at one of the main facilities---possibly the Agricultural Pavilion. This project is designed to education the general public, as well as students on the campus and to increase awareness of alternative energy sources and sustainability.

Energy Star Partnership
The university has been an EPA Energy Star Buildings Partner [ix] and through this a Green Lights Partner, since 1996 when EPA recognized MSU's commitment to energy efficiency. The MSU Physical Plant Construction Standards specify T8 fluorescent lamps in all new construction and renovation projects. Currently Physical Plant is undertaking a program of renewal of light fittings in the Main Library. This building is open 24 hours a day and the installation of T8 fluorescent lights over its approximately 0.5million square feet of floor area will reduce the building load by 146 kW.

Conclusion

The recommendations of the energy audit of an MSU teaching building stimulated new initiatives leading towards sustainability.

The Energy Policy seeks to relate energy efficiency to the teaching mission of the university and to its responsibilities within society.

The Energy Strategy seeks to translate the Policy into practical behaviour. Management, and Works/Capital oriented activities.

The work of the MSU Energy Conservation Campaign Committee seeks to transpose the activities and values of the UCSC into the culture and daily life of the university.

In harmony with the ethical, philosophical and pragmatic aspirations of the UCSC this paper indicates how the concepts of FM have been integrated into (and have inspired) the developments at a variety of levels. Facility Management provides a framework which allows Academics and Administrators to work closely with practitioners, such as the professionals in Physical Plant, for the betterment of the community.

While much remains to be done at MSU, it is suggested that this case study offers a good indication of the potential value of the adoption of FM concepts in supporting the drive towards a sustainable campus. FM is designed to support the user. In this case progress is being made to reduce dependency upon fossil fuel, increase awareness of the benefits to the environment and the community, and engender a culture which will sustain these aims into the future by involving and enlightening the students of the university---the leaders of the next generation.

Acknowledgements

The writers of this paper acknowledge the support given by the Chair of the UCSC (Terry Link), the Chair of the Energy Sub-Committee of the UCSC (Bob Ellerhirst), and a member of the Sub-Committee (Lynda Boomer). The writers also acknowledge the use of various documents (prepared by or for the UCSC) that are central to this paper.

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[v] See http://cpm.Stanford.edu/process_new%20sustainable_Brochure.pdf

[vi] See http://www.usgbc.org/programs/leed.htm

[vii] See http://www.baywindpower.com

[viii] See http://www.energy.doe.gov and http://www.eren.doe.gov/greenpower

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Optimization of MVAC Systems for Energy Management by Evolutionary Algorithm

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Abstract: *Energy management in existing building services installations is an essential focus of the contemporary facilities management. The subway company that is one of the major utilities services in Hong Kong Special Administrative Region (HKSAR) has considered better energy management schemes in its subway stations to reduce the running cost. In the past few years, in order to achieve energy saving in the stations, some feasible measures in the Mechanical Ventilation and Air Conditioning (MVAC) systems were implemented, however the engineering decisions were supported by the trial-and-error or imprecise estimation. Improvement to this process would be possible if numerical optimization methods were to be used. Evolutionary algorithm coupled with external plant simulation programme, was applied to determine the optimum conditions of the essential parameters of the MVAC systems in a holistic energy management approach. For the centralized MVAC systems of the subway stations under studies, the developed optimization and simulation model was found useful to appraise the energy management opportunities for effective design and facilities management.*

Keywords: Evolutionary algorithm, optimization, energy management, MVAC systems.

1.0 INTRODUCTION

1.1 Promotion of Energy Management Opportunities

Effective energy management in existing building services installations becomes a primary focus of facilities management, not just because of the environmental and sustainable concerns, but also due to the adverse impact of the global economic recession in these few years. In Hong Kong Special Administrative Region (HKSAR), such influence has not only bound to the commercial and industrial sectors, but even to the utilities companies. The Electrical and Mechanical Services Department of HKSAR government has promoted a series of energy management schemes, one of them is to identify the energy management opportunities (EMOs) through energy audits. There are three categories of EMOs: Category I requires no or insignificant capital investment to implement; Category II can be carried out at relatively low cost; and Category III needs significant capital investment but reasonable payback period. Therefore there is a great priority and motivation to seek for the EMOs of Category I which may have insignificant investment implication but possible cost saving. In typical Heating, Ventilating and Air Conditioning (HVAC) systems, this category practically involves the ideas such as to readjust the operating conditions like space air temperature, supply air flow rate, chilled water supply temperature, etc. without sacrificing the built comfort requirements; to reset those operating conditions in the mid-seasons and during the non-peak periods; to reduce the operating time of the equipment not affecting the normal operation; or to minimize the night mode operation of the major equipment.

The choice of the EMOs of Category I depends on the system design, provisions and complexity. These EMOs can be implemented immediately, and their effects in energy saving can be evaluated quickly. However in readjusting the operating conditions of the main equipment, it may render to contradictory situation. For example, increase of supply air temperature due to raising chilled water supply temperature would save energy in chillers, but the supply air flow rate hence energy consumption of air side equipment would be increased accordingly. This may counter-balance the advantage of the temperature adjustment in water side. So suitable optimization models are needed in order to consider the changes of different parameters in a holistic approach, and the objective of energy saving can be really achieved.

1.2 Usefulness of Optimization and Plant Simulation Models

The subway company that is one of the major utilities services in HKSAR, has considered better energy management in its subway stations to reduce the running cost. In the past few years, in order to achieve energy saving, some feasible measures in the Mechanical Ventilation and Air Conditioning (MVAC) systems were implemented by the subway company, for instance, to increase the space air temperatures of different function areas, and to readjust the time of start/stop of the MVAC systems. Although all those measures were adopted without sacrificing thermal comfort within the spaces, the engineering decisions were supported by the trial-and-error or imprecise estimation. And it depended on whether the operators could exercise the appropriate judgement in making the parametric changes and interpreting the results correctly. Therefore it would be better to use more robust tool to determine the satisfactory operating conditions and improvement schemes.

Nowadays, computer-based simulation is becoming increasingly popular and more designers and clients use this approach to evaluate the design alternatives (Kennett 2001) and year-round energy consumption (Fong *et al* 2001). For design and operation optimization, a radical breakthrough would be possible if numerical optimization methods were used instead of operator judgement. Recent advancement in plant simulation model and development in optimization model would enable such problems to be tackled using appropriate optimum-seeking methods. Among different optimization methodologies, evolutionary algorithm (EA) has been found useful in a variety of problems (Michalewicz and Fogel 2000), and they are able to handle common HVAC scenarios that often have discontinuous, non-linear and highly constrained characteristics in the search spaces.

The plant simulation package TRNSYS was used to model the whole MVAC systems including the chiller plant, water side, heat rejection and air side systems. In addition, EA was applied to determine the optimum conditions of the essential parameters of the MVAC systems in order to provide a holistic energy management approach. The external plant simulation program TRNSYS was intentionally coupled with EA for evaluating the fitness of different parametric combinations. The results would suggest the solutions for the EMOs of these subway stations.

1.3 MVAC Systems of Subway Stations

This study was focused on the MVAC systems including a 6000 TR central chiller plant and the corresponding air side systems serving 5 subway stations in the urban line. The schematic diagrams of the central chiller plant and the air side system are shown in Figures 1 and 2 respectively, and the features are summarized as follows:

a. The 5 subway stations were served by a central chiller plant which consisted of 6 numbers of 1000 TR water-cooled chillers, each had an associated constant speed chilled water pump. Differential pressure bypass circuit was applied.

b. For heat rejection, a cooling water pump was used to serve a group of 2 chillers, and carried heat to a plate heat exchanger, in which heat was removed by a sea water pump. Therefore there were altogether 3 sets of pumps and heat exchangers. Both the cooling water and sea water pumps had constant speed.

c. For the air side system, the supply air was used to handle cooling loads from two major sources in sequence: the platform and the trains. Firstly the platform cooling loads were tackled to maintain a platform space temperature T_s, which were checked against the pre-set platform design temperature T_p. On the other hand, return air grilles were intentionally installed under the platform and above the air-cooled condensers of the subway trains, so as to tackle the cooling loads from the trains, as shown in Figure 2.

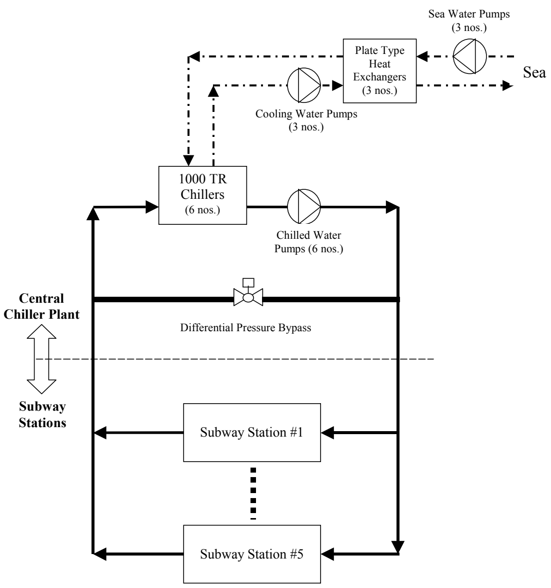

Figure 1: Central Chiller Plant and Chilled Water Distribution

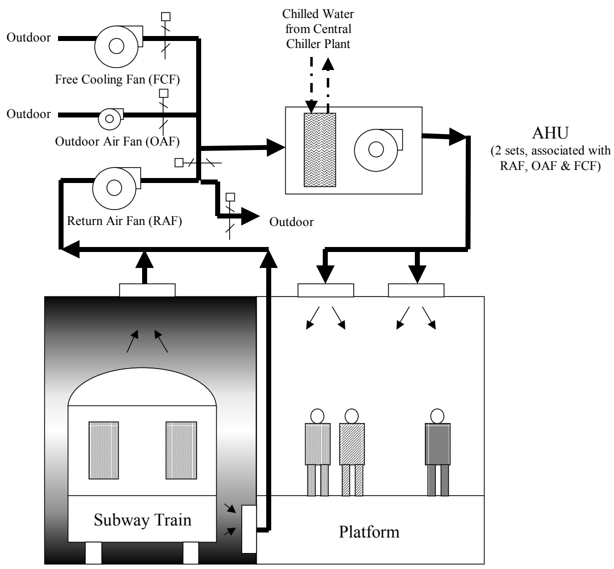

Figure 2: Air Side System of a Typical Subway Station

2.0 PLANT AND ENERGY SIMULATION

With the simulation package TRNSYS, the plant and energy simulation model of the subway stations were developed according to the actual MVAC installations and operations, and the characteristics are summarized as follows.

a. Since it was not a dynamic simulation, all the operation conditions of different equipment were determined by the hourly cooling loads and outdoor air conditions, and the simulations were generated in steady state at the corresponding hours as illustrated in Figures 3 and 4. For each operating hour, total energy consumption was the sum of energy consumptions of all the major operating equipment, and the year-round energy consumption was the sum of all 8760 hours.

b. For part load control of the chillers and pumps, the control signals were determined by the amount of hourly cooling loads as shown in Figure 3.

c. From full load to part load of the air side system, there were 4 strategies based on different loading situations:
   - Full load cooling mode: AHU working in full speed.
   - Part load cooling mode: AHU operating in half speed.
   - Full load free cooling mode: free cooling with all fans in full speed.
   - Part load free cooling mode: free cooling with all fans in half speed.

   The change from full to half speed was determined by comparing T_s against T_p (with deadband 1 °C). The change from normal to free cooling mode was based on the outdoor enthalpy h_o lower than the actual platform space air enthalpy h_s (with deadband 2 kJ/kg). These full and part load control strategies are shown in Figure 4.

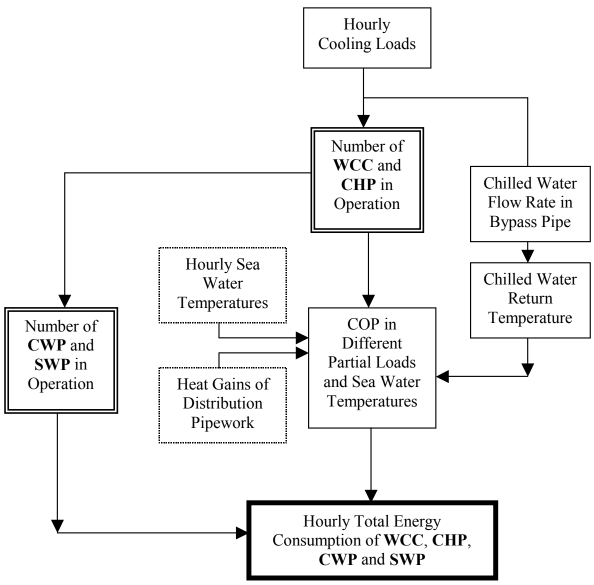

Figure 3: Determination of Energy Consumption in Central Chiller Plant

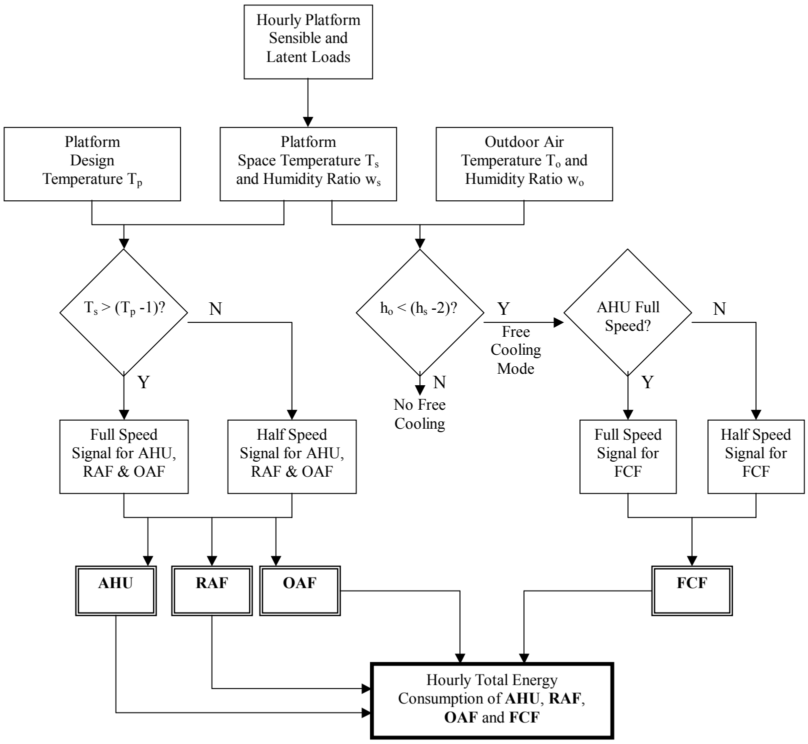

Figure 4: Determination of Energy Consumption in Air Side System

3.0 EVOLUTIONARY ALGORITHM

3.1 Development of Optimization Techniques

The best optimization model should be both efficient and effective to determine the optimum conditions within the search space, approaching to the global optimum instead of the local ones. The optimization techniques have been developed for many years, from gradient-based methods, direct search methods (Hanby and Wright 1989) to the recent random and evolutionary approaches (Wright 1996). EA becomes a popular stream of optimization techniques recently, and it includes the genetic algorithm, evolutionary programming and evolution strategy (Bäck *et al* 1997). Their differences depend on the emphasis and approach adopted for selection, recombination and mutation. Basically genetic algorithm and evolutionary programming are generally implemented in probabilistic and stochastic approach, while evolution strategy is deterministic during the selection stage. Although it seems impossible to find a single method which can be applied in all problems (Bäck *et al* 2000), application of EA is effective in handling many HVAC problems with discrete, non-linear and highly constrained characteristics (Michalewicz and Fogel 2000).

3.2 EA Coupled with Plant Simulation Model

The developed EA was real-coded, and handled floating point and integer variables by the use of variation operator. Modularity was the major characteristic, therefore the optimization model was developed by MATLAB which could effectively handle the parametric matrices across different generations. The plant simulation model was not integrated into the EA, but was coupled together and communication between these two modules was via an operating system call. There were four main constituents in this EA, they were initialisation, evaluation, selection and variation. The flow chart of the developed EA model is shown in Figure 5.

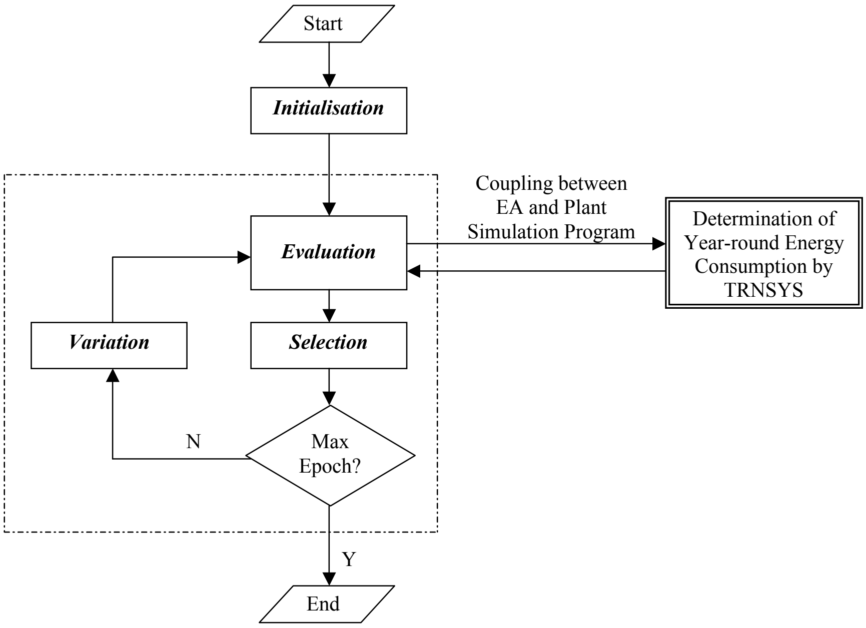

Figure 5: Flow Chart of EA Coupled with Plant Simulation Model

a. Initialisation

Before starting the search for the optimum parameters, some basic information was decided:

i. Parameters to be optimized;
ii. lower and upper bounds of each parameter;
iii. population in each epoch; and
iv. maximum number of epoch to be investigated.

In EA, each set of parameters to be optimized was treated as an individual, and the required number of individuals formed the population for each epoch of search. The stochastic nature of EA means that larger number of population would result better choice of elites without trapping at local optimal. Similarly larger number of epoch would guarantee the convergence of parameters contained in individuals. However the running time of optimization was compromised for this case, since the dominating processing time was not in EA itself, but in the plant simulation program already coupled with EA for evaluation purpose.

At the very beginning of the optimization, an initial population of individuals for investigation was produced. This initial group (first epoch) of individuals was generated randomly within the corresponding specified ranges of those parameters involved.

b. Evaluation

In general, an evaluation function should be developed and incorporated in this step in order to give the optimum and feasible solutions. In this study, since the overall year-round energy consumption of the subway MVAC systems was the ultimate target, and optimization was simply to determine the minimum energy amount. Therefore each set of feasible parameters within the population should be input into the plant simulation program so that the evaluation solution could be determined and compared in the following stage.

The main feature of this evaluation process was being coupled with the external plant simulation program TRNSYS, so operating system call was involved between EA and the plant simulation program for each individual within the population in every epoch. This was the most time-consuming step for the complex simulation problems, for instance it took about 15 minutes to run a full set of 8760-hour energy consumption for the entire MVAC systems of the subway stations for an individual being assessed. No matter how efficient was the programming of EA and how fast was the processing speed of the computer, the bottleneck was the number of hours involved in a year-round study, so the frequency of simulation could not be reduced and the running time of the entire optimization model could not be advanced significantly.

c. Selection

After evaluation, selection of the individuals for variation should be carried out. Selection is a process to determine the next population based on current individual's quality. It can be carried out in either stochastic or deterministic way. The stochastic approach would generate a probability function, e.g. through Roulette Wheel, over the possible compositions for next epoch; while the deterministic approach would develop the next generation according to the prescribed composition of parents and offspring.

As a preliminary study in this case, the selection process was carried out in the following ways:

i. The philosophy of elitism was applied and the fittest individual was placed into the next epoch without any variation.
ii. The remaining individuals were all carried forward for variation.

d. Variation

In variation, suitable variation operator should be selected for the problem, and it is crucial to generate new population of individuals which would approach the true optimum but not trapped by local ones. This step has the same purpose of crossover (mating) and mutation in genetic algorithm (Wright 1996), for acquiring offspring with better fitness from parents in probabilistic approach. In addition, after applying variation operator, appropriate constraint handling technique is used in order to effectively highlight the feasible and fittest individuals, and repair the infeasible ones back to the search range.

In this study, Gaussian-distributed random number was applied as the variation operator since it was proven to be effective in perturbations and mutation (Michalewicz and Fogel 2000). This number has a mean of zero and a dynamic standard deviation, and offspring were "born" by adding it to the parents. An initial range was set for the random variation of each parameter, and the standard deviation factor σ which decreased exponentially with each epoch was applied. This factor was determined as follows:

$$\sigma = e^{-\frac{g-1}{c}} \tag{1}$$

where, g = epoch
c = constant

On the other hand, constraint handling technique was applied for any infeasible parameter which was out of its specified range, and it was reset back to the respective lower or upper bound that was nearer to the mutated value. This generally occurred in the early stages of the search, before the standard deviation factor σ was reduced significantly.

4.0 OPTIMIZATION FOR ENERGY MANAGEMENT

Based on the developed EA optimization and simulation model of the MVAC systems for the subway stations, optimization of different operating parameters could be carried out. The results were used to check against the existing operating conditions, and optimum settings could be suggested for the EMOs of Category I. After thorough appraisal of the currently installed equipment, operating speeds of the chilled water pumps, cooling water pumps and sea water pumps were all constant, so there was little chance to change the related parameters. For the major air side equipment, 2-speed fans were used, and the algorithm of changing speed was already incorporated into the plant and energy simulation model, so there was also little opportunity to optimize their parameters. Finally there were two essential parameters which could be investigated through optimization:

- The set point of chilled water supply temperature of chiller T_{cws}; and
- the platform design air temperature T_p.

For the existing plant operation of the subway stations, the set points of T_{cws} and T_p were 7.2 °C and 27 °C respectively. Although in the optimization model the number could be accurate up to many digits, it was meaningless to determine the optimum settings in such details. Since the resolution of the installed central control system of the subway stations was just up to the first decimal place in both T_{cws} and T_p, so the degree of convergence in optimization would be based on one-tenth degree C.

4.1 Input Data

For the developed EA model, the following input data were used in optimization:

Lower bound of T_{cws}:	6 °C
Upper bound of T_{cws}:	8 °C
Lower bound of T_p:	25 °C
Upper bound of T_p:	27 °C
Population:	10
Maximum epoch:	20

For T_{cws}, the range of 6 - 8 °C was used since it was common in practice to balance the required dehumidification effect in air side and good efficiency of chillers. For T_p, since the maximum platform design temperature should not be higher than 27 °C, so it was set as the upper bound. The lower bound was preliminarily set according to the temperature difference of 2 °C as that of T_{cws}. Since the optimization running time was mainly the plant simulation time, the numbers of population and epoch were determined by compromising the stochastic selection and variation, and the efficient convergence of T_{cws} and T_p.

4.2 Optimization Results

Based on the developed EA optimization and simulation model, the optimization results of the MVAC systems of the subway stations were determined, and those of year-round energy consumption, T_{cws} and T_p are presented in Figures 6, 7 and 8 respectively.

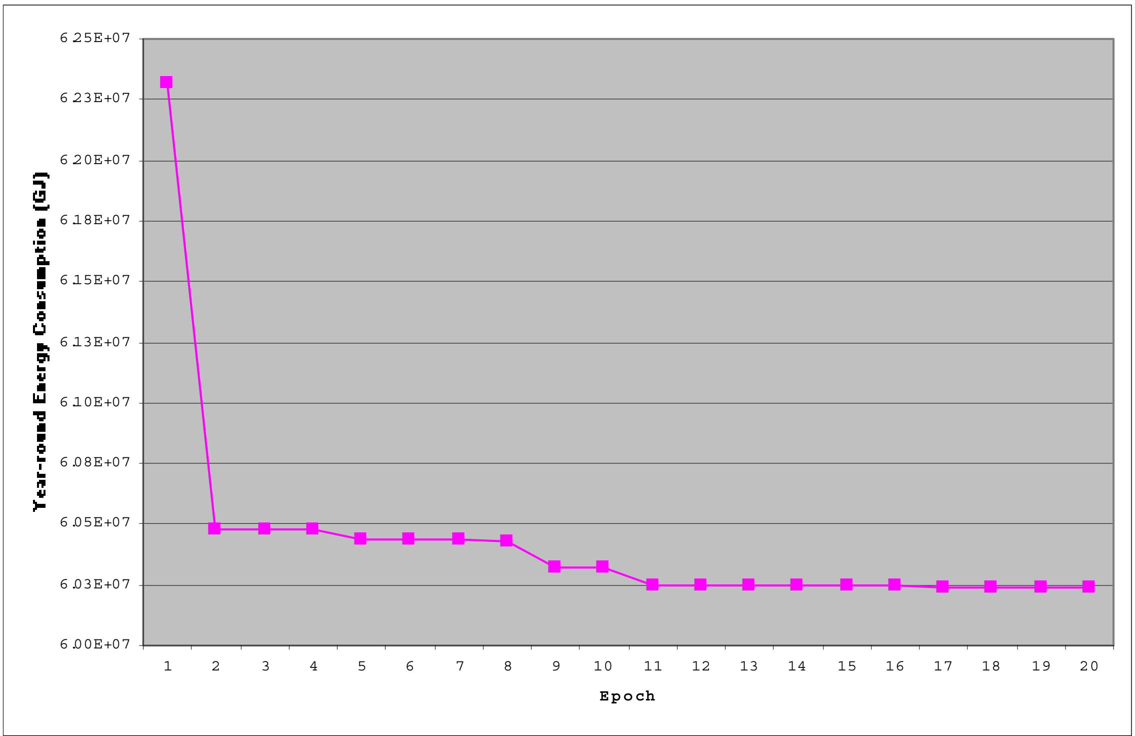

Figure 6: Optimum Year-round Energy Consumption in Each Epoch

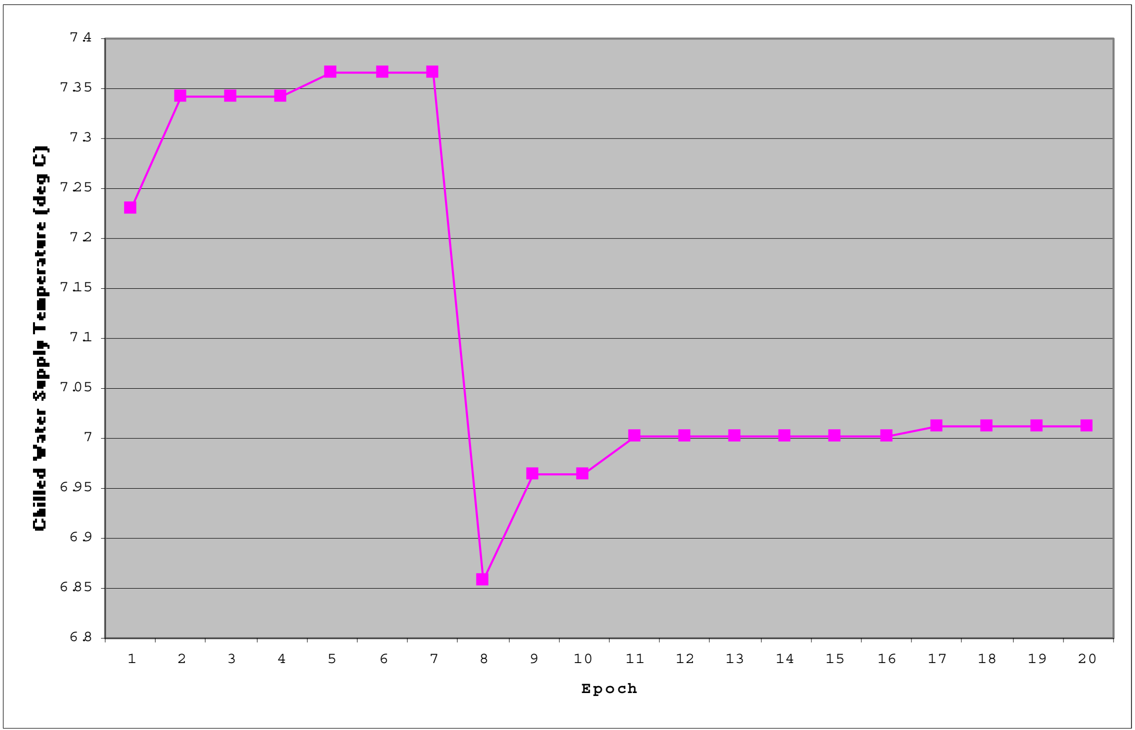

Figure 7: Optimum Chilled Water Supply Temperature in Each Epoch

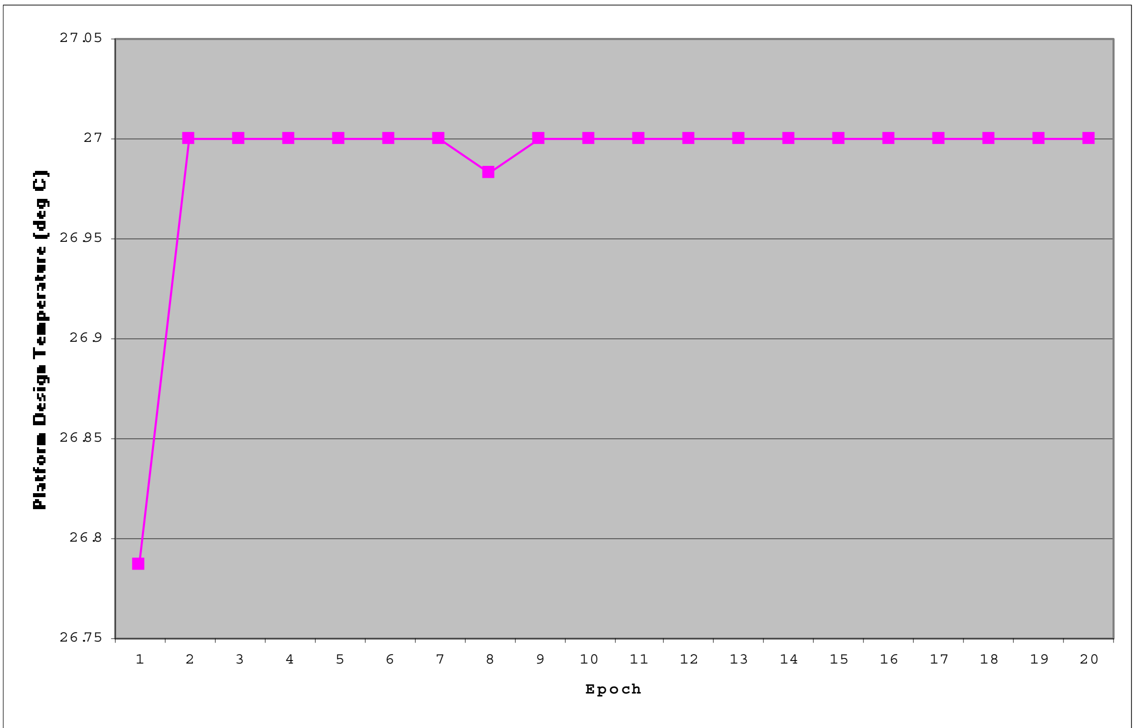

Figure 8: Optimum Platform Design Temperature in Each Epoch

From Figure 6, the minimum year-round energy consumption was found from epoch 11 and there was no significant change thereafter. From this evaluation result, the optimum conditions of T_{cws} and T_p were 7.0 °C and 27.0 °C respectively. As compared to the existing conditions 7.2 °C and 27 °C, the set point of T_{cws} could be further decreased by 0.2 °C and no change was required for T_p. Although the optimization results were close to the existing ones, it indicated that lower T_{cws} could be achieved since the effect of less operation of air side equipment could outweigh the reduced efficiency of chillers during part load situations. In reality, if the optimum conditions were determined by the judgement of the plant operators, there would be a tendency to increase T_{cws} for chillers for saving energy, but ignore the effect from the air side and part load operations. Therefore the EA model provided an effective and numerical mean to determine the optimum conditions, instead of trial-and-error experience and insight.

4.3 Further Applications

The studies were mainly focused on the EMOs of Category I, which was the starting point of energy saving based on the installed equipment and systems. In fact the developed EA optimization and simulation model can also be used to investigate the energy saving potential for different EMOs of Categories II and III, i.e. involving investment and saving return. For example, the existing installations consist of constant speed pumps, saving potential can be determined by changing them to variable speed type. Another idea would be to study the replacement of the 2-speed fans of major air side equipment by variable speed fans. Therefore the current EA optimization and simulation model can be used in handling a variety of different scenarios in performance-based approach for the subway stations.

5.0 CONCLUSION

Although it was common to use simulation in design, it could also be effectively adopted in facilities management, especially to consider different EMOs and to review the current settings of system operation. In this study, plant simulation package was adopted to develop the model of the MVAC systems of subway stations in a holistic approach, with full considerations of their part load operations, in order to determine the year-round energy consumption. Regarding the EA model, it was developed for searching the optimum for different design and operating parameters. Through the coupled EA and simulation model, the optimum chilled water supply temperature and the platform design air temperature were determined. EA was demonstrated to be useful, and it could replace the traditional parametric studies for the HVAC optimization problems.

On the other hand, further development would be focused on a more robust optimization and simulation model, which would be useful for both design and facilities management of the HVAC systems. Especially in the processes of variation and selection, more choice of operators and approaches should be allowed, so that different HVAC problems can be optimized in efficient way. For constraint handling technique, constraints can be introduced by incorporating penalty function, so the fittest individuals can be sought out more easily, and convergence of evaluation can be achieved more quickly. Since plant simulation process is lengthy, more effective variation and selection would reduce the number of running plant simulation, hence the optimization and simulation package can be more useful in different applications.

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Renovation of offices in The Netherlands: reasons, points for attention and obstacles

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Abstract:
Recently a research study is carried out at the OTB Research Institute for Housing, Urban and Mobility Studies together with the Faculty of Architecture of Delft University of Technology on renovation of office buildings in the Netherlands. The central aim is how to improve the changes of a successful renovation. We define renovation as follows: "Structural technical intervention of a building, by means of which the building is adapted to new functional and technical quality requirements, without the original functional purpose being changed." In this context, renovation should not be confused with redevelopment. In redevelopment, large parts or even the whole supporting structure may be demolished and the original functional purpose may well be changed.

As a first step in the research, on the basis of the available literature an inventory is made of the quantity (m^2 of floor surface area) and the quality of the Dutch office stock. This literature research reveals that no reliable quantitative and qualitative data about the volume of the stock are available. The research also made it clear that no data is available with respect to the number of renovation projects and the amount of money involved. There is also practically nothing reported in the literature about the reasons for and possible obstacles to making the decision to renovate office buildings. This is striking because in practice decisions are taken daily in this area.

To address this knowledge gap the OTB undertook a renovation project analysis and involved a large group of principal clients commissioning projects, project developers and architects (Vijverberg 2001a). The results will be presented in this paper.

Keywords: Renovation, Office buildings, Quantity and quality, Investments, Reasons and obstacles for renovation.

Volume of office buildings in The Netherlands in the various property categories

Estimates of the amount and composition of the stock of office buildings in the Netherlands diverge widely. The reasons for this derive from a deficient understanding of the very diverse offices market (locations, regions, various property categories), definition differences in the assessment of the floor surface area (gross, net, functional), definition differences in the design of office space, different layout and reference data used. Estimates of the volume of office buildings in the Netherlands in 1999, the year of measurement range from about 36 million to 50 million m^2 gross floor surface area (EIB 1998; Twijnstra Gudde 1999; Bak 1999; NVM, 1999 and NVB 1998a).

There are also markedly divergent estimates of the property categories. Renting is still the favourite form of occupation in the Netherlands. It is estimated that between 50 per cent (Twijnstra Gudde, 1999) and 71 per cent (NVB, 1998b) of office space is rented. The share of leased property is estimated at between 2 and 5 per cent. About 29 to 48 per cent of the office space is owned by the occupiers. The research studies also contradict each other with respect to estimated future preference for buying or renting office space. Twijnstra Gudde and the TU Delft (Dewulf et al., 1994) anticipate an increased pre ference for renting rather than ownership of office space; the Netherlands Association for the Building Industry (NVB, 1998b) reports an increasing need for office space to buy.

Quality of the Dutch office buildings

The research by Twijnstra Gudde revealed that in 1999 about a quarter of the office stock was of a high quality level; the level for half the stock was average; the rest was of moderate quality (Twijnstra Gudde, 1999). A high quality level is defined in this context as “attractive architecture, flexible layout opportunities, standardised building, high value air conditioning and electrical installation and data-infrastructure.” That is not to say that the majority of organisations accommodated in offices are dissatisfied with their current buildings. On the contrary, various surveys have revealed that about 70 to 80 per cent of office based organisations in the Netherlands were reasonably to very satisfied with their accommodation (Dewulf et al., 1994. NVB 1998b, Twijnstra Gudde, 1999). The location is the most highly valued aspect; the structural technical situation of the building the least. The assessment of the functionality and the spatial-visual quality takes an intermediate position.

In 1994, about 24 per cent of organisations occupying office space had made fairly concrete plans for their future accommodation. This percentage increased by 1999 to about 35 per cent. Of this 35 per cent, about 22 per cent were seeking to move within three years (although the move issue was not always a matter of the accommodation, but could also be the consequence of management decisions). The percentage is about the same for the public and private offices market and for the different size classes of companies. Of the office organisations seeking to move, about 60 per cent would leave behind an office in an urban location. Three quarters of the premises are small, namely up to 1,500 m^2 total floor surface area. About 40 per cent of the premises were built after 1980 (NVB, 1998b; Twijnstra Gudde, 1999).

In addition, 13 per cent of the organisations occupying office space have plans to renovate their accommodation (NVB, 1998b). This percentage is about the same for the public and private sectors (as it is for those seeking to move). There are indeed marked differences according to size class. For large companies, the percentage is higher (20 per cent) than for the small companies (10 per cent).

Vacancy, demolition, change of purpose and renovation of office buildings

After a rise in the first half of the 1990s, from 1995 the number of unoccupied offices in the Netherlands fell markedly. The National Offices Market Research estimated the amount of unoccupied office space in 1999 at 1.7 million m^2 total floor surface area (or 1.3 million m^2 floor surface area capable of being let). This is about 4.2 per cent of the total stock of office space in the Netherlands (Twijnstra Gudde, 1999). A substantial part of the unoccupied m^2 comprises offices of low quality. These buildings are certainly not always old. About 45 per cent of this low value unoccupied stock was built after 1980 (and 25 per cent even after 1990). The chance that poor quality unoccupied buildings at poor locations may still be utilised is limited. The maxim in the Netherlands is thus to look out for a good location and build on it high value buildings (and accompanying facilities) which can readily be let. Low value buildings on good locations can be renovated, provided they are structurally sound (supporting structure, standardised measurements, flexible) and exploitation is technically safe.

There are no reliable data for the number of renovation projects in office premises. At the beginning of the 1990s, according to the consultancy bureau DHV there were an estimated thousand projects per year involving a joint total floor surface area of 500,000 m^2 (including all projects whether or not they were combined with extension and/or partial change of purpose). For the 1990s, DHV expects there to have been a doubling of renovation activities (MVROM/DCB, 1991). Recent research indicates that 13 per cent of organisations occupying office space have renovation plans. When this figure is expressed in m^2 floor surface area (as reported, estimates run from 36 to 50 million m^2) then that amounts to between 4.65 and 6.5 million m^2 total floor surface area in the Netherlands (Vijverberg 2001b)

The withdrawal of office buildings involves demolition and change of purpose. The quantity (m^2 total floor surface area) of office space which is withdrawn annually from the stock is equal to the quantity of office space which is demolished, plus the quantity in m^2 of office space which is reallocated to another function, minus the m^2 of non-office space reallocated to office space. In 1994, TU Delft's research into the office market estimated the amount of floor space undergoing a change of purpose or demolition involved 300,000 m^2 total floor surface area per year (Dewulf, 1994). This figure is based on 1 per cent of the stock. This percentage is also used by the Economics Institute for the Building Industry in the Netherlands (EIB, 1998). The expectation is that, in the next few years, change of purpose and demolition will attain a scale of about 400,000 to 450,000 m^2 total floor surface area per year.

Change of purpose usually only takes place on a modest scale. Buildings in the city centres have the greatest chance. In Amsterdam, 10 per cent of the office accommodation released in the 1980s acquired another function (residence, but also change of purpose, for example for education or health care). Change of purpose is usually not an option for offices in the outskirts of the city (industrial and companies estates).

The need for limited numbers of low quality value office buildings will certainly be sustained, because such buildings usually attract a lower rent/purchase price. In a time of a booming economy the demand for office buildings is high. Scarcity increases the chance that at that point in time unoccupied buildings with a low value quality will also be rented/sold. Should a recession then follow, as occurred in the Netherlands in the beginning of the 1990s, the demand for office buildings falls along the whole line and (so is our expectation) the surplus at the bottom end of the market increases substantially. Low value buildings on poor locations then have no chance. Many outdated buildings will then have to be demolished.

Preferences of office organisations with respect to their accommodation

Research reveals that at present office organisations are particularly interested in high quality buildings. A shortage situation is beginning to arise, mostly for larger office spaces (more than 5,000 m^2) in the Randstad (provinces of South and North Holland and Utrecht in the Netherlands).

In the 1990s, the growth in the number of employees was mostly taken up within an organisation's existing buildings. As a consequence, people were often accommodated in cramped conditions. The average organisation occupying office space seeking to move wishes to increase its office space area by 80 per cent. Research also indicates that when moving people increasingly tend to choose existing premises (65 per cent) and opt less often for new construction. This preference may derive from the increased quality of the existing stock and the stringent location and parking requirements for present day new construction (NVB, 1998b). This picture is supported by the Economics Institute for the Building Industry in the Netherlands (EIB); they anticipate a slackening off of production in new construction in the public sector and the commercial services and a fall in new construction in the remaining private sectors. One of the reasons put forward by the EIB is the reduction in space used per employee through such developments as teleworking and flexible office use (EIB, 2000).

Research indicates that companies in the Netherlands seeking to move would like on average 1 parking place for 33 m^2 total floor surface area and 1 parking place for 100 m^2 floor space for government organisations. The desired number of parking places after moving is on average about 20 per cent higher than in the current situation. In 1999, the average rent paid for office space in the Netherlands amounted to € 116.62 per m^2. For a potential move, people are prepared to pay an average of € 126.60 per m^2. Most (87 per cent) of the office organisations seeking to move are looking for accommodation within the same region (NVB, 1998a; Vastgoed Profiel, 1998).

With respect to the desired form of accommodation, in the 1990s the share of joint collective offices fell drastically from 39 per cent (1993) to 26 per cent (1999). There is a clear tendency for an organisation to be accommodated in a building as the sole user (or to share with only a small number of subsidiary users). Only on railway station locations in the Netherlands does the joint collective office retain a substantial market share, namely 64 per cent (Twijnstra Gudde, 1999).

Investments in the renovation of office buildings

The literature research made it clear that no data were available with respect to the number of renovation for office buildings in the Netherlands. The amount of money involved in such projects is also unclear. To address this knowledge gap, the TU Delft undertook a project analysis. This analysis concentrated on a part of the offices market, namely buildings for "administration and commerce". An analysis was made on the basis of the Netherlands newspaper *Cobouw* over a period of one year (April 1999 up to and including March 2000). In drawing up the list of projects, those involving an investment of more than € 136,134 (= NLG 300,000) were selected. There were 177 projects in the period indicated. The average investment amounted to € 1.51 million (= NLG 3.32 million) per project. The total volume of investment amounted to almost € 272 million (= NLG 600 million) per year. There were in addition an estimated 300 to 400 registered projects with an investment up to € 136,134 (mostly extensive maintenance projects). We estimated the ”investment sum” of these projects at € 90.756 (= NLG 200,000) on average (in total, € 27 to 36 million).

Reasons for renovation

The reasons for renovating offices depend self evidently to some extent on the property situation and the initiative of the parties involved. We distinguish three types of parties: the owner-user, the investor-owner (pension funds and insurance companies in particular), and the project developer. The two first named parties take the renovation decision from an involvement in the management of the building; in principle, the project developer is not involved in the management and has a clear choice opportunity. A project developer can (alone, together with, or for an investor) move to acquire premises to renovate (or redevelop). There will only be a move to acquisition if the expected yield of the purchase and subsequent activity is sufficient. In addition to the yield, the time frame is also of importance. Project developers and small investors in the Netherlands often commit themselves to a relatively short period, after which sale follows. Renovation fits in with this strategy when the yield over a short term offsets the risks and the nuisance of the renovation. Owner-users and investor-owners often use a somewhat longer time frame.

We selected the relevant aspects capable of providing a reason for a renovation initiative on the basis of the available literature. The aspects which cannot be influenced by a renovation (the location of the building with respect to interesting service companies, for example) were excluded from the study (Dewulf, 1994; Vijverberg, 1997). We distinguished three categories of reasons, namely: locational (3 in total), functional and technical (11), and financial and market (7 in total). The 21 reasons distinguished were presented by means of a questionnaire to a group of about 60 principal clients commissioning projects, project developers and architects (see table 1). The response lies in a range of 77 to 88 per cent. They were asked to rate the importance of the various potential reasons for the renovation initiative. They expressed their assessment as a report grade (five point scale, in which 1 stands for unimportant and 5 for very important).

Results

The architects found the *functional and technical* reasons the most critical. The average importance attached to the reasons in this category was 3.4 (on a 5-point scale). Scores were particularly high on four of the reasons in this category, namely increased attractiveness of the appearance, enhancement of the building’s usefulness, change in office layout, and improved climate in the building. The architects found the *locational* reasons the least important category (average 2.8). In particular, the architects did not find an improvement in the parking facilities by the building an important reason for renovation. The average report grade the architects attached to the category *financial and market reasons* was 3.2, an intermediate position (see Table 1).

The principal clients and developers awarded substantially higher report grades (than the architects) to all three categories of reasons. The principal clients and developers also found the *functional and technical* reasons the most important (average 3.6). As with the architects' assessment, the improvement in appearance, enhancement of the building's usefulness (layout, net/gross floor surface area ratio) and improvement of the building's climate all had very high ratings. Principal clients and project developers also found important (4.0) the improvement of facilities in the building (toilet facilities, meeting spaces, etc.). With a rating of 3.1 on the other hand, changing the office concepts was assessed substantially lower. It is striking that the principal clients and developers found the locational reasons much more important than the architects did (average 3.4 versus 2.8). The higher assessment relates to two items, namely improvement of parking facilities by the building and improvement of social safety.

	Architects	Principal client/ Developers
Locational reasons:		
Improvement of access to the building (entrance)	3.5	3.2
Improvement of parking facilities by the building	2.2	3.4
Improvement in the social safety of the building and location	2.7	3.6
Total assessment for locational reasons	2.8	3.4
Functional and technical reasons		
Improved appearance (building, entrance, interior areas)	3.9	4.0
Enhanced usefulness of the building (layout, net-gross ratio of floor surface area, and so forth)	4.0	4.2
Improvement/installation of facilities in the building (entrance, main lobby, toilet facilities, meeting rooms, parking facilities)	3.3	4.0
Altered office concepts (single room, group office, office garden)	4.0	3.1
Improvement climate in the building (temperature, heat insulation, ventilation, comfort, lighting and so forth)	4.0	4.0
Improvement data communication system, cabling, energy provision	3.5	3.7
Improvement of structural technical state	3.4	3.4
Improvement in prevention of burglary and control of access	3.0	3.1
Improvement in fire safety	2.9	2.9
Improvement in environmental quality (removal of asbestos, lead water pipes, reduction in emissions, materials applied, etc.)	2.5	3.2
Improvement working conditions	3.5	3.6
Total assessment for functional and technical reasons	3.4	3.6
Financial and market reasons		
Maintenance/Increase in the yield	3.6	4.4
Improvement of the costs/quality ratio for the building	3.5	3.7
Reduction of structural maintenance costs	3.0	3.5
Reduction of the costs of installation maintenance	3.2	3.6
Reduction of energy costs	3.2	3.3
Reduction of cleaning costs	2.3	2.6
Increased occupation level	3.4	3.8
Total report grade for the importance of financial and market reasons	3.2	3.5

Source: Vijverberg 2001a

Table 1 *Report grades of the importance of reasons for renovation an office building (1=unimportant; 5=very important)*

The principal clients and developers also put the category *financial and market* reasons in a middle position (average 3.5). The maintenance or increased yield from the office building formed an exception; with a rating of 4.4, this reason was considered the most important.

Finally, in the category *functional and technical reasons* the relatively low score for the improvement of fire safety and the improvement of the building's environmental quality is striking.

Obstacles to the decision whether of not to renovate

In addition to assessing the reasons for renovation, the principal clients, developers and architects were asked to indicate the points for attention and the obstacles which played a part in the decision whether or not to renovate. We distinguished a fourth category, *policy and legislation,* in addition to location, functionality and technical structure, and finance and market in the classification of the possible points for attention and obstacles. *Policy and legislation* are exemplified by the acquisition of building permits, subsidies, and so forth. The government plays a dominant part in policy and legislation. Sometimes the government is able to improve the locational circumstances of office premises (accessibility, feeder roads, parking facilities, and so forth). On the other hand, in the Netherlands the government can act restrictively in undesired developments. Examples can be found in the application of spatial planning policy (zoning plan, land issue and so forth), parking policy, traffic and transport policy, environmental policy, urban renewal, land policy and fiscal policy (Vijverberg, 2001c).

Points for attention/obstacles

The architects' group and the group comprising the principal clients and the developers both found the points for attention and obstacles derived from the market and the financial perspective the most important (see Table 2). Both groups of respondents allotted to this category an average rating of 3.9 (on a 5-point scale). The respondents found the category *policy and legislation* the least important (averages 3.0 and 3.2 respectively). The functional and technical and locational points for attention and obstacles took a middle position.

The principal clients and the developers accorded considerably more importance to the *locational* points for attention and *obstacles* than did the architects (this differential applies broadly to all the items listed within this category). On the other hand, the first group accorded a lower importance than the architects to potential obstacles from legislation. This differential applies to all the items except one, namely: private law obstacles. In addition to the items indicated, the respondents identified further potential obstacles, namely: requirements from the conditions of the Netherlands Employment Act, the cooperation with the planning of the energy and other public utility companies and (as a supplement to the private law obstacles) a regulation for any possible planning damage for the owners of adjoining premises.

It is striking that neither category of respondents found the acquisition of a subsidy an important item in the decision to renovate.

	Architects	Principal client/ Developers
Locational points for attention and obstacles:		
Situation of the building with respect to companies and services	3.3	3.8
Status/power of attraction of the district in which the building stands	3.8	4.2
Accessibility of the building by car	3.5	4.1
Accessibility of the building by public transport	3.0	3.6
Parking possibilities at or in the vicinity of the building	3.8	3.9
Possibilities for improvement of the building access (entrances)	3.2	3.2
Possibilities for improvement of parking facilities by the building	3.3	3.7
Possibilities for improvement of social safety of building/location	2.7	3.5
Total report grade for locational points for attention/obstacles	3.3	3.8
Functional and technical points for attention and obstacles		
Flexibility of construction typology (modular structure, demountable outer walls)	3.5	2.9
Maximal accessible net/gross floor surface area ratio	3.3	3.6
Maximal accessible rented/gross floor surface area ratio	3.5	3.8
Maximal accessible useable/gross floor surface area ratio	3.3	3.8
Planning grid of outer wall in relation to the office design to be realised	3.4	3.1
Planning grid within outer walls (across the outer wall)	3.0	3.2
Total depth within outer walls (across the outer wall)	3.2	3.4
Number of different office designs that can realised be in the building (division of accommodation spaces)	3.5	3.5
Possibilities of creating independent units (for split rental)	3.6	3.5
Flexibility for laying pipes and installations (vertical zone layout)	3.3	3.6
Possibilities for opening up the building horizontally (passageways and entrances)	3.5	3.5
Possibilities for opening up the building vertically (lifts and stairwells)	3.9	3.6
Total report grade for functional and technical points for attention/obstacles	3.4	3.4
Financial and market points for attention and obstacles		
Rise in market value in relation to the extent of renovation costs	4.3	4.0
High commercial value after renovation (a fall in commercial value signifies an unprofitable intervention)	4.0	4.0
Yield improvement after renovation	4.0	4.0
Level of rent after renovation in relation to alternative buildings in the district with equivalent performance	4.0	4.2
Level of exploitation costs after renovation in relation to exploitation costs of alternative buildings with equivalent performance	3.9	3.8
Occupation level after renovation	3.3	3.8
Total report grade for the importance of financial and market points for attention/obstacles	3.9	3.9
Potential obstacles from policy and legislation		
Obtaining licences (building licence, health, fire services, environmental licences, parking licences and so forth)	3.9	3.7
Obtaining a subsidy for renovation	2.6	2.1
Zoning plan (alteration)	3.9	3.5
Monuments Act	3.1	3.0
Private law obstacles (land on long lease, lease obligations, intellectual property rights on architecture, etc.)	2.5	2.8
Total report grade for the importance of obstacles from policy and legislation	3.2	3.0

Source: Vijverberg 2001a

Table 2 *Report grade points for attention/obstacles to renovate an office building (1=unimportant; 5=very important)*

Important factors for the success and failure of renovation projects

The respondents were asked what retrospectively they found had been the most important success and fail factors in the renovation projects of offices the bureaus had implemented. The responses made it clear that Netherlands architects and principal client/ developers have different opinions. For the architects, the design perspective was predominant. This group of respondents found the attractive appearance and representative qualities of the building the most important aspects. The principal client and developers placed a good organisation of the project and the capability of being let of the product at the top.

Conclusions, recommendations and further research

In summary, it can be concluded that the research of the TU Delft makes clear that no reliable quantitative data are available about the scope and composition of the stock of office buildings in the Netherlands. A recommendation is to work strictly in accordance with accepted definitions of the concepts of office space, company class layout and for example floor surface area in the collection of data. The literature study carried out reveals that the state government has commissioned hardly any research into the quality of the construction in the utilities sector in the Netherlands. Such research has been left to local authorities and private initiative. It is interesting to note that the Netherlands state government sees a directive role for itself in housing construction (the periodic Qualitative Dwellings Registration). Many office buildings in the Netherlands are located in cities. It is estimated that a quarter of the stock is of low quality. The influence on the residential environment is substantial. We therefore advocate a directive role for the Netherlands state government in research into the quality of the construction of utilities (including the offices stock).

There is also practically nothing reported in the literature in the Netherlands about the reasons for and possible obstacles to making the decision to renovate office buildings. Also an international literature research did not bring new insights (Vijverberg, 2002). This is strange, because in practice decisions are taken daily in this area by principal clients commissioning projects and project developers. The TU Delft research offers a preliminary glimpse into the situation on the Netherlands. A broad cross project survey has been involved. A follow-up research study in 2002 will go into more depth by means of an analysis of a number of renovation projects that have been carried out. At project level, in addition to the reasons and the potential obstacles it is possible to zoom in on more project specific topics which could not be included in the questionnaire. You will receive further information as soon as the results are available.

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Strategic planning of maintenance and functional changes in facilities owned by the city of Oulu

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Abstract:
Aging buildings require an increasing amount of regular maintenance. The need for maintenance depends on a building's attributes and to a certain degree on the strain caused by use. A strategic maintenance plan should, however, also consider activity-induced fundamental improvements, which are usually implemented at the same time and with the same resources.

VTT Building and Transport and the city of Oulu have together developed an operating model for strategic planning of maintenance. In 2001 – 2002 the model has been applied to 16 sites owned by the city of Oulu.

The condition assessment of a building begins with a review of the design documents and a survey of the users of the site. On the basis of the survey it is possible to pinpoint a site that most probably has either moisture damage or indoor climate problems caused by insufficient ventilation. Based on the user survey, a "perception index" and a "symptom index" were compiled to indicate the condition of the site. In a healthy building the perception index is below 250 and the symptom index is below 150. In an ailing building the perception index is above 600 and the symptom index is above 400. Sites with figures between these values have problems, but they are of the type that only some of the users suffer from them.

With a user survey it is possible to quickly determine which sites in a large stock of buildings immediately require a more specific investigation. Condition index is used as a common term, which may be compared to a person's blood pressure measurement (systolic pressure / diastolic pressure).

A list of risks was developed to support the document review. With the list it is possible to detect sites that most probably suffer from problems on the basis of the design of the building.

A condition assessment was made of the sites, including examinations based on the senses and moisture measurements, carbon dioxide content measurements and in certain sites, thermal camera images of the building shell. By making field studies, an optimal operating model was found for planning of strategic maintenance by public building owners.

The study also developed a simple spread-sheet application with which a strategic maintenance plan was compiled for the sites. The maintenance plan also includes an energy efficiency inspection.

Experiences obtained with the procedure are promising. There is a definite positive correlation between the condition indicators and the measurements and observations made at the site.

1. The system description

In appendix A a system is described. The planning process is divided into 6 stages. Stages 1 - 4 can be done before we visit the building. It is still recommended that with stage 3 interviews of building managers and maintenance stuff is done. But this is not necessarily if we have building plans and data from HVAC systems. By stages 1-4 we shall classify buildings. Group1 (Probably healthy buildings), G2 (Probably problems in use), G3 (Probably lightly sick buildings and G4 Probably sick buildings). The filters we are using are risk analysis and users perceptions and symptoms. These studies gives us valuable information from the house.

The condition assessment system we use in Finland today, is developed in 1990's. It is described for example in ref. 1 (see appendix C).

After stages 1 - 4 we have no buildings with different profiles. Detailed surveys and mould analysis are focused to the most urgent cases (G4). Also the routine field study in these cases demands more time. It is still be remembered that this process is strategic. The primary aim of the research is to show the owner how to allocate repair money in the future. If we find a real sick building, the active repair work have to start immediately. In some cases even a condition surveyor can give the first aid. Because strategic condition process is a little bit lighter than the normal process, it is also cheaper for the client. For property manager it is interesting to see what is the profile of his building stock. How many buildings exist in G1, how many in G4 ? What is the average energy efficiency of the building stock, how it has been in the past and which are the target figures in the future ?. How much repair money is needed in the planning period ? Is there differences between the operational effectiveness ? What is the average indoor air quality ?

Figure 1 presents a method used in condition assessments and an estimate of the number of work hours in each phase in the case of a school building. The total amount of work in a 2000 – 3000 m^2 (7000 – 10000 m^3) site is around 80 – 100 hours, and the cost is about 4000 – 5000 euros plus value-added tax. If the site includes many technical systems, whose technical life span is not expiring yet, it’s also worth including other technical measurements (air tightness, lighting intensity, etc.) in the condition assessment.

Phase	Procedure	Amount of work (hours) and cost (euros)
1	Review of documents and risk estimation	16 hours/site 400 - 800 euros/site
2	User survey and evaluation of results, calculation of perception and symptom indexes	16 hours/site 400- 800 euros/site
3	On-site observations (building technology, HVAC technology)	24 hours/site 500 - 2000 euros/site
4	On-site measurements (CO_2 content, indoor temperature, relative humidity of indoor climate)	8 hours/site 400 - 800 euros/site
5	Energy study - heat consumption - electricity consumption - water consumption	8 hours/site 200 - 400 euros/site
6	Technical repair plan for 10 years - immediate need for repair - repair projects during the planning period	8 hours/site 200 - 400 euros/site
7	Report compilation - summary for users - study report - can be appended to the facility’s maintenance manual	16 hours/site 400 - 800 euros/site

Figure 1. Content of a condition assessment of a 2000 – 3000 m^2 school building for strategic maintenance planning.

Figure 2 presents a method used in risk evaluation. Evaluation of the seriousness of risks is based on VTT's experiences with the causes of moisture damage and indoor climate problems in buildings. The quality of building maintenance is also included as a risk, which can only be determined by an on-site inspection.

Size of risk	Building component /technical system / operating process	Factors taken into consideration
0 – 100 p	Geological features of the building site (soil)	- time of construction - trees - construction of surroundings
0 – 200 p	Building base and foundation	- cellar - footing drainage - surface water drainage - age of sewer line
0 – 200 p	Building frame and materials used outside	- main building material (stone/concrete/wood) - eaves, windows - rainwater system - roof (roof inclination)
0 – 50 p	Heating system	- age of primary heating system and location of piping - age of piping and radiators
0 – 50 p	Water and sewer system	- age and location of plumbing - exceptionally high water consumption
0 – 300 p	Ventilation system	- type and age of ventilation system - exceptionally low heat consumption
0 – 100 p	Quality of facility maintenance and cleaning	- cleaning method - facility maintenance staff's attitude toward the work

Figure 2. Risk estimation in a strategic maintenance plan

Figure 3 presents a calculation of the condition index factors, i.e., the perception and symptom indexes. Normally, a condition assessment doesn't require examinations where the structures of the building must be opened. A more detailed examination of damage is made as a scheduled procedure in a site where the risk estimate or condition index indicates the presence of hidden problems.

Perception index (add the percentages of the yes responses)	Symptom index (add the percentages of the yes responses)
Have you experienced as a problem? - high room temperature - low room temperature - varying room temperature - drafty windows - cold floors - dry indoor air - moist indoor air - stale indoor air - unpleasant odors - dusty air - dusty surfaces - noise from outside	Have you had the following symptoms? - red eyes - runny or stuffed nose - hoarse voice - coughing - difficulty in breathing - asthma - respiratory infections (repeatedly) - fever - skin rash - headache - tiredness - difficulty in concentrating

Figure 3. Calculation of a building's condition index based on the perception index and symptom index.

2. Benefits of scheduling maintenance and activity-induced changes

Scheduling of building maintenance and functional improvements brought about by users involves identifying future repair needs, determining the resources required to do the repairs, and scheduling the repairs during a specific period. The general goals of scheduling are:

1 Optimal use of resources
2 Sensible prioritization of repairs
3 Formation of advisable project entities
4 Enabling of horizontal repair entities
5 Minimal disruption of facility activity
6 Easier repair budgeting
7 Development of maintenance planning and
8 Determination of the actual market value of buildings.

On the one hand, optimal use of resources means integration of the city's own resources and service purchased externally to produce the best possible final result. The city's own resources should be used as evenly as possible. Subcontracts and external contracts are subjected to competitive bidding by observing the field's economic development and making use of quieter times in construction. This is possible because the nature of renovation procedures allows flexible scheduling of their implementation within a time span of several years.

Prioritization of repairs means that in the order of urgency, first procedures or sites are taken care where postponement would cause a health hazard or safety risk to the users. Then procedures that improve performance, comfort or energy efficiency are implemented. The consequences of each procedure and the cost of the consequences should always be determined.

Advisable project entities refer to bundling of procedures into repair projects that are completed at the same time. This minimizes the detriment to use and as the size of the projects increases, also achieves rationalization benefits and lowers costs.

Horizontal repair involves linking similar repairs into entities of several projects. In the sites owned by the city of Oulu, repair entities that can be suitably horizontally linked could be, for example, roof modifications, renewal of windows and exterior doors, renewal of heating systems, etc. Linking brings an average cost savings of 5 –10 %. In larger projects it's easy to employ model repairs, which promotes the quality assurance of the procedure.

Minimizing disruption of activity is important from the users' point of view. With the help of a repair plan, users can plan their own activities, avoiding a rush to find alternative school or day care facilities, for example. This results in a cost savings and makes it possible to find temporary facilities that are as suitable as possible for the intended use.

With a repair plan it's possible to set a target cost for the repair work. The goal is realistic and based on damages detected at the site. It's easier to decide on the necessary resources if decision-makers can be shown the yearly need for resources and how the figures have been arrived at. With an up-to-date repair schedule it's also possible to continuously take into consideration any changes in the use of resources.

Maintenance scheduling is a part of overall facility upkeep planning. A repair schedule always includes several buildings. A repair schedule consists of building-specific project schedules. A project schedule is part of a building's service manual.

The technical value of a building is comprised of its purchase value, which is defined according to its space usage, and from which is subtracted the costs of repairs due to aging and wear (repair debt). It's possible to specify the reliable, up-to-date technical value of a stock of buildings on the basis of an up-to-date repair schedule.

Repair scheduling is important in forming a general picture of maintenance upkeep. A carefully compiled, up-to-date repair schedule gives a good picture of the operation of the maintaining organization and is also positively reflected in user satisfaction.

3. Experiences

In appendix B there are two examples of "customers". A day care centre from the 1960's has high technical risk (850/1000), perception and symptom index is extremely high (948/ 650), energy efficiency is l normal or little bit low , which indicates the function of air ventilation system is poor. The building is in G4 and needs detailed surveys. Afterwards we found out that content of CO_2 was in some rooms over 3400 ppm (suitable value is under 1500 ppm), surface temperatures were low and indoor temperature varied between 17 - 24. Mould was found in cellar. During the planning period this building needs about 1000 euros/ floor-m^2 and renovation degree is high (80 %).

The other example is an elementary school which have been built in two stages. The older part of the house is built in 1958 and new part in 1993. Air ventilation system has been renovated in 2000. Technical risk was low (330/1000), perception and symptom index too (420/360), energy efficiency good and repair costs during the planning period were 150 euros/floor-m^2. This is a G1-building. We made still indoor air quality measurings, which showed that users perceptions and measured air quality had a positive correlation. No signs of mould were seen.

4 Conclusions

The procedure makes condition assessment of a building easier and more systematic. The risk evaluation makes it easier to become familiar with the building and a large part of the field study can be done at the desk. The condition assessment report compiled at the desk is used as a base which is supplemented by measurements and observations made at the site. The greatest benefit of the procedure is the time savings. Because the time spent in the field study can focus on the known risk points, the reliability of the condition assessment is improved.

Some of the factors related to the risk evaluation cannot be verified until the field study is made (quality of building maintenance, strain caused by activity, requirements of activity).

User perception and symptom indexes compiled on the basis of the user survey correlate positively with observations made at the site. If the symptom index of the site is clearly above the average index of similar buildings, it is probable that the site has an indoor climate problem and possibly also microbe damage. The correlation is not as clear with the perception index, because users may perceive the indoor climate of a building in relatively good condition to be unpleasant. The perception and symptom indexes function as an indirect measure that provides additional information. In no way do they replace a reliably made condition assessment.

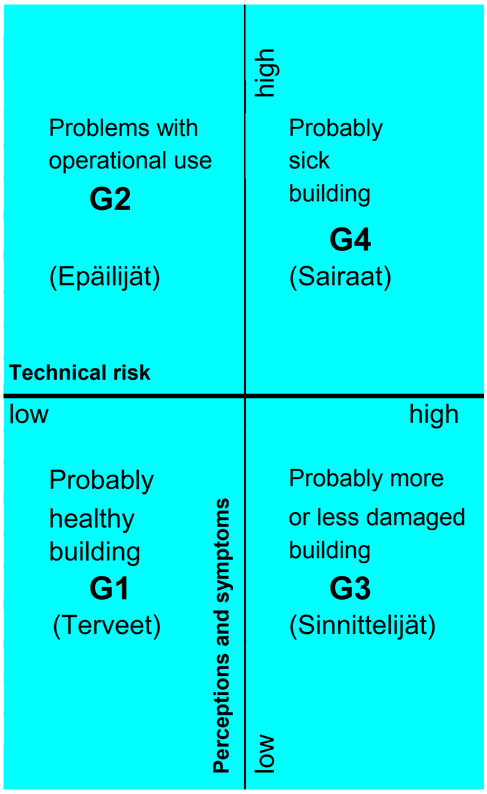
Heat, electricity and water consumption are also examined in conjunction with the condition assessment. In public buildings the problem is not high heat consumption. The buildings usually consume less heat than specified as the target consumption. This is because the quality of ventilation is not at the required level. The energy study should identify such sites that suffer from ”hypothermia”. A high perception or symptom index may be caused by overemphasized energy conservation.

Until now totally 16 public buildings in the city of Oulu has this kind of strategic repair and maintenance plan. List of the buildings is shown in appendix C. At the moment 6 school buildings, an ice hall, a library and an apartment house for elderly people are on line. Later on this autumn we are going to apply this method in 50 multistorey apartment stories. After that there is a huge hospital and wellness centre.

Appendix A: Condition assessment system in strategic PM process

Stage 1 Collection of Basic data
Location and building (renovation) year
Building area and building volume
Amount of users
Structures and HVAC-systems
Repair history, operational defects

Stage 2 Risk analysis
Soil, building surroundings
Footing drains, foundation, cellar
Outer walls, balconies and windows
Roof
Waterproofing inside the building
Air tightness
Heating system
Water and Sanitary system
Air ventilation system
Maintenance



Stage 3 Users perceptions and symptoms
room temperature, indoor air quality, noise
symptoms

Stage 4 Energy economical profile
Heating energy
Electricity
Water consumption

Stage 5 Condition assessment
Site
Building
Rooms
HVAC-systems

Stage 6 Strategic repair plan
Additional surveys
Repair costs during the planning period (10 years)
Operational rates

Building profile (G1 / G2 / G3/ G4)
Energy efficiency profile (E1-E5)
Repair costs (eu/floor-m^2, 10 years)
Indoor air quality (mould, CO_2)

Appendix B: Examples

A day care centre in Välivainio, Oulu. Built in 1965.

Research costs

	euros
Profile	500
Condition Assessment	1000
Surveys	1500
Report	1000
Total	4000

Floor area	**670**
Technical risk	**high**
Perceptions and symptons	**extremely high**
Energy effiency profile	**normal**
Conclusion	**detailed surveys needed**
Profile	**G4 (Probably sick)**

Results from condition assessment and additional surveys

Mould	**Exist, in cellar**
Indoor temperature	**low surface temperatures, drafty windows**
Co2	**high, over 3000 ppm in some rooms**
Repair costs in 2002-2011	**over 1000 euros / floor-m2**

An elementary school in Oulu. Built in 1958 and 1993.

Research costs

	euros
Profile	500
Condition Assessment	1000
Surveys	250
Report	1000
Total	2750

Floor area	**2900**
Technical risk	**low, new air ventilation system**
Perceptions and symptons	**quite low**
Energy effiency profile	**good**
Conclusion	**no mould surveys needed**
Profile	**G1 (Probably healthy building)**

Results from condition assessment and additional surveys

Mould	
Indoor temperature	**21-24 during the winter**
Co2	**normal, under 1500 ppm in classes**
Repair costs in 2002-2011	**150 euros / floor-m2**

Appendix C: References

1 Hekkanen M, Kunnossapidon hinnoittelu (Cost estimation method for Repairs), Kiinteistöalan kustannus Oy- REP Ltd, Kuopio. 1995. 39 pages + 52 appendix pages.

2 Strategic repair and maintenance plans (no public reports) for day care centres in the city of Oulu
- Välivainion päiväkoti
- Merikosken päiväkoti
- Voikukan päiväkoti
- Kaukovainion päiväkoti
- Allinpuiston päiväkoti
- Hintan päiväkoti ja hammashoitola
- Haapalehdon päiväkoti
- Kaijonharjun monitoimikeskus

3 Strategic repair and maintenance plans (no public reports) for school buildings in the city of Oulu
- Tuiran ala-aste
- Korvensuoran koulu
- Karjasillan yläaste
- Pateniemen yläaste ja lukio
- Hönttämäen ala-aste

4 Strategic repair and maintenance plans (no public reports) for special buildings in the city of Oulu
- Central fire brigade station
- Healthy care centre in downtown
- Koskelan neuvola ja kirjasto

Low-Cost Maintenance Approach to High-Rise Buildings: A Critical Appraisal of Low-Energy Refurbishment Scheme in Birmingham

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Abstract: *During the 1960's a significant number of high-rise and medium rise walk-up blocks have been designed and constructed using prefabricated concrete cladding systems. It was estimated that a total of 6535 blocks were built in the UK; 848 blocks were built in the West Midlands; this counts for one eighth of those built in the UK as a whole. Most of these blocks were characterised by inferior quality material and poor workmanship, poor supervision and inadequate environmental services which subsequently deteriorated to a state of disrepair. The main culprits were condensation, water ingress and cold bridging effects due to low energy efficiency standards and lack of thermal insulation. At the end of their life span it was initially contemplated that these problems could be remedied by adopting a more 'high-tech' sophisticated components of composite cladding methods, and highly automated environmental services to improve the operational efficiency and optimise their long- term durability and life-cost cycle.*

However, the cost of these components has proved to be higher than expected and beyond clients' affordability. Attempts to optimise these buildings to meet the requirements of today's users and the current Building Regulations required rethinking of the whole process; therefore an alternative cost effective maintenance and energy efficient approaches need to be developed.

In an effort to address these issues this paper is being set out to investigate and critically evaluate the modus operandi of low-cost maintenance and refurbishment approach to high-rise buildings in Newtown South Aston area in Birmingham.

It is anticipated that this paper will highlight issues for open discussion amongst planners, decision makers and facilities managers that might increase the level of understanding and awareness between all those involved in the process of maintenance and refurbishment of buildings.

Keywords: Low-cost maintenance, Low-energy design, high-rise, refurbishment, cladding, whole life cycle costing.

1. Maintenance of Buildings

Maintenance of buildings is an invaluable process and plays an integral role in the design and construction of buildings. Its primary aim is to retain the value and the quality of a building as a place where users/occupiers can perform to their full potential The condition and quality of buildings in our built environment is so important to retain such value. This derives from the need to preserve the utility of buildings to the wider range of users activities and functions. Buildings which support individuals' needs socially, psychologically and intellectually is more likely to enhance performance; optimise efficiency and empower users to achieve their full potential and will be in greater demand.

It is obvious that real assets investment value relies primarily on supply and demand; in the absence of demand a building has no value to be maintained and neither the initial cost nor the standard of maintenance has any economic significance. Such a vicious circle If such a demand is established and any attempt to retain these assets should take into account the long-term financial consequences, occupational cost, running cost amongst many others and should not be based solely on initial costs.

The total costs of owning and using asset over its predicted life span can be calculated as below (Lee, 1995).

LCC= Ic + (Mc + Ec + Cc+ Oc) + (Vc) - Rv

Ic = Initial cost,

Running Cost (Revenue Expenditure)
Mc = Maintenance costs,
Ec = Energy costs,
Cc = Cleaning costs,
Oc = Overhead and management costs,

Vc = Occupational Costs,
Rv= Resale value.

When such a demand exist, much of that will be affected by the quality of building design, specifications and durability of materials as much as on the level of energy and services cost which in turn determine the type and level of maintenance requirements. This particularly true in high-rise buildings. They represent a significant part of our building stock; they are valuable assets in our built environment.

It was estimated that a total of 6535 blocks were built in the UK; 848 blocks were built in the West Midlands; this counts for one eighth of those built in the UK as a whole. However, some of these blocks were characterised by inferior quality material and poor workmanship, poor supervision and inadequate environmental services which subsequently deteriorated rapidly to a state of disrepair. The main culprits were condensation, water ingress and cold bridging effects due to low energy efficiency standards and lack of thermal insulation amongst many others. Lack of maintenance and inadequate Routine inspection and repair have exasperated these problems further.

There are plethora of studies which have highlighted the gravity of the problems. Some of socio-economic repercussions including urban degeneration, dissatisfaction, social distress, vandalism and crimes amongst many others (Derbyshire, 1993; Lee, 1995) The knock on effect of such distress has led to a rapid depreciation of the actual value of the asset, creating unhealthy and most certainly unfit environment for human habitation; some of these building have to be demolished as they become unsafe and hazardous to the occupants. So what can be done to resolve these problems? What measures can be undertaken to optimise their asset value? What benefits can level of maintenance and energy efficient measures bring about and how can these be harnessed to reduce maintenance and energy cost? What roles can award authorities; investors, clients and occupiers play in achieving these objectives. It is anticipated that this paper will be focused on some of the key issues related to low–cost maintenance and low-energy design measures for the high rise.

1.1 Life Cycle of High-rise Buildings:

There is no clearly defined data about high-rise residential buildings but one can extrapolate from the many observations on high-rise buildings. Some rough estimations can be arrived at as shown in table 1. Clearly the range of average life span of the high rise varies considerably between countries with the highest in Britain and the lowest in Japan.

<table>
<tr><th>New Zealand</th><th>Australia</th><th>Britain</th><th>USA</th><th>Japan</th></tr>
<tr><td></td><td></td><td></td><td></td><td>20 Years</td></tr>
<tr><td></td><td></td><td></td><td colspan="2" rowspan="2">35 Years</td></tr>
<tr><td>50-60 Years</td><td>50-60 Years</td><td>60 Years</td></tr>
</table>

Table 1: A *comparison of life cycle of high-rise buildings in different countries*

When a high-rise like any other building type building fail to respond to change either become redundant or obsolete which could be described primarily as physical, functional and financial; this might justify the need for a new building. This may occur particularly when maintenance cost becomes exceedingly greater than new construction cost. In establishing which course of action maintenance and facilities managers mangers have to work closely with other built environment professionals to assess the financial viability of new build; a meticulous cost- benefit- analysis is needed, this is based primarily on the capital Value of the cleared site for its best use less the cost of demolition and new construction. Otherwise they might decide to adopt a major improvement /renovation programme which will be measured in terms of the capital value of existing building and site minus the cost of conversion. In this case such major improvement would entail to bring the building to an acceptable standards.

Clearly there are no absolute standards, which would be equally acceptable, to every over a period of time. The fact is a high-rise building was initially designed and built at lower standards then the standards acceptable at the time when improvement carried out will be more likely to be higher than the initial design standards. There must be an element of improvement to justify such undertaking. It can be argued that such improvement should be performed to bring every part of the building to currently acceptable standards and new way of thinking in the 21 century, which would minimize future maintenance cost.

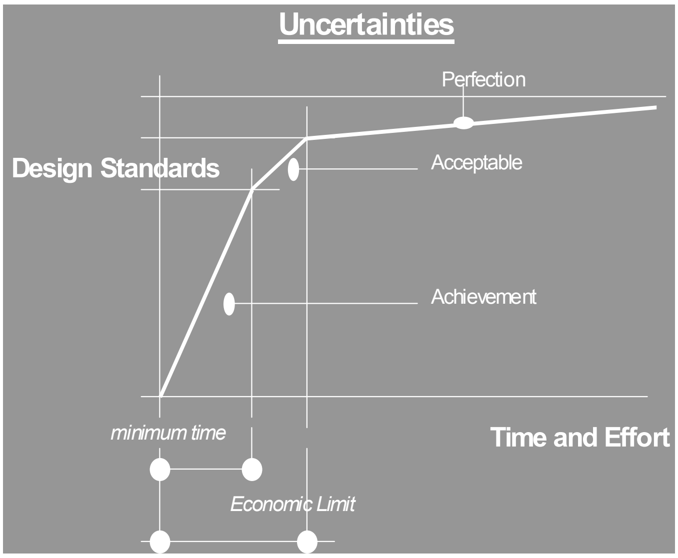

Figure 2: Acceptable vs. achievable standards

And increase the life span of the building considerably. This is particularly true given the end users and occupiers, mainly families who should be entitled to a humane environment as their right regardless of the added value such improvement might bring about.

Figure 3: High-rise has been demolished due to a higher value of the site.

2. Low-energy High-rise Buildings:

What constitutes Low-energy design or eco-design attributes? How are these manifested in high-rise buildings?

In Britain, the term low-energy design is much more widely used and is generally synonymous with the term eco-design. The emerging notions of 'eco-design' and 'green building' have received much greater publicity recently amongst many practitioners (e.g. architects, building surveyors, estate and facilities managers). This has echoed many descriptive and evaluative building studies over the last ten years or so (Evans, 1990; Forman, 1994; Brookes, etal, 1993; Stuart, etal 1993; Birkeland, 1996). However, these concepts are as old as the Greek atrium and Roman baths.

Figure 4: High-tech cladding has a higher capital cost value and might prove difficult to maintain.

There is no widely accepted definition of what constitutes a low-energy design solution, but it is commonly agreed that there is a wide range of eco- design characteristics and *ad hoc* environmental attributes which can be identified, depending on the building type (e.g. residential, commercial, office buildings); the usage of the building and the quality of technical services needed to sustain a building to an optimal level of performance (Logan, 2002).

These low-energy design characteristics might include some or all of the following, inter alia,

- Greater reliance on natural means of ventilation including chimney stacks, venting and cooling surfaces.
- Optimisation of natural heating and cooling methods such as thermal mass, solar heating and radiation, ventilated cladding.
- Efficient usage of natural and artificial lighting.
- Flexible use of the building spaces and resources and easiness of upgrading of the building envelope.
- Reuse and recyclability of building materials.
- Use of energy efficient materials and better specification.

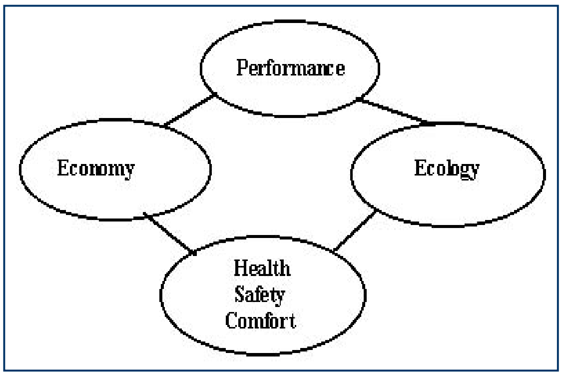

Figure 5: Objectives of low-energy design buildings.

To what extent can these characteristics be incorporated in the renovation of high-rise residential blocks? How can these be effectively achieved at low maintenance cost? What impact they have on the envelope and environmental requirements of the building? This is given that they are the most likely to change to meet different building Regulations?

2.1. External Envelope:

The external envelope of a high rise building should be designed to provide an efficient wall-to-floor ratio as this will influence not only the initial cost of the building but also its performance over time with regard to maintenance, running cost including heat losses and cooling. The wall-to-floor ratio is aimed at maximising the amount of floor area contained by 1 m2 of wall. Buildings, which are long and thin in plan, tend to have a high wall-to-floor ratio and consequently can be expensive to build and to operate as compared with tower blocks. This is almost entirely the case with Walk-up Blocks as compared to Tower Blocks (Clarke, 1990).

It is well documented the external walls of these blocks is of a higher U-value. This is particularly true in concrete infill panels with various finishes and U-values of 0.90-1.10 W/m2 K, which contribute to excessive heat losses.

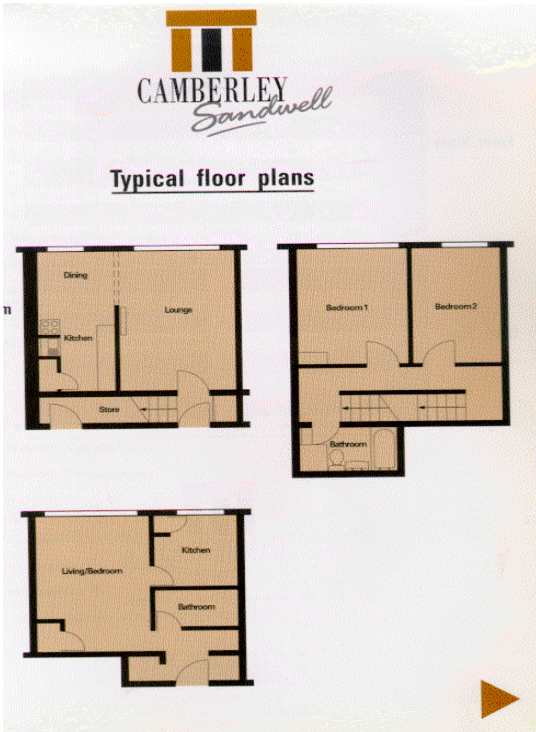

Figure 3: Tower blocks are more compact and have less floor-to walls ratio

Therefore any attempt to renovate the external fabric should aim to achieve affordable heating together with an improvement in energy efficiency at a U-value of 0.50-0.60 to keep it in line with the Building Regulations so that the fabric will be maintained at temperature and humidity that will prevent its deterioration[1]. This will equally reduce the chance of cold bridging and minimise the risk of mould growth and the likely health problem associated with it. Double skin façade can achieve a whole

[1] It is has been argued that the cost of upgrading thermal insulation by internal dry-lining is one quarter of the cost of cheapest external insulation but it is difficult to achieve suitable U-values (Clarke, 1990)

range of benefits and acts in tandem with other environmental aspects including improvement in building acoustics, allowing access for maintenance as well as improving the thermal performance of the building with a wider implications to level of thermal comforts.

However, thermal performance of double skin façade is highly affected by a whole range of factors (Williams, 2002).[2] Which is beyond the scope of this paper.

It becomes imperative that in any conversion scheme much greater emphasis should be given to take into account these factors to upgrade the average thermal performance of the external fabric to at least new-build standard and where possible higher.

2.2. Environmental Requirements:

A window is an important part of the design of the external skin of most buildings including high rise, for it needs to provide good outlook with comfortable conditions without glare or draughts. Many of the high-rise buildings were constructed using large concrete panel systems with relatively larger window sizes, most of which are single glazed within a metal frame. Whilst the main intention was to design windows for natural ventilation very little attention has been made in many high-rise developments to avoid excessive draughts, heat loss, excessive background noise level and discomfort.

The current Building Regulations stipulate that an external wall has a U- value of 0.45 W/m2 K. This can be achieved in a variety of ways including double glazed opening windows and insulated spandrel panels. Although the initial cost of providing a high performance external wall may be more expensive, it can provide cost benefits over the life span of a building.

The design of the external skin itself can provide high levels of insulation; it is also possible to improve its performance further by providing sun screening on exposed facades and highly glazed areas.

The most vulnerable facades for solar gain in building on sites in Britain are those facing south and west. Facades facing east are less susceptible to solar gain. However, there may be conditions on east-facing glazed facades where glare is the problem.

The design of external screening should take into account the elevation of the sun, which will be high in the sky on the south and require horizontal screens, whilst vertical screens are more appropriate to provide protection from the lower sun angles, which are experienced on the east and the west.

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[2] Width of the skin. Shading. Air flow. Heat transfer. Absorptive and reflective qualities of the glazing and structural members. Orientation. Direction of prevailing winds. Mode of operation.

3. The Case Study:

Many technical and environmental problems have been identified as the result of the use of concrete in high-rise buildings, together with some design faults which will be examined, along with a critique on their impacts on the occupants of the high-rise.

Most of the high-rise blocks in Newtown South Aston in Birmingham were constructed with a reinforced concrete frame and floors and large concrete infill panels. Some were poorly built and defective. Poor workmanship can be attributed to poor quality, or inferior quality materials and construction detailing. For instance, poor insulation, incorrect use of the panels and defective sealant have led to subsequent problems of moisture and water logging.

Other technical problem related to roofs, walls and windows have been identified including the incompatibility of materials in the construction of walls and roofs, condensation, mould growth and leaking roofs. Windows were single glazed in steel frames. These problems have resulted in the present-day need for the refurbishment of the housing stock of the city. However the decision was solely based on two main factors.

Firstly to cater for new users requirement and to improve the performance of the tower block spatially and environmentally to meet the current building regulation requirement. Adaptability of the design layout to accommodate current users requirements and expectations was the main priority and hence different users groups were encouraged to be actively involved and participate in the early discussion, developing and refining internal design brief. Several design ideas about how best to cater for new requirements were explored and alternative layouts were developed accordingly which subsequently assessed leading to best- fit design layout.

3.1. The Roofs:

Most of the roofs of the tower blocks are slabs of pre-cast concrete, usually with an insulating agent bonded to their underside and covered by a waterproof membrane, usually of asphalt.

It has been suggested that the life of any flat roof is limited to around 10-15 years, which determines maintenance cycle. In high-rise building, problems have occurred mainly due to the effects of thermal movement; the slab moves at a different rate to that of the bituminous asphalt covering, therefore encouraging the separation of the slab and its covering allowing the ingress of water, the freezing of which can further split the waterproof membrane. On many of the low-rise maisonette blocks flat roofs have been replaced with traditional tiled pitched roofs, which are considered to be longer lasting; the pitched roofs are more aesthetically pleasing than flat ones and of longer life span.

Whilst the addition of pitched roofs to tower blocks would enable them to become, “primary, city-wide landmarks which can also enhance the area’s legibility and quality of ambience such improvements would create difficulties in the management and maintenance of pitched roofs at such a height. In other words, the pitch would have to be sufficiently high so as to allow the accommodation of lift gear, which is usually placed on the roof of high-rise blocks. On the refurbished units in Newtown, roofs have been left flat. The roof finish was stripped back and new vapour barrier and thermal insulation was added on the top to give a U-value of 0.40 W/m^2 K. This has been re-covered by two layers of bituminous felt finish in a suitably strong, yet malleable waterproof covering.

3.2 External Claddings:
External concrete panels have been identified in literature to be a major source of concern in high-rise buildings (Hinks, 1992; Ransom, 1995). "Currently, Birmingham City Council is carrying out structural tests on 150 tower blocks following the discovery of serious defects in some large panel system building [Martin, 1999]. It is evident from the case study that the large steel reinforced concrete panels making up the outer skin of many tower-blocks are anchored via metal fixings; many of which may have become corroded over the years, or were simply incorrectly used during initial construction procedures. This is together with poor thermal insulation associated with dense concrete.

This has led to cracking which is usually treated by raking out the crack, thus removing loose debris, and infilling with either powder concrete or, in some cases, a polymer sealant in order to prevent the further ingress of water. In some cases, the replacement (re-cladding) of a panel has been undertaken; this can cause difficulty where the panels have been slotted into one another during initial construction and, in the case of the Bison design, the rear of panels has been infilled with cast-in-situ concrete to improve insulation.

An alternative solution has been utilised on the Five Towers where an additional twin-block "skin" has been built up around the tower, with the window frame moved out flush with the new cladding. Not only has this improved the sound and the thermal insulation of the building, but it has also proved to be more aesthetically pleasing once completed. The disadvantage of such a method is that it is expensive and can create dust and debris harmful to residents, most of whom were in residence while such works were carried out. Clearly higher cost of decanting has led to such health and safety hazards and disruption to the daily life activities of the occupants?

When tower blocks undergoing re-cladding; a further disadvantage to such an exercise was demonstrated during an interview with a tenant, who stated that she had "lost all privacy, and had to keep all of the lights on because the windows were covered up, increasing electricity bills. Such temporary inconvenience should be weigh against decanting cost and health and safety of the occupants. Another tenant complained of being burgled as a direct result of the scaffolding erected around his balcony.

3.3 The Windows:
Many of the windows were delivered as an integral part of a wall panel and were made of metal bonded into the concrete panels. The window units themselves created a "cold bridge" (Barry, 1992). Being removed from the panels, to which they were bonded, would have caused irreparable damage. Therefore, the ideal time to replace the windows was when the new cladding was being built around the blocks. The windows in the Five Towers have been replaced by maintenance-free UPVC

double glazed units providing a U-value of 2.9 W/m^2 K and up to 32db sound reduction; the fact that cladding has been added to the tower blocks on top of the original panels has minimised the problems caused by the removal of the original window frames.

All of the previously open balconies have been infilled with double-glazed, sealed windows providing sun space, thus preventing the escape of any heat, reducing the background noise level while further improving the safety and security of the building.

4. Discussion:

Whilst many of these buildings were constructed shown to be short-sighted and short-lived. What was considered to be modern, low-cost and low-tech public sector housing at the time has proved to be deficient highly inadequate to 1990's users expectation and aspirations. No doubt, lack of long- term vision was one of the most contributory aspect to such dilapidations. Cutting cost at the initial design and construction stages has led to significant increase in the long-term cost of replacing faulty components and running cost. This deemed many high-rise energy inefficient. it proved to be costly option and very exasperating to occupiers. To maximize energy cost-effectiveness, thermal insulation together with re-cladding or double skin cladding proved to be beneficial in providing solar gain reduction and reducing heating loss; hence enhancing overall thermal performance which has contributed to occupant's satisfaction and comfort levels.

Element	**Before Refurbishment**	**After Refurbishment**
External Walls	Concrete infill panels 0.90-1.10 W/m^2 K	Twin-block "skin" has been built up around the tower added U-value 0.48-0.60 W/m^2 K
Internal Panels	of pre-cast or cast-in-situ concrete U-value 0.82 W/m^2 K	50 mm rock wool added U-value 0.32 W/m^2 K
Roof	Pre-cast concrete, with an insulating agent bonded to their underside	Thermal insulation added U-value 0.40 W/m^2 K
Windows	Single glazed steel windows U-value 5.4 W/m^2 K	Maintenance-free UPVC double glazed units providing a U-value of 2.9 W/m^2 K and up to 32db sound reduction.

Table 2: Energy Efficiency Improvements

The case study demonstrates that the major problem areas with high-rise buildings are poor quality materials and poor specification of the external envelope which encompasses roofs, walls and windows.

Because incompatible materials were used to construct the roofs, mingled with the poor quality of the concrete used in casting the roof slab and lack of regular planned maintenance, this has resulted in the present-day need to replace roof coverings with materials more suited to the task. The problems affecting the walls were the result of the use of concrete inappropriate for the facing of high-rise buildings together with lack of thermal insulation; the concrete used allowed the ingress of water and condensation. This has led to dampness being experienced internally and the loss of the facing of the concrete sections externally.

The window frames used in nearly all high-rise buildings were made of steel, which itself creates a “cold bridge” resulting in considerable heat loss from the dwelling and encouraged condensation internally, yet the remedies have proved to be a low-energy orientated and long-lasting.

Controlling and optimising the use of energy through effective environmental management must be the priority, and in that, high-rise have a critical role to play in terms of the amount of energy they consume which affect energy cost. This is a collective responsibility which requires a holistic approach by the profession as a whole to increase the overall performance of the housing stock to an acceptable level. The cost of introducing these low-energy design features should be justified on the basis of long-term energy cost saving and reduction of failures, lower maintenance cost and possible increase in property value. However, one should bear in mind that the actual value of any energy- efficiency measure is frequently determined by the perception of different stakeholders, owners, users and the general public at large.

The accumulated evidence over the last two decades has shown that these building are more prone to rapid decay and deterioration which can occur due to condensation and water penetration mingled with poor thermal insulation. Whilst the refurbishment should ensure the use of these buildings for a further thirty years to suite the changing users’ requirements, it is debatable whether this will, in fact, happen. Such improvements however, should create cost-effective, yet a sustainable living environment which, at the very least, perform thermally, socially and aesthetically in tune with their immediate needs and expectations.

5. The Way Forward:

While tower blocks could be considered to be an unsatisfactory method of providing housing, their new fabric should be carefully maintained; a comprehensive planned maintenance programme should be introduced. No doubt, proper maintenance management and work planning will be pivotal to ensure economic and rational use of resources. A number of principles or guidelines can be recommended as follows:

I. Greater reliance on refurbishment based on well thought through design and suitable materials and methods of construction will be a safeguard in extending the physical life of high-rise buildings. This remains to be a viable option by careful consideration of user-friendly materials, optimisation of the current techniques, judicious construction detailing and much greater emphasis on the mix and the composition of the surrounding landscape and infrastructure.

II. Adopting a more holistic whole-life performance approach based on life cost cycle analysis is needed embracing an assessment of components specifications together with durability of materials towards more accurately predicting their life cycle. Anticipation of failures through routine monitoring and inspection will be a safeguard for maximising their life span.

III. Clarity and appropriateness of procedures for prevention and rectifications of defects as and when they occur towards minimizing overall long-term maintenance cost.

IV. Providing adequate resources, which can be proactively deployed including, *inter alia*, cyclical responsive and planned preventive maintenance to reduce the level of physical and functional obsolescence and any subsequent financial depreciation.

V. Encouraging users participation in the design and management of their own asset toward better appreciation which might promote greater awareness via changing general public perception and attitudes towards the high-rise.

After years of neglect and inner city blight, the high-rise can only regain its prominence in the skyline of our cities in Britain, retaining their utility and value and redefining their role as focal points or landmarks, which bring harmony and pride and regenerate inner towns and cities.

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APPENDIX TWO

Pictures of the refurbishment of Briarley continued

58

Evaluation of soiling due to rain trace on the coated layers

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Abstract: The soiling due to rain trace observed on the coated layers is one of the important problems especially for commercial buildings located in urban area and often becomes a complaint because of the degraded appearance. Paint manufacturers have been developing various types of new coating materials to control soiling behavior by modifying their surface properties. Consequently, there are many coating materials on the market which control the soiling due to rain trace.

In order to confirm the effectiveness of these coating materials, outdoor exposure was conducted in this study. To evaluate soiling on the coated layers, visual inspection was conducted by using a developed pictorial designation system. As a result, the newly developed coating materials generally showed better performance in the outdoor exposure test.

Keywords: Coated layer, Outdoor exposure, Paint, Soiling, Rain trace

Introduction

Surface appearance of as a whole building or a part of it should be one of the aesthetic requirement for the building as defined in ISO standard (ISO 6241:1984) as one of the “visual user requirement” which composed of several sub-factors as such color, texture, regularity, flatness etc, and it has been one of the long-time major issue how to sustain the surface appearance in an acceptable condition, even though the acceptable level depend fully upon each building.

The typical cause of degrading the appearance would be deterioration of surface material and surface soiling mainly due to chemical, biological agents as specified in ISO standard (ISO 15686-1:2000), air contaminants including dust that act or adhered on the surface.

As to the soiling of external envelope, it can be divided into the uniform and the local one, which stand for uniformly soiling and partial or dotted soiling within a certain area of a plane of building or a component. In general, the latter one is much noticeable than the former one. For example, Motohashi & Sakai (1993) pointed out the dotted soiling behavior on the fluoropolymer paints as one of the important deterioration phenomena.

Much attention has been paid to cope with this contamination in buildings. Various countermeasures to avoid soiling had been tried both from design aspect such as shape, dimension, details of external component and from material modification aspect by changing water repellent property, hydrophilic property, electrostatic property, solubility property etc.

In this background, paint manufacturers have been developing various types of new exterior coating materials to control soiling behavior. Consequently, there are many coating materials on the market which control the striped soiling due to rain trace. In this study, the outdoor exposure test was conducted to confirm the effectiveness of these newly developed coating materials.

Experiment

Specimen

The coating materials listed in Table 1 were evaluated. They can be classified into an organic solvent type and a water based type. For comparison, not only the soiling controlling paints but also the ordinal paints were tested. The dimension and some details of the specimens are shown in Figure 1. Bent aluminum sheets (1mm thickness) were used as substrate of specimens. Each paint in Table 1 was coated on the substrate with the rate of 300g/m^2. The color of all the paints in Table 1 was white.

Organic solvent type/ Water based type	Type of base polymer	Number of tested products	
		Ordinal	Soiling controlling
Organic solvent type	Fluoropolymer	10	10
Organic solvent type	Acrylic-Silicon	7	6
Organic solvent type	Polyurethane	6	5
Organic solvent type	Acrylic	0	1
Water based type	Acrylic-Silicon	4	7
Water based type	Polyurethane	3	3
Water based type	Acrylic	7	4
Water based type	Acrylic with HALS	2	2
Water based type	Others	2	3

Table 1 The tested coating materials

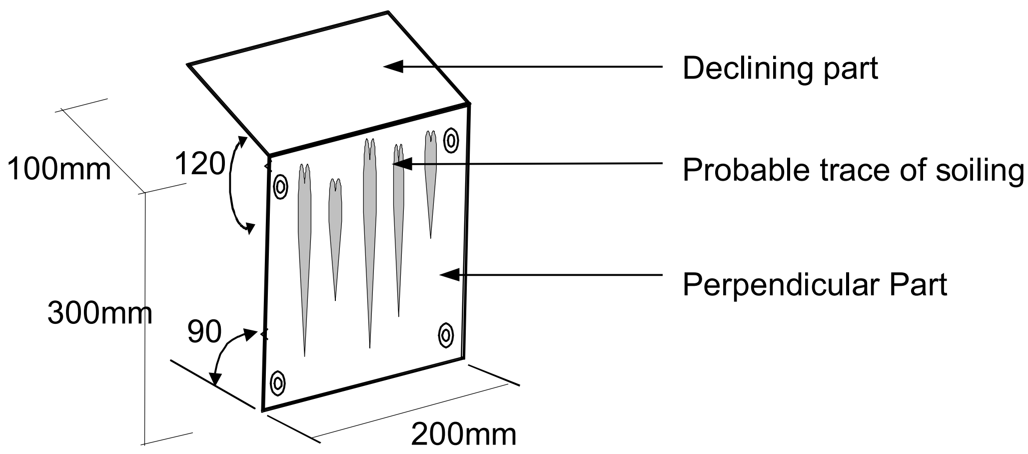


Figure 1. Detail of the specimen

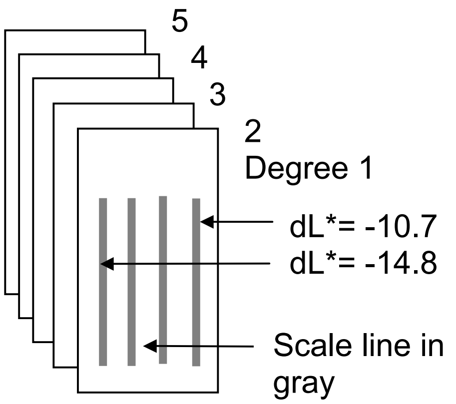
Outdoor exposure

Outdoor exposure of the specimens was performed in outdoor exposure site of Building Research Institute (Tsukuba-City, Japan). The specimens facing south were exposed up to 17 months.

Visual evaluation of soiling

Visual evaluation was conducted by using the pictorial designation system. In this study, the pictorial designation of state of soiling for coating systems has been provided with intention to include evaluation of striped soiling mainly as a result of rain water flowing on the coated layers.

Striped soiling state was classified into five degrees from none to excessive on the basis of previous on-site investigation data on the soiling of coating systems. Each degree can be divided into five sub-degrees in the order of soiling state within each degree and this can be printed on a sheet as shown in Figure 1, then, actual evaluation of soiling can be carried out by applying these five designation sheets. The actual evaluation work was operated by 4 to 5 members with taking the pictorial designation sheets at around two meter apart from each specimen. Figure 2 shows a exposed specimen and one of pictorial designation sheets.



Degree	[dL*] value
Degree 1	-14.8 ~ -10.7
Degree 2	-5.6 ~ -3.1
Degree 3	-2.5 ~ -1.8
Degree 4	-0.8 ~ -0.3
Degree 5	None

Note [dL*]: Value measured by MINOLTA CR300
White base sheet [L*] = 92.0

Figure 1. Pictorial designation of soiling states of surface coating system for visual evaluation

Measurement of value [dL*]

Evaluation in this study was focused on behavior of soiling over time by the visual evaluation and the measured [dL*] parameters. Soiled state can be defined as a difference of value between the initial value and a measured value at certain time.

The value [dL*] was measured by using two different color meters as MINOLTA CR300 (10.0mm• scope) and MINOLTA CR321 (3.0mm• scope), the former one is for relatively uniformly soiled area (Declining Part and Perpendicular part with & without rain trace in Table 2) and the latter one is for smaller spotted area (Perpendicular part with rain trace only and Perpendicular part without rain trace in

Table 2). In principle, the value [dL*] is an average out of three points within a plane of specimen. The [dL*] parameters in each part of specimen were defined according to Table 2.

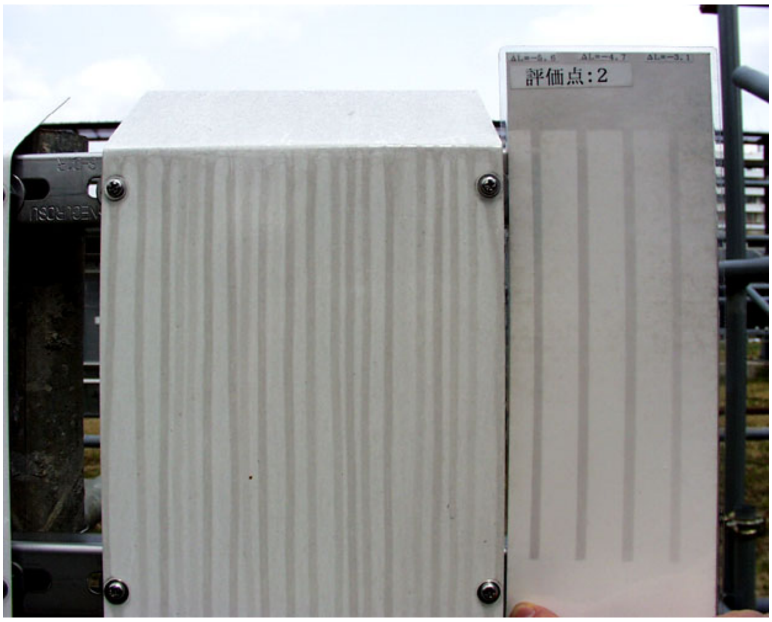


Figure 2. An exposed specimen and one of the pictorial designation sheets

Part of specimen	Soiling parameter
Declining part	Value [dL*] in an average of whole area vs. initial value
Perpendicular part with & without rain trace	Difference between [dL*(With & without rain trace)] with & without trace in an average of each area vs. initial value
Perpendicular part with rain trace only	Value [dL* (rain trace only)]in an average of the traced area vs. initial value
Perpendicular part without rain trace	Value [dL*] in an average of without trace area vs. initial value

Table 2. Soiling parameters in each part of specimen

Results and Discussion

Correlation between visual and [dL*] value evaluation

Taking the result as shown in Figure 3 as an example, the coefficient of correlation between visual and [dL*(perpendicular part with rain trace only)] value evaluation shows a high value after 11 months' exposure; however, such high correlation can not be expected at the beginning of the exposure test as shown in Figure 4. The main reason of the low coefficient of correlation at the beginning could be due to the difference of soiling mode on the surface of coated layers, that is, noticeable rain trace could not be recognized at the early stage of the exposure test.

As it is not shown in the paper, the same tendency was recognized for all the types of parameters in Table 2. As far as the rain trace of the specimens are clear, there is good correlation between visual evaluation by use of designated pictorial sheets and each [dL*] parameter. Moreover, it seems that the value [dL* (perpendicular part with rain trace only)] shows the best correlation among the value [dL*] parameters after 6 months of outdoor exposure as shown in Figure 4.

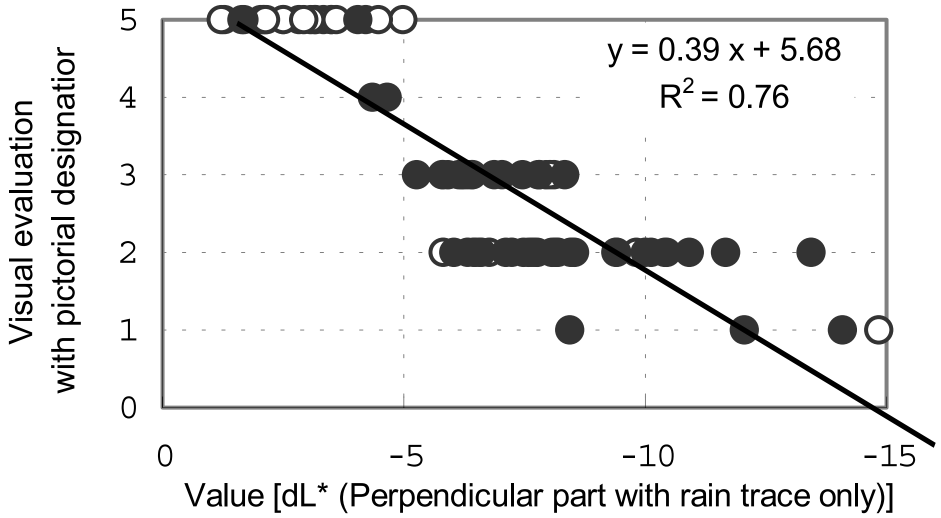


Figure 3. Correlation between visual evaluation and value [dL(rain trace only)], measured in "Perpendicular part with rain trace only" as in Table 2, after 11 months (Blank circle :Soiling controlling type; Filled circle :Ordinal type)*

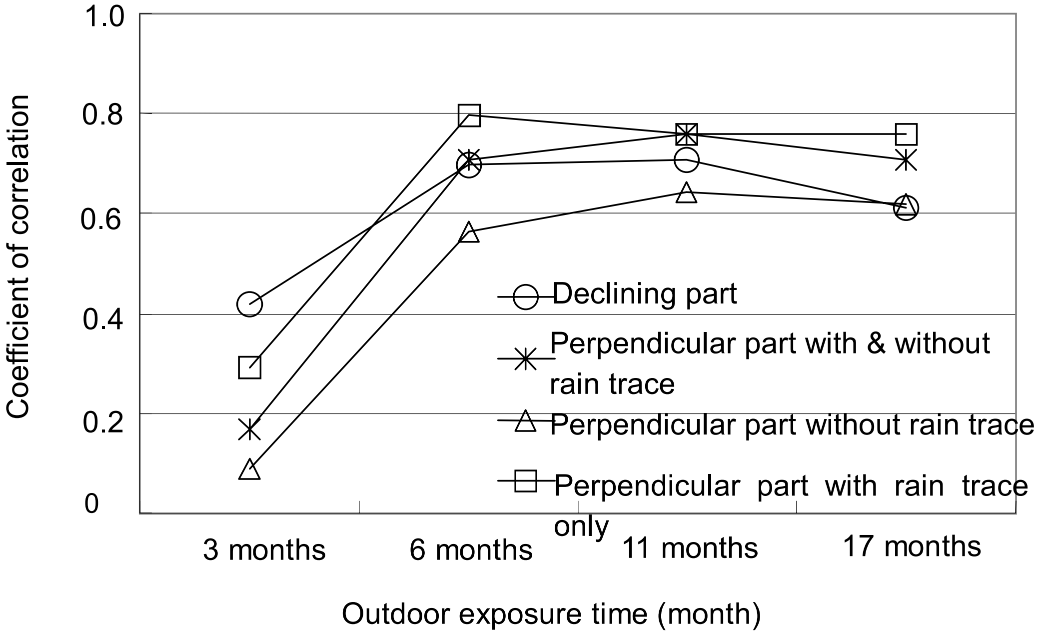


Figure 4. Change of correlation between visual evaluation and various value [dL] parameters (Each symbol correlates to soiling in Table 2)*

Effectiveness of soiling controlling paints

Taking results on the effect of the soiling controlling type of coating materials as shown in Table 3. Effectiveness of the soiling controlling type against the ordinal type could be remarkable recognized throughout all types of coating materials. When the ordinal type of coating materials and the soiling controlling type of coating materials are compared in Table 3, it is evident that the soiling controlling coating materials showed better results of visual evaluation. It can be also pointed out that the organic solvent type of coating materials showed better results of visual evaluation comparing with the water based coating materials.

Water based coating materials are more demanded from the viewpoint of the environmental safety, therefore, more soiling controlling performance is expected to the water based coating materials. Such development is intensively being conducted in many manufacturers.

Types of coating materials	Results of visual evaluation (Degree)				
	5	**4**	**3**	**2**	**1**
Organic solvent type, Ordinal	2	2	11	7	1
Organic solvent type, Soiling controlling	18	0	0	4	0
Water based type, Ordinal	0	0	4	12	2
Water based type, Soiling controlling	4	0	5	9	1
Total	24	2	20	32	4

Table 3. Results on visual evaluation after 11 months' exposure and the number of the specimens in each degree

Conclusion

Soiling of external envelope is one of important problems for aesthetic performance of buildings. To avoid soiling on the coated layers, paint manufacturers have been developing a soiling controlling type of coating materials.

In this study, outdoor exposure was carried out to evaluate actual performance of the soiling controlling type of coating materials. Evaluation of the soiling was performed by visual evaluation with pictorial designated sheets and by the [dL*] parameters of each part of the specimen obtained by optical measurement.

The results obtained are summarized as follows;

1) The effect of the soiling controlling type could be clearly recognized in the outdoor exposure test. In comparison between the organic solvent type and the water based type, the latter showed inferior results. Soiling controlling performance of water based coating materials needs to be more improved in future.

2) There is high correlation between the visual evaluation of the soiling by using designated sheets and the [dL*] parameters obtained by optical measurement.

Acknowledgements

A part of this paper refers to the joint research activity between Building Research Institute and “Evaluation of soiling controlling performance” committee organized in the Japan Masonry Coating Materials Manufacturers Association. Authors are grateful to the members of the committee.

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A new renewal method for external walls using plastic film

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Abstract: *Various metallic materials are used for the exterior finishings of buildings in Japan, with aluminum alloy being the most common. Over time, these surface finishings deteriorate and/or the metallic materials corrode according to each building's unique circumstances.*

A new renewal method for the deteriorated metallic external walls of existing buildings has been developed. The method involves an overlaying of thin plastic film which acts as a superior weather resistant surface material. This same plastic film has long been used in the finishing of outdoor billboards, and it is recognized for its superior durability.

In this paper, an outline of subjects, characteristics, materials and the application method of the new renewal system are mentioned. Experimental evaluation results of the method and real construction results are also described.

Keywords: Film adhesion, Metallic external walls, Plastic film overlaying, Renewal method

Introduction

Various metallic materials are used for the exterior finishings of buildings in Japan, with aluminum alloy being the most common. Over time, these surface finishings deteriorate and/or the metallic materials corrode according to each building's unique circumstances.

We have conducted research on renewal methods for deteriorated external walls in the past. These findings have been presented at the CIB W70 International Symposium and at other international conferences on the durability of building materials and components. However, the objective of our previous research has only been deteriorated mortar plastering and ceramic tiling.

This new renewal method has been developed for the deteriorated metallic external walls of existing buildings. The method involves an overlaying of thin plastic which acts as a superior weather-resistant surface material. This same plastic film has long been used in the finishing of outdoor billboards, and it is recognized for its superior durability.

In this paper, an outline of subjects, characteristics, materials and the application method of the new renewal system are mentioned. Experimental evaluation results of the method and real construction results are also described.

Outline of the Method

Application Procedures

The procedures for the application of the newly developed renewal method for deteriorated existing metallic external walls are shown in Figure1.

START
↓
Investigation of existing finishing conditions
↓
Surface cleaning with alcohol or neutral detergent
↓
Repair of surface damage (Mainly coating)
↓
Overlaying of plastic film
↓
Cleaning the film surface
↓
END

Figure1. Standard application procedure of the newly developed renewal method

Characteristics of the Method

Characteristics of the newly developed renewal method using plastic film are as follows.

(1) The method can make a new finishing surface by merely overlaying film onto existing metallic external walls.
(2) The method is unnecessary to remove the existing deteriorated metallic materials.
(3) The method is unnecessary to cure the renewal materials. It releases no solvent.
(4) The method can reduce the waste volume which occurs during application, and it shortens the construction term.

Materials for the Method

The thin plastic film laminated a superior weather resistant fluorocarbon layer onto the surface is used in this method. The film has press-on adhesive that is protected by a backing sheet. The backing strippable sheet is easily removed when the film is applied.
A cross section of the plastic film is shown in Figure 2.

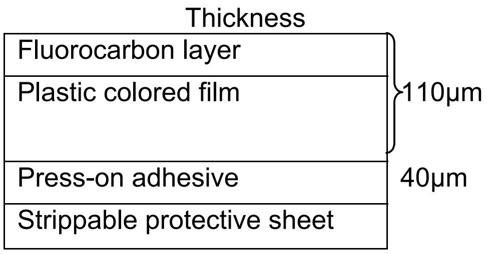


Figure2. A cross section of the film used for the renewal method

Evaluation of the Renewal Method

Some evaluations of the method were performed to approximate its use on an actual building.

Substrates for experiments

Aluminum alloy is the primary material used for the metallic exterior of buildings.
It was assumed the existing aluminum exterior was either sheet A1100P, as defined by JIS H 4000, or extrudes A6063S, as defined by JIS H 4100. These substrate surfaces were treated as shown in Table 1.

Specimen	Substrate	Surface treatment	Thickness
A	A110P	Anodic oxidation	9microns
B		Electrolytic coloring (Silver-color)	9microns
C		Electrolytic coloring (Amber-color)	9microns
D		Chemical conversion + Acrylic baked enamel	40microns
E	A6063S	Anodic oxidation	9microns
F		Electrolytic coloring (Amber-color)	9microns
G		Anodic oxidation + Polyurethane clear coating	9+7microns
H		Chemical conversion + Acrylic baked enamel	40microns

Table1. Specimens for experiments

Accelerated weathering tests

Specimens that had been covered with the thin plastic film onto the substrate surface were tested by a Sunshine carbon-arc weathering tester and by a Xenon lump weathering tester. Gloss retention and color differences were measured in each test term.

Results of these tests are shown in Figures 3 to 6.

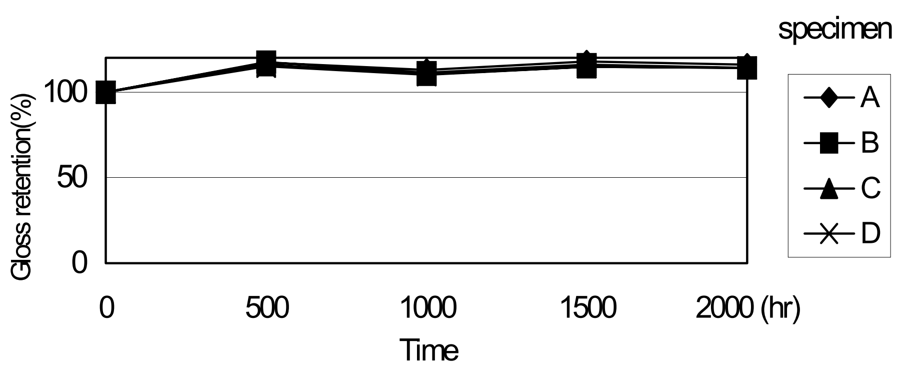


Figure3. Gloss retention change in Sunshine carbon-arc weathering tests

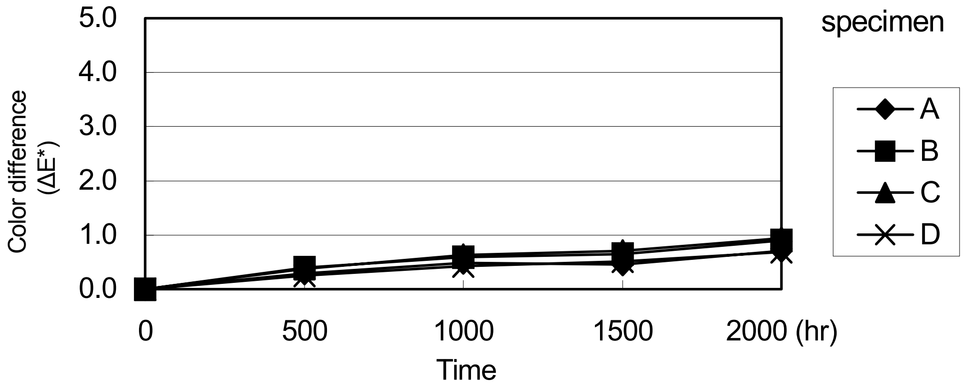


Figure 4. Color difference change in Sunshine carbon-arc weathering tests

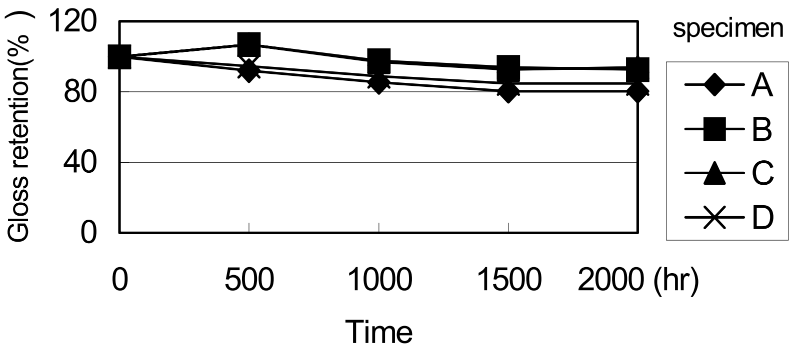


Figure 5. Gloss retention change in Xenon lump weathering tests

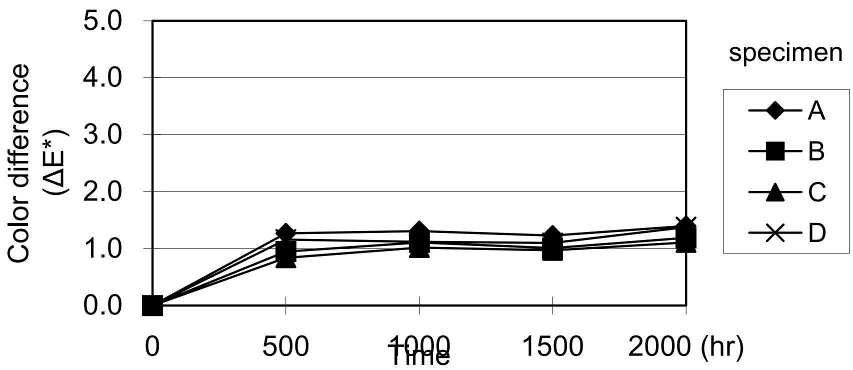


Figure 6. Color difference change in Xenon lump weathering tests

Heat resistance and hot water resistance tests

Specimens that had been covered with the film were subjected to the following conditions:

1. 60 degrees Celsius
2. 80 degrees Celsius
3. Hot water of 40 degrees Celsius
4. Alternating hot and cold conditions ranging between -30 and 80 degrees Celsius

Results of these tests are shown in Figures 7 and 8.

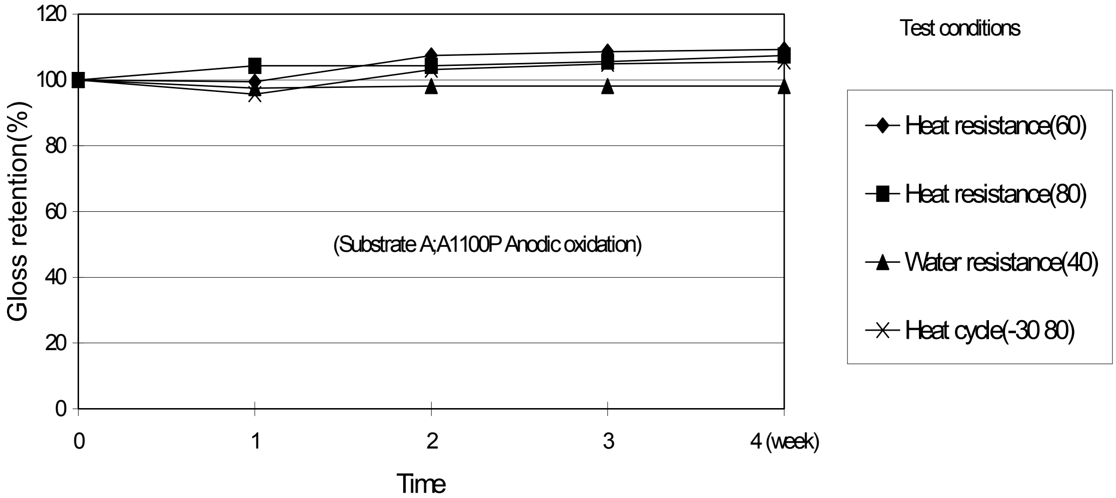


Figure 7. Gloss retention change in heat resistance tests

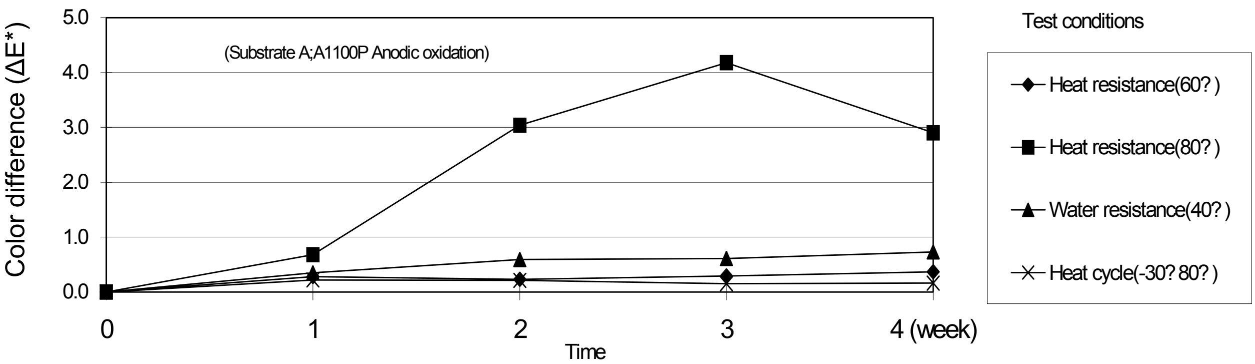


Figure 8. Color difference change in heat resistance tests

Adhesion tests

Specimens that had been covered with a 25mm width film were subjected to the following conditions:

1. 48 hours in 20 degrees Celsius (Initial)
2. 60 degrees Celsius
3. 80 degrees Celsius
4. Hot water of 40 degrees Celsius
5. Boiling water
6. Alternating hot and cold conditions ranging between –30 and 80 degrees Celsius
7. 2000-hour Sunshine carbon-arc weathering test

After being subjected to each of these conditions, the film was peeled off the substrate in a 180-degree direction and at a peeling speed of 300mm/min. The strength observed was determined to be the adhesion strength of the film.

Results of these tests are shown in Figures 9 to 15.

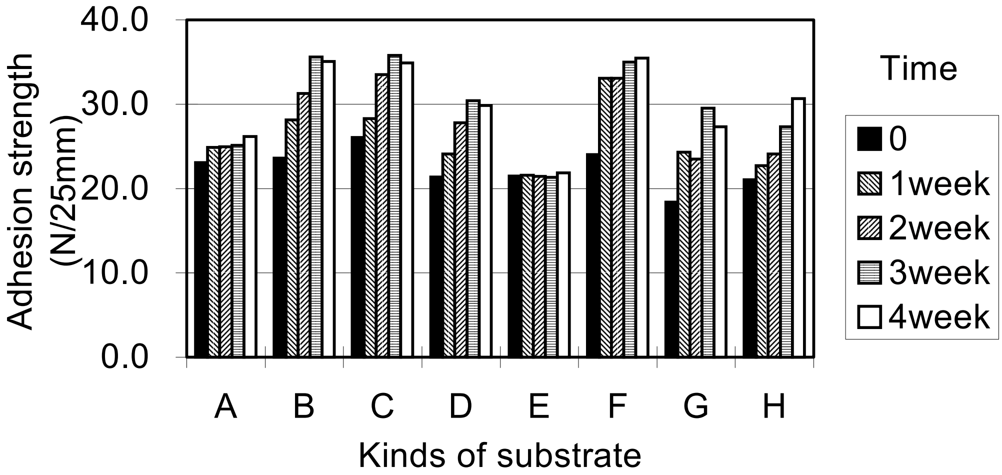


Figure9. Adhesion strength after 60 degrees Celsius heat tests

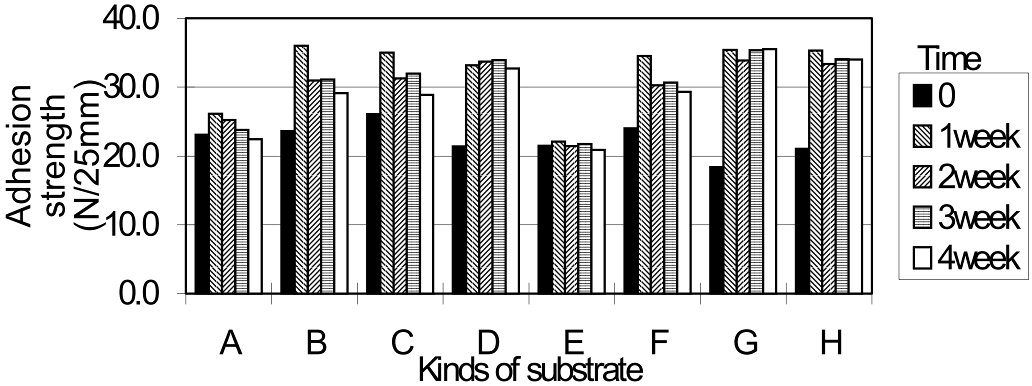


Figure10. Adhesion strength after 80 degrees Celsius heat tests

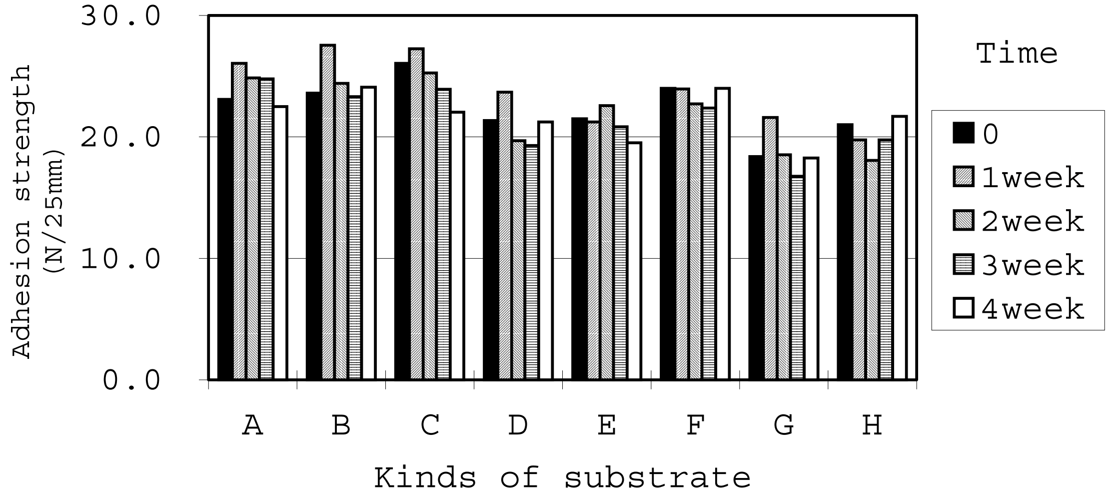


Figure 11. Adhesion strength after 40 degrees Celsius hot water dipping tests

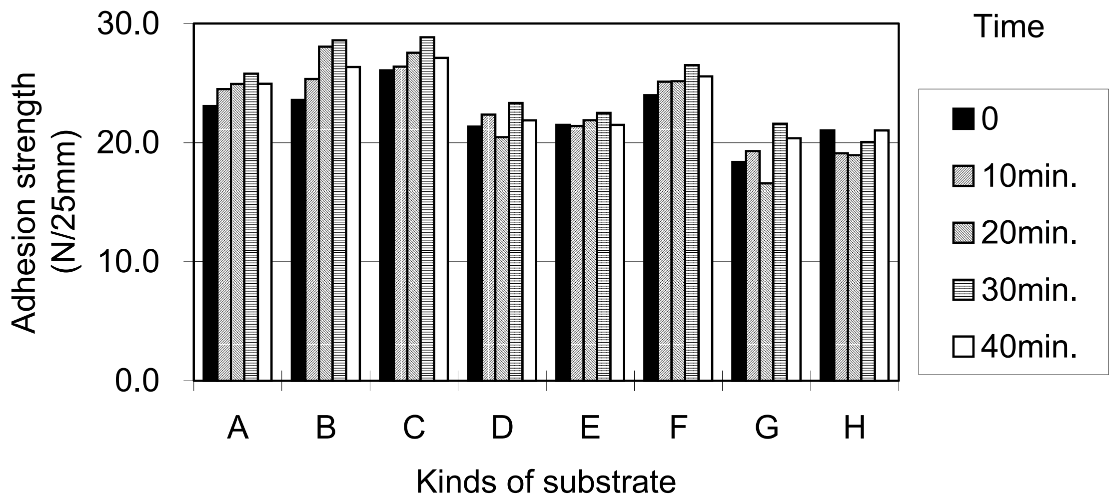


Figure 12. Adhesion strength after boiling water dipping tests

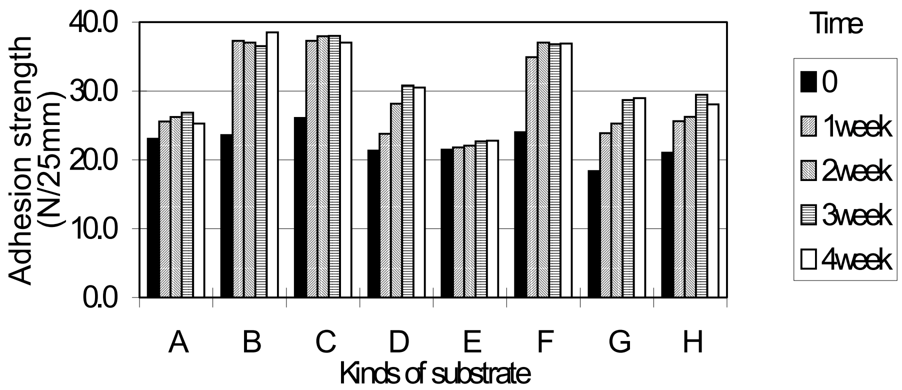


Figure 13. Adhesion strength after alternating hot/cold tests

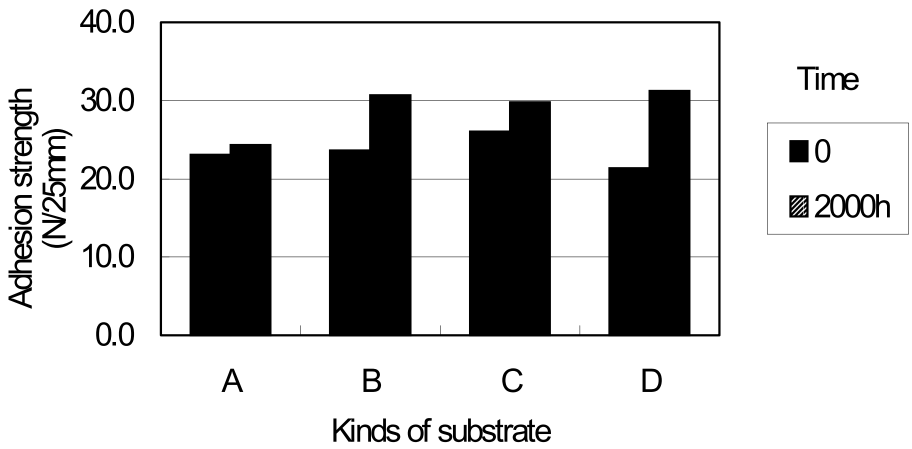


Figure 14. Adhesion strength after 2000-hour Sunshine carbon-arc weathering tests

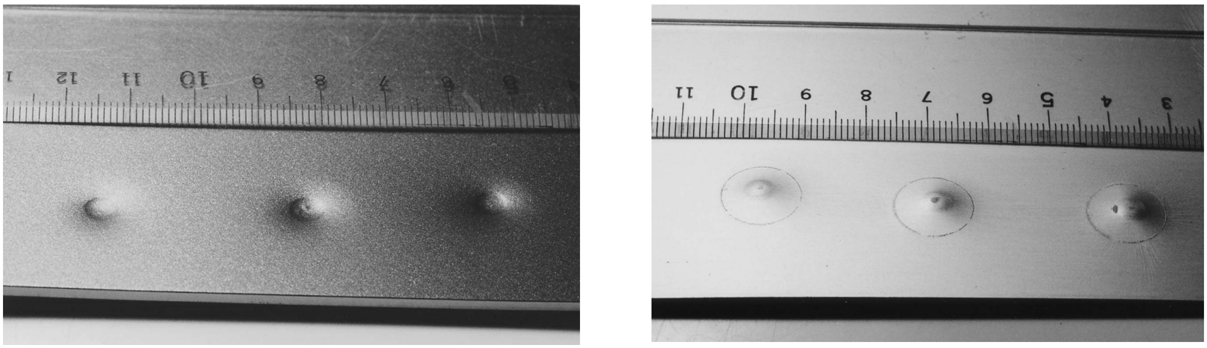
Impact resistance tests

The impact resistance of the specimen covered with film was tested using a Du-Pont type impact tester with a 500g weight and a height of 50cm.

Results of these tests are shown in Table 2 and Picture 1.

Temp	0 degree	10 degrees	20 degrees
A	No crack on film	No crack on film	No crack on film
B	No crack on film	No crack on film	No crack on film
C	No crack on film	No crack on film	No crack on film
D	No crack on film	No crack on film	No crack on film

Table 2. The result of Du-Pont type impact tests



Surface *Back face*

Picture 1. Appearance after impact tests

Considerations

Weather Resistance

It was found that a difference of substrate had no effect on the weather resistance of the specimen in either the Sunshine carbon-arc type weathering test or the Xenon lump type test. These tests showed that within 2000 hours, the film had superior weather resistance.

Resistance to Heat and Water

Only after the 80 degrees Celsius-heat-test was there an observed color change in the appearance of the specimen.
There was no color change noted after the alternating hot/cold test between -30 and 80 degrees Celsius.
Therefore, it was judged that a singular phenomenon occurred in the case of the continuous heating.

Adhesion Strength

In this paper, peeling strength in a 180-degree direction was determined to be the adhesion strength. The peeling strengths from the substrates after the heat tests were higher than the initial states. The maximum strength was reached after the 80 degrees Celsius-heat-test in 1 week. Therefore, the film had a lower observed adhesion strength following the heating tests using lower temperatures such as 60 degrees Celsius.

This fluctuation in the adhesion strength was not observed in the water dipping-tests. Surprisingly, the adhesion strength after the 60 degrees Celsius-heat-test of specimen B, C, F (Electrolytic coloring) was high, and all of the specimen had good adhesion in every condition. A difference of substrate had no effect on their adhesion strength.

Therefore, it was judged that the material is effective for practical use.

A vertical pull-off test for the evaluation of adhesion strength is widely used in the Japanese construction industry.

It was determined that the following relation exists between peeling and adhesion strength based on the pull-off test for the specimen with the peeling strength of 23N/25mm.

Peeling strength 23N/25mm = Adhesion strength 0.75N/mm^2

Therefore, it was judged that the method had enough resistance to withstand wind load on the building walls.

Impact Resistance

Even after limited impact damage to the substrate, the film did not peel or tear.
Therefore, we believe the method has sufficient impact resistance.

Real Construction

It was judged that the method could be applied for real renewal construction based on the above evaluations.

Application to a Baked Enamel Aluminum Exterior

The method was used to treat a building with an exterior of baked acrylic enamel coating on aluminum sheets. The building was a 9-year-old structure located in Setagaya Tokyo. The construction work is shown in Picture2.

The construction work was successful, and it was completed ahead of schedule.

Picture2. The renewal construction work on a temporary scaffolding

Application to an Anodized Aluminum Exterior

The method was used to treat a building with an exterior of anodized aluminum sheets. The building was a 30-year-old structure located in Urazoe Okinawa. The existing exterior surface was remarkably deteriorated. The completion state is shown in Picture3.

The surface treatment for the existing exterior material was painstakingly applied in this case. Therefore, the renewal construction work was successful.

Picture3. The exterior after the renewal construction work

Conclusion

A new renewal method using thin plastic film has been developed for treating buildings with metallic exteriors.

The evaluation results in this paper showed enough adhesion and weather resistance to justify its application to building exteriors, especially aluminum alloy.

In the near future, we anticipate discussions on enlarging the application of this method and on developing maintenance methods to keep the plastic film in good condition long after the renewal construction.

Acknowledgements

This study was conducted by a research committee of the Sumitomo 3M Corporation. Members of the Japan Building Renewal Association and employees of Design Spot Wings Inc. worked together to construct the actual renewal examples.
The authors would like to express their heartfelt thanks to all of the research participants.

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Evaluation of Building Sealant by Using Artificial Accelerated Test Apparatuses

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Abstract
In this research, the durability of the sealant was evaluated through two accelerated weathering testers with different light sources. One is an accelerated weathering tester using a sunshine carbon arc light which is popular in the Japanese Industrial Standard. The other is an accelerated weathering tester using a xenon lamp which is popular in Europe and North America and has been adopted in the Japanese Industrial Standard recently.

The purpose of the research includes the comparison of two types of the accelerated weathering testers and the comparison of sealants. The tested sealant samples were 12 in total including polyurethane system, modified silicone system and polysulfide system. The evaluation was performed after the irradiation of 500, 1000, and 3000 hours, respectively. Measurement of 1) color difference, 2) crack and chalking, 3) dynamic viscoelasticity and 4) tension test were performed in the study.

As the results of the tests, the difference due to two types of accelerated weathering testers was hardly recognized. No change was recognized in the measurement of the dynamic viscoelasticity between the samples before exposure and the samples after exposure. The results obtained showed that types such as polyurethane system, modified silicone system and polysulfide system could not classify the weatherability of the sealant, and that difference in weatherability among the commercial products was sometimes remarkable even in the same type of sealant.

Keywords: Accelerated test, Correlation, Sealant, Sunshine carbon arc, Xenon lamp

Introduction

Sealant for buildings is filled in the joints to be generated between members for obtaining water-tightness and air-tightness. The sealant is considered to be deteriorated gradually by the influence of various factors such as light, water, heat, gas when it is exposed in the atmosphere (Japan Sealant Industry Association 1993).

The deterioration rate of sealant varies due to conditions such as place, direction, shelter, and the painting on the surface; however, a type and quality of the sealant itself can be the one of the important factors among them.

It has been pointed out that the average service life of the houses in Japan is much shorter than that in the United States of America and Europe. However, as the “Housing Quality Assurance Law” has been enforced since 2000 (Motohashi and Nireki 2002), the houses aiming at the longer service life have been supplying through the house manufacturing companies in Japan. The ten years liability was introduced as a part of “Housing Quality Assurance Law.” Under this law, ten years of water tightness liability is compulsory for all the dwellings which was constructed after April, 2000.

From the abovementioned viewpoint, the proper applying process of the sealant and periodic inspection are necessary to keep its waterproof performance for a long duration. In addition, the improvement of durability for the sealant is essentially required. For this reason, the sealant of high weather resistant type is being intensively developed in each sealant manufacturer.

There are an outdoor exposure test and an accelerated weathering test to investigate the weather resistance of the sealant. The outdoor exposure test enables to know their service lives with high reliability. However, it takes extremely long time, from several years to tens of years to complete the outdoor exposure test. The accelerated weathering test is performed to solve such problems. The accelerated weathering test enables to evaluate the quality of the sealant quickly. In addition, the service lives could be predicted by studying the correlations with the results of the outdoor exposure test.

In this research, the two types of acceleration tests were carried out. One is the sunshine weathering meter (SWOM) using the sunshine arc. The other is the xenon lamp type of weathering meter (XWOM).

Accelerated Weathering Test Method

Table 1 shows the 12 samples of sealant used in the accelerated weathering test. The 12 samples consist of 1-component type polyurethane sealant, 2-component type polyurethane sealant, 1- component type modified silicone sealant, 2-component type modified silicone sealant, and 2-component type polysulfide sealant.

The curing condition for sealant was at 23 Celsius degrees, 50%RH for 14 days and at 30 Celsius degrees for 14 days for 1-component type and at 23 Celsius degrees, 50%RH for 7 days and at 50 Celsius degrees for 7 days for 2-componet type.

Figure 1 shows appearance of the sheet specimens of the sealant. The sealant was casted on the Teflon tape to be a sheet of 70mm wide × 150mm long × 2mm thick. The sheet was mounted on the fiber reinforced cement sheet as shown in Figure 1.

Table 2 shows the accelerated weathering tester and the test conditions. Both SWOM and XWOM were used in the acceleration test. The both testing machines were manufactured by SUGA Tester Co., Ltd. As to features of light source, SWOM has larger energy in ultraviolet region than the sunlight, and XWOM has the spectral distribution which is similar to the that of the sunlight.

The test condition was based on the Japanese Industrial Standard JIS A 1415 (The exposure test method of polymeric building materials by use of laboratory light source).

The specimens were evaluated after 500, 1000 and 3000 hours' of irradiation. The irradiation energy was determined by the following methods. In case of the SWOM tester, irradiation energy in 300–400 nm ultraviolet region was estimated based on the energy ratio of the sunshine carbon arc light which was reported by the manufacturer. Regarding XWOM, irradiation energy in the ultraviolet region was directly obtained from the tester.

Sample	Composition	Curing system
PU1	1- component polyurethane	Moisture curing (Alicyclic non-yellowing isocyanate)
PU2		Moisture curing (Aromatic hard-yellowing isocyanate)
PU3		Moisture curing (Aromatic isocyanate)
PU4		
PU5	2- component polyurethane	Reactive curing (Aromatic isocyanate)
PU6		
MS1	1- component modified silicone	Moisture curing (Dimethoxysilyl group)
MS2		
MS3	2- component modified silicone	Reactive curing (Dimethoxysilyl group)
MS4		
PS1	2- component polysulfide	Reactive curing (Mercaptan group)
PS2		

Table 1 Type of the evaluated sealant (12 samples)

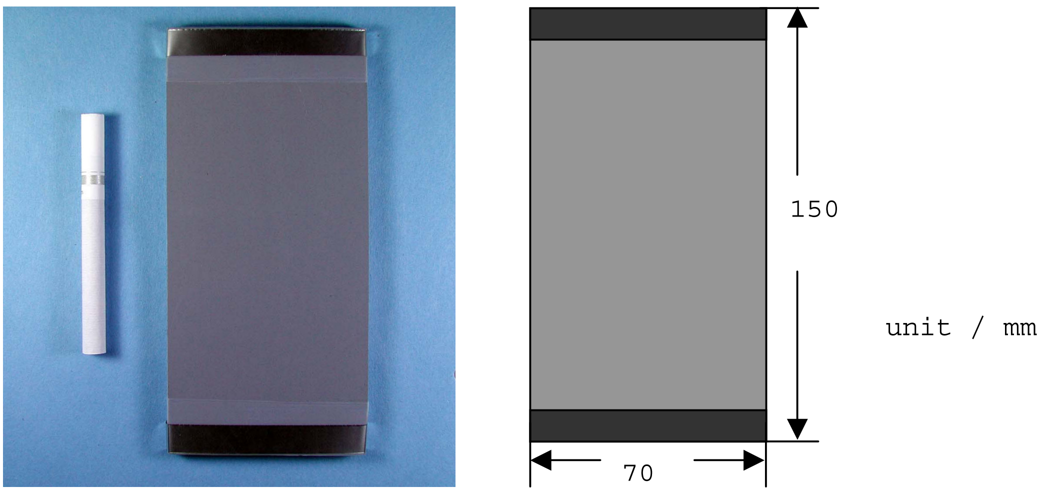

Figure 1 The specimen for the acceleration test

Tester	SWOM	XWOM
Types	WEL-SUN-DCH	X75
Manufacturer	SUGA Test Instruments Co.,Ltd.	
Light sources	sunshine carbon arc light	xenon lamp
Irradiance (Wavelength)	76W/m^2 (300-400nm)	60W/m^2 (300-400nm)
Irradiation method	Continuous irradiation	
Black panel temperature	63 Celsius degrees	
Relative humidity	50%	
Spraying time	18 minutes out of 120 minutes	
Irradiating time	500, 1000 and 3000 hours	

Table 2 Accelerated weathering testers and the testing conditions

Sealant Evaluation Method After The Acceleration Test

The following evaluation for the sealant was performed after the acceleration test.

Color difference of the specimens was obtained by measuring L*, a*, and b* values before and after the exposure. Crack and chalking were inspected visually.

Dynamic viscoelasticity was measured by using Rheovibron DDV-3 manufactured by A & D Co., Ltd. The measuring frequency was 110Hz, and the temperature range was from -100 Celsius degrees to 0 Celsius degrees with a temperature rising speed of 2 Celsius degrees•min.

The Tensile test of the dumbbell shaped specimens standardized JIS K 6251 was carried out. The tensile speed was 500mm•min.

Test Results and Considerations

Color Difference

Figure 2 shows the comparison of color difference at the same length of irradiation time for SWOM and XWOM. The positive correlation was recognized, but SWOM showed the larger influence than XWOM for some of the samples.

Figure 3 shows the relationship between the SWOM irradiation time and the values of color difference. The change in color difference after 500 hours' irradiation was larger in 2-component type polyurethane (PU5, PU6), 2-component type polysulfide (PS1, PS2) and PU3. In some specimens, color difference values at 1000 hours' irradiation were smaller than the values at 500 hours' irradiation. It is considered the this is due to the remarkable chalking of the sealant or fluctuated discoloration of the surface.

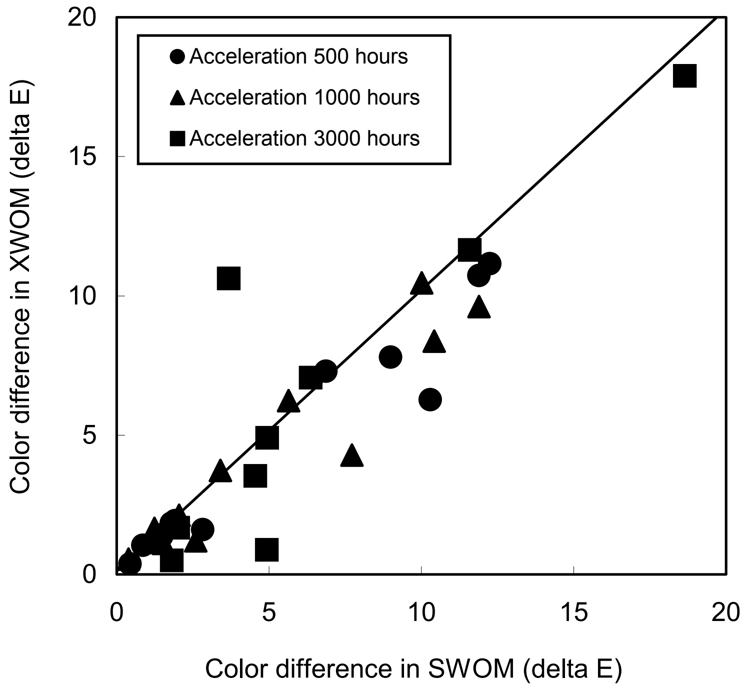

Figure 2 Comparison of the color difference in SWOM and XWOM

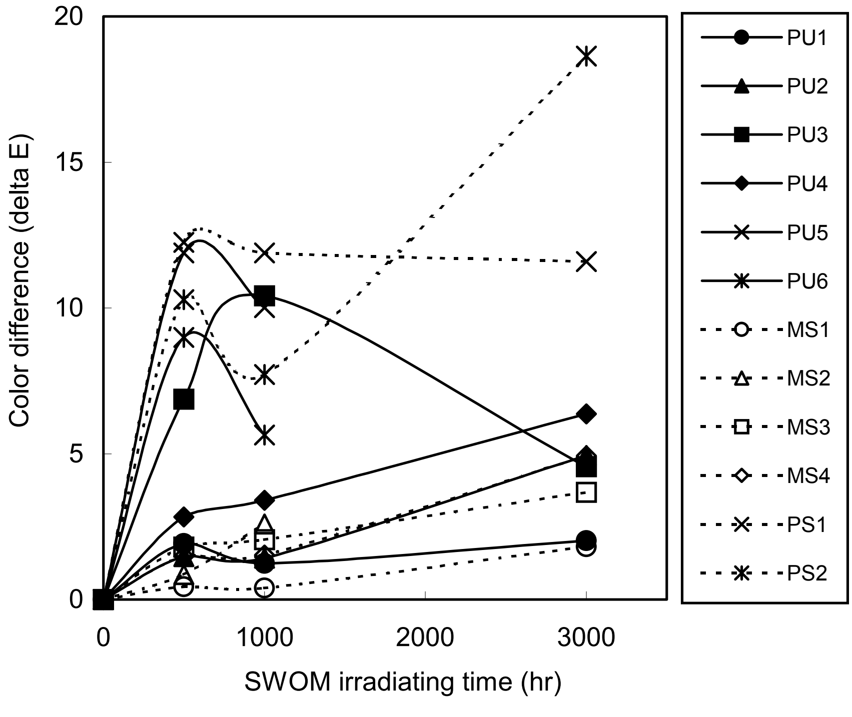

Figure 3 SWOM irradiation time and the change in color difference

Crack and Chalking

Figure 4 shows the photographs of the surface after 1000 hours' of XWOM irradiation. Though it was not shown, it was confirmed that the crack and chalking generated in SWOM were as same as in XWOM. Both crack and chalking were not recognized in the 4 samples, namely, PU1, PU2, MS1, and MS2. The crack or chalking was observed in the other 8 samples.

Figure 5 shows the photographs of the surface after 3000 hours' of XWOM irradiation. At this point, the specimens were deteriorated considerably and the missing of the sealant sheet was observed in some samples. However, it was confirmed that the crack was not generated in 2 samples, namely, PU1 and PS2 even after the irradiation of 3000 hours.

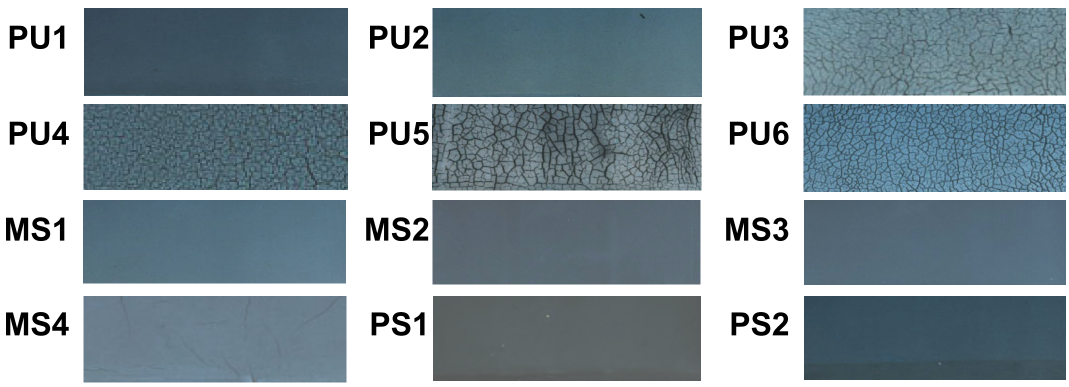

Figure 4 Photograph of the surface after 1000 hours of XWOM

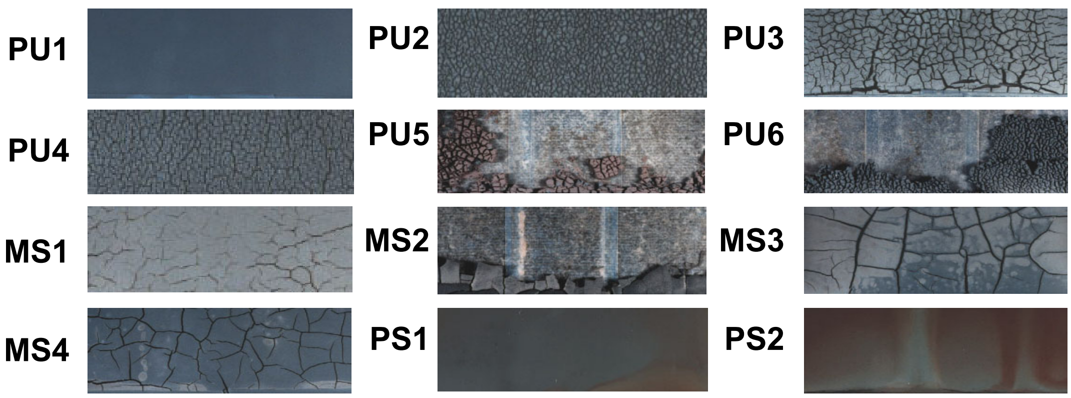

Figure 5 Photograph of the surface after 3000 hours of XWOM

The following can be pointed out from the results of color difference, crack and chalking.

1) The polyurethane system had large difference even in the same type and the durability of PU1 was excellent.
2) The change in color difference of the modified silicone system was small in general, but the crack was observed in all test pieces after 3000 hours' irradiation.
3) The change in color difference of the polysulfide system was large, and the remarkable discoloration was observed even in visual inspection.

Dynamic Viscoelasticity

Figure 6 shows the comparison of loss tangent (tan delta) peak temperature between before and after the acceleration test. The change in the tan delta peak temperature after 500 hours' of XWOM irradiation and after 1000 hours' of SWOM irradiation was hardly recognized comparing with the temperature before the acceleration test. Accordingly, the glass transition temperature of the sealant was hardly changed. For comparison, the same measurement was performed for the PU1 specimen after soaking in the n-hexane and extraction of the soluble part. In this case, the tan delta peak temperature moved to 6 Celsius degrees higher. However, all the specimens after the acceleration test did not show such movement of tan delta peak temperature in both the SWOM test and the XWOM test. That is, even the sealant test piece (2mm thick) which showed visual deterioration such as discoloration or crack or chalking on the surface had no significant change to be recognized in tan delta peak temperature which was affected by viscoelastic property.

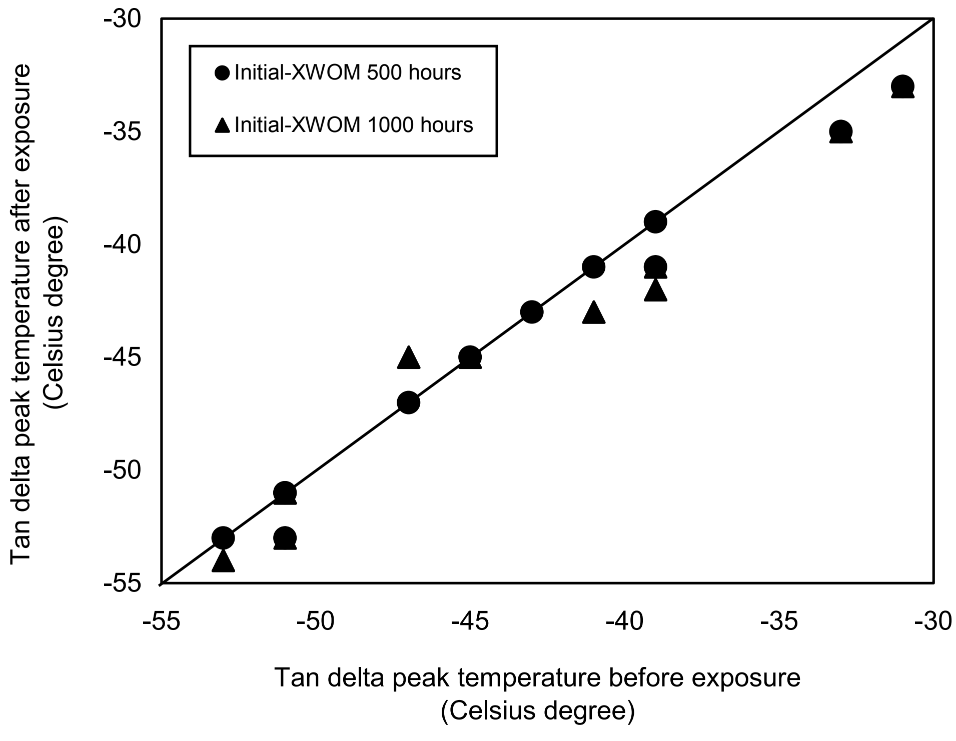

Figure 6 Comparison of tan delta peak temperature

Tensile Test

Figure 7 shows the comparison of the tensile strength retention in the SWOM test and the XWOM test. The difference between the two types of testers was hardly recognized as in the case of color difference.

Figure 8 shows the relationship between the XWOM irradiation time and the change in tensile strength retention. The tensile test was impossible for five samples, namely, 2-component type polyurethane (PU5, PU6), PU3, MS2, and MS3, because the cracking occurred at 3000 hours' of irradiation and the dumbbell shaped specimens could not be obtained. The decrease of the tensile strength retention was observed in 4 samples, namely, PU2, PU4, MS4, and PS1 after 3000 hours' acceleration.

Figure 9 shows the relation between the irradiation time and the tensile strength retention for both the specimens with cracking and the specimens without cracking. The tensile strength retention values of the 12 types of sealant were all plotted in each irradiation time of SWOM and XWOM. And, the linear regression equation could be obtained for both the specimens with cracking and the specimens without cracking. The decrease of the tensile strength retention was observed on the test specimens with the crack more clearly. That is, it is considered that the crack becomes the starting point of the fracture in the tensile test, and consequently, the lower tensile strength is obtained.

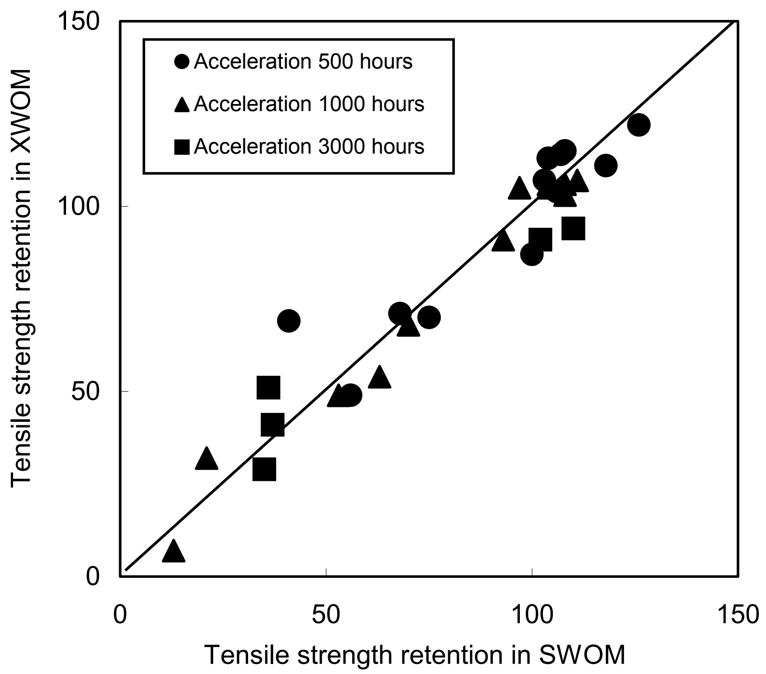

Figure 7 Comparison of the tensile strenght retention in SWOM and XWOM

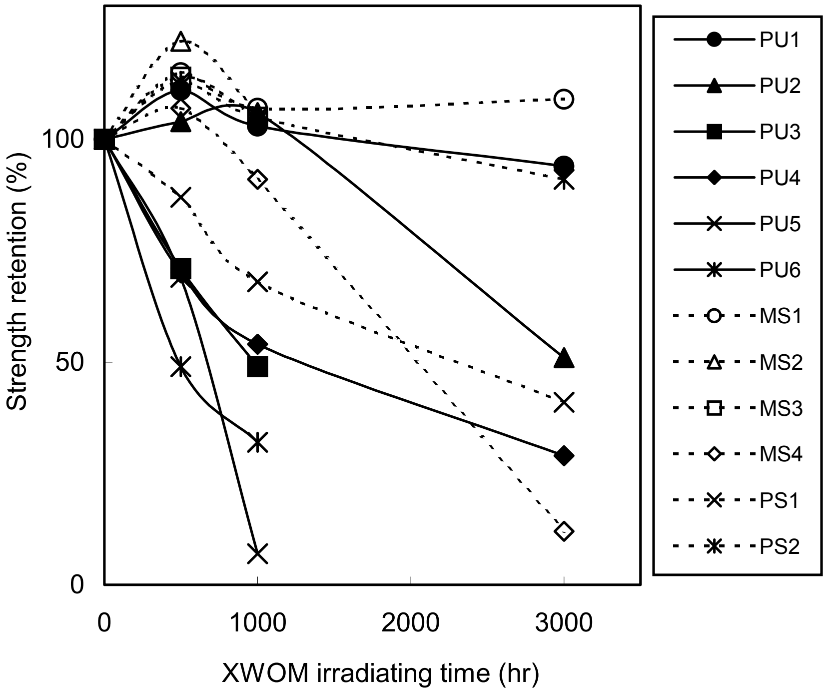

Figure 8 XWOM irradiation time and the change in tensile strength retention

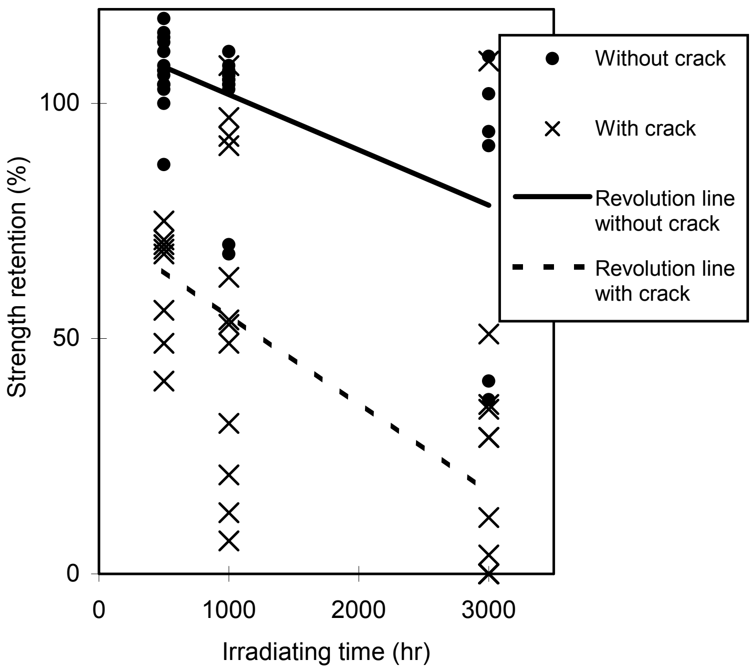

Figure 9 Relations between the existence of cracks and the tensile strength retention rate

Conclusion

The accelerated weathering tests by use of SWOM and XWOM were carried out up to 3000 hours for the 12 samples of the sealant. The following conclusions were obtained from various evaluations.

On Correlation of SWOM and XWOM

In the comparison of SWOM and XWOM, the difference between the two was hardly recognized. That is, the same result was obtained on the deterioration of the sealant in the both acceleration tests.

On Durability of Samples

Table 3 summarized comprehensively the evaluation results based on the results shown in Figures 3, 4, 5, and 8. The PU1 obtained all "Good" rating and showed excellent durability. It is confirmed that the PU1 possesses high durability. It proved that the durability could not be classified based on the types of sealant such as polyurethane system, modified silicone system, and polysulfide system and that the difference in durability was recognized even in the same types of sealant. In particular, the remarkable difference could be observed among the sample of polyurethane systems.

Evaluation	Color difference		Crack		Chalking		Tensile test		Number of "Good"
Irradiation Time	1000	3000	1000	3000	1000	3000	1000	3000	
PU1	Good	Good	Good	Good	Good	Good	Good	Good	8
PU2	Good	Med.	Good	Poor	Good	Med.	Good	Med.	4
PU3	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	0
PU4	Med.	Med.	Poor	Poor	Med.	Med.	Poor	Poor	0
PU5	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	0
PU6	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	0
MS1	Good	Good	Good	Med.	Good	Med.	Good	Good	6
MS2	Med.	Poor	Good	Poor	Good	Poor	Good	Poor	3
MS3	Med.	Med.	Med.	Poor	Good	Med.	Good	Poor	2
MS4	Good	Med.	Med.	Poor	Good	Med.	Med.	Poor	2
PS1	Poor	Poor	Good	Med.	Med.	Med.	Med.	Med.	1
PS2	Poor	Poor	Good	Good	Med.	Med.	Good	Good	4

Note: Med. = Medium

Table 3 Comprehensive evaluation

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The Changes in Maintenance of Co-operatives Buildings in Wrocław (Poland)

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Abstract: *This paper is an attempt of evaluation of effects of reform in housing introduced three years ago in Poland. After 1999, the dwellings in Poland being the private, co-operative, municipal and company's property gained the new possibilities of management as stipulated in housing law. The comparison will be made between effects resulting from management of municipal housing resources by newly established commercial, estate managing companies and those housing resources managed by traditional housing co-operatives.*

Keywords: Co-operative dwellings, municipal dwellings, maintenance.

Housing resources

The dwellings in Poland, in respect to their ownership, belong to the following groups: private, co-operative, municipal and company-owned. According to data of Central Statistical Office, in Poland there are 11 688 000 dwellings. Further in this paper, we will be focused on the buildings belonging to the below mentioned groups (Statistical Yearbook, p. 241):

a) Municipal tenement houses - comprising 1 555 000 dwellings (in buildings owned as well as co-owned by municipalities). (Fig.1)
b) Housing co-operative buildings - comprising 3 329 000 dwellings, from which 2 044 000 is owned by the co-operative society members (dwellings occupied on the basis of co-operative ownership right to a residential premise). (Fig.2)

The first group subject to analysis are municipal dwellings in 19th century and early 20th century buildings of conventional masonry construction with wooden floors and rafter framing, usually in a poor technical state and of high consumption of energy for heating. Also the old-fashioned, last centuries floor arrangement does not meet the to-day's needs.
In the group of housing co-operative buildings, erected mainly in 60s, 70s and 80s, the multi-story, prefabricated, large-panel constructions prevail. The dwellings in such buildings feature:

- a small floor area averaging to 59.1 sq. m. (with average index of 3.15 person per dwelling or 17.1 sq. m per person),
- blind kitchens and bathrooms,
- a rigid arrangement of interior walls which unable the rearrangement of rooms and their adaptation to various needs, e.g. for handicapped persons or numerous families.

The evident fault of these buildings is a very high consumption of energy for heating purposes. This is primarily a consequence of poor insulating quality of external walls (calculated for heat-transfer coefficient K = 0.5, commonly assumed at that time) but also of leaky windows and doors and lack of heat meters in individual dwellings. The living conditions are additionally aggravated by the poor surrounding, lack of essential services (schools, health care units, shops, parking lots, etc.), green and recreational areas.

The consequences of long-years' negligence in repairs and maintenance of both, municipal and co-operative dwellings became the essential organisational and economic problems. This resulted both, from the lack of sole owner who would be responsible for the technical state of the building and the dwellings and for timely repairs and maintenance having the necessary funds and authorisation for this purpose and also from too low financial layouts assigned in the last 5 decades for repair and modernisation of housing resources. The „collective property" was perceived as an „ownerless" property what caused the careless usage and deterioration of municipal dwellings. According to statistical data, the average degree of consumption in construction is 39.7 %.

The political changes of 90s, accompanied by establishing the system of capitalist economy in Poland, have brought the legislative regulation of property right relative to land, buildings and dwellings. At the same time, a problem of responsibility for the repair and maintenance has also emerged. The reform of 1999 assumed the restraint of the deterioration process. This problem is in so far important as the poor technical state of the buildings, particularly of municipal ones, substantially delays their privatisation. Prospective owners, legally obliged to keep their property in good technical state, are reluctant to acquire the old, neglected dwellings, which in the near future will require the substantial capital expenditures.

Reform of Building Maintenance System

In 1999 the Housing Policy Bureau (Poland) introduced the reform which was intended to provide assistance for occupants in resolving their housing problems. The aim of this reform was the increase of number of dwellings, improvement of services relating to building maintenance, improvement of technical state of buildings, reduction of management costs and facilitation of procedures of exchange of dwellings and acceleration of their privatisation (Rozdestwinski 1999, pp.3).

Management of resources - a present state

Till 1999, the housing resources in Poland were managed in double-level system, by two organisations. The first of them, being the first level of management, was the Municipal Management Board (ZGK) which, in principle, performed only two functions: committing the tasks and monitoring their completion. The other level was constituted by Occupants Service Regions (ROM) and Housing Management Offices, which in practice had no authority. Such organisational structure had not clearly outlined competence and responsibility for maintaining the buildings, did not provide any incentives to improve the services and was also not adapted to the changed economical/social situation which, among others, was connected with privatisation of municipal dwellings.

Organisational structure of reformed system

The reform of housing, gradually implemented in Poland since 1999, was to introduce both, the separation of owner function from managing function and clearly define the scope of responsibility. The owner function was taken over by the Housing Policy Bureau which formed a kind of decision-making and planning centre, operating on behalf of Community as one of the owners of „housing communities". The Bureau handles also, to such extent to which it is an owner of housing resources (*Polityka Mieszkaniowa* 1999, pp.4) the following problems:

- co-ordination of housing and land policy, finding new sites for building development,
- premise policy,
- rental policy focused at both, diversification of rents relative to standard of premise and defining the criteria of selection of tenants,
- compilation of catalogues of dwellings for exchange, preparation of programs of complex renovation of municipal buildings both, of large-panel and 19th century construction, monitoring the scheduled repairs,
- controlling the administrators, supervising the quality of services provided by administrators, settling the costs of repairs (committed to administrators or outside companies).

The Bureau evolved then into the Housing Policy Department, which was, after widening the scope of its authority, to become - till not existing - decision-making centre. The separated managing functions were taken by the privatised, commercial companies, which replaced the former Municipal Management Boards (ZGK). These companies, i.e. „estate administrators" enter with the municipality into special „agreements on managing the dwellings". These companies are not bound with Community by capital (*ABC reformy 1999,* pp.7) and in the initial phase only the Community supported them by providing the premises and organisation of specialistic training on estate management for their staff. The employment of such company is based on free competence - via a tender procedure. Within the scope of the most important duties are: keeping the records of estates and their tenants, maintenance of buildings and surrounding areas, small repairs covered by agreement, performance of repairs committed by Housing Management Bureau of „housing community" and responsibility to Community or „housing community" for quality of services. The advantages of such solution are:

- possibility to choose the best one from among many companies (administrators) due to the competence between them,
- reduction of costs of managing the municipal buildings,
- enabling the „housing community" to influence the decisions made,
- shortening the duration of repairs and improvement of services offered.

The management of buildings, called estates, is to be made according to special plan prepared at least every 3 years and which comprises (*Zawartsc* 1999, pp. 1-2):

- information on the estate (legal status of the estate, localisation, description of technical state, description of technical and functional features, mode of utilisation and management of the estate, required repairs and modernisation);
- determination of market area, customer requirements and preferences, comparison with other, competitive estates;
- financial analysis (incomes, maintenance costs, potential cost reductions, value of the estate);
- strategic analysis (positive and negative aspects, variants of conduct, assessment of particular variants and indication of optimum solution);
- plan of realisation of the most advantageous variant and formulation of final conclusions.

Management Estates

Management of co-operative buildings - assessment of activity in 1999-2002

In the overall structure of housing management, remained the large housing co-operatives with their property, operating along old lines, which as old administrators of housing resources of co-operative societies. Now, after transformation of management structure, in a very effective manner operate commonly with Housing Estate Boards undertaking the systematic, phased actions aimed at:

- improvement of technical state of the buildings,
- reduction of energy consumption with consequential reduction of maintenance costs,
- the actions of which bring the lower rents than commercial and higher repair funds.

These co-operatives, when initiating the long-term undertakings, plan the successive actions due to which a gradual improvement of living conditions takes place. The advantageous feature of such organisations is the continuity of actions and, above all, the possibility to make use of repair funds earned and saved in their non-profit activity as well as possibility to obtain the large, low-interest credits to ensure the continuity of repair actions. In the majority, these co-operatives initiated actions connected with thermal renovation in order to cut down the costs of maintenance (replacement of heating systems, installation of heat meters, lagging the walls and replacement of windows), what in effect reduced the costs of energy for heating purpose by 30-40 %. The savings thus obtained were assigned for routine repairs.

An example of such activity is the Housing Co-operative „Poludnie” in Wroclaw (Poland), a city of 700 000 inhabitants. This co-operative, one of three largest housing co-operatives in Wroclaw has about 10 000 dwellings and 25 000 inhabitants grouped in 4 housing estates, what makes about 5% of housing resources in the city. One of the oldest housing estates, „Anna”, was being erected from 1968 till 1999. Now, this housing estate has 19 buildings, where in 2531 dwellings of total floor area of 117 941-sq.m live approx. 5000 occupants - what gives respectively:

- 1.97 person per dwelling,
- 23.5 sq. m of floor area per one person,
- average floor area of the dwelling - 46.5 sq. m.

For comparison, in Wroclaw the above indices are, on the average, as follows:

- 2.80 person per dwelling,
- 20.1 sq. m of floor area per one person.
- average floor area of the dwelling - 56.3 sq. m.

This housing estate belongs to „old” ones and in consequence is difficult to administrate. Requires high financial expenditures. Currently, the majority of financial means amounting to about 50 % were assigned for lagging the buildings, according to earlier prepared long-term plan of thermal renovation:

- The program of thermal renovation started in 1995 with preparation of thermal balances of the buildings.
- In 1996, the heat meters in heat distribution centres were installed what allowed to measure the heat energy supplied by thermal-electric power station and obsolete heat distribution centres were replaced by the modern, compact centres with full automation.
- Within 1996 -1997, the modernisation of internal heating systems was carried out and thermostatic valves were installed.
- In 1998, differential pressure automatic controllers in riser pipes were installed.
- In 1999, a modernisation of internal heating system was completed.

The next step planned in the thermal renovation program for „Anna” housing estate is a combination of aesthetic appearance of the buildings with improvement of insulating properties of external walls. To this end, in 1999, a competition for design of colour scheme of housing estate was announced associated with selection of appropriate lagging technology. The purpose of this competition was also the desire to change the image of this ill-looking and neglected housing estate. It was assumed that the nice colours would serve as the means for betterment of psychical comfort of inhabitants and for breaking with the image of dull and neglected set of blocks.

The energy consumption in repaired buildings in 2000 shoved above 30 % of savings as compared with 1995. This surplus of financial means was assigned for the successive step of thermal renovation. In 2000, the first lagging work was carried out, i.e. three oldest and also the largest buildings in which live more then 1500 persons were lagged. (Fig.3).

In 2001, realising at the same time the lagging work and replacement of heating systems, all heat distribution centres were replaced by the compact, weather-controlled units. In this year, the next 3 buildings were lagged. Also, a wider scope of repair work was undertaken with the purpose to improve the fire protection. The modernisation of entry doors has also commenced (Fig. 4).

After comparison made in 2002 of balances of energy consumption for heating the buildings prior and after the lagging, the another 7-8% of savings in energy consumption was attained, what in effect gave the further reduction of maintenance costs. The completion of thermal renovation program is planned for 2003, while in 2006, the credit obtained for financing the work undertaken in the housing estate will be repaid. This work was financed in 50% from the repair fund and in 50% by the operating surplus and low-interest, commercial credit. The housing co-operative did not use the refunded credits for thermal renovation because of high costs of audits and difficulty with evaluation of actual savings in energy consumption. The preferential credit was chosen for this reason that no additional administrative costs were involved.

How are appraises the actions of housing co-operative managing this housing estate? As compared with other housing estates, the results of changes introduced in presented example are appraised very high. The savings obtained due to the planned management of energy are directly perceptible for occupants. Also, owing to this, the repair fund substantially increased. In case of housing estate in question, it amounts to 21% of monthly rent whilst, for example, in the adjoining house estates this repair fund isolated in the monthly rent is only 9%, on the average. It was also noted, that despite of the continually rising prices of media, the rents in this housing estate do not increase more than the inflation rate, and owing to improvement of technical and aesthetic features resulting from thermal renovation and new painting of the buildings, the price for sq.m. of floor area has become stable and does not drop despite of downward trend on the market caused by tax preferences applied when acquiring new dwellings.

The housing co-operatives, within 3 years after introduction of housing reform and after adaptation of their structures to the nowadays market requirements (for example, committing the construction work by inviting to the tender), show now the evident advantage over the commercial administrators due to the statutory nature of co-operative society, which does not assume to gain the profit from the operations. Hence its competitiveness in fees for managing the property as well as incomparable greater financial and technical potential of large economic unit which the co-operative is in comparison to small, private managing companies.

Management of municipal buildings - assessment of activity in 1999-2002

According to assumed principles of housing reform, a new group of newly established commercial companies - private administrators - emerged and began to operate. They take part in tenders for managing the estates owned by Communities and are financed by Communities and „housing communities” from rents and operational profits. The inhabitants have a relatively low opinion of them due to poor efficiency and repair effectiveness, too high rents and low repair fund.

The reform in its initial 3-year phase did not bring in full the expected results and did not impose the required order in the field of management of municipal property. In opinion of inhabitants, small managing companies, not tied with interests of housing estates did not stand the test. These firms are severely criticised. In the analysis made on the basis of inquiry organised by the Association of Dwelling Owners - the inhabitants most frequently complain of poor cleaning, lack of response to reported defects, diminishing numbers of repairs with consequential increase of malfunctions and rise of maintenance costs. These effects are caused by difficulties in winning the financial means for repair and modernisation from Communities and „housing communities” but also by the lack of proved methods of co-operation with „housing communities" and considerable distrust showed by inhabitants to new administrators. In many cases, the ill reputation results also from misunderstanding of the role of administrator, who does not repair itself but commits (by tenders) the repair and modernisation work. Situation of small managing companies is difficult as they are dependent on funds designed for repairs and modernisation, which funds are at disposal of Communities and „housing communities".

The separate appraisal of the existing administrators was performed by the Housing Commission. In the 5-point scale, the present administrators selected in tender procedures obtained the score of 2.45 points on the average. The results of this analysis will be taken into account by the Housing Commission in further invitation for tenders. The references will have an effect on selection of new administrators since there is a legal clause enabling exclusion from the tender this company which did not fulfil its earlier obligations.

The efficient work of administrators is additionally impeded by fact that the competencies of both, administrators and „housing communities" are still not defined with sufficient clarity. There are also cases of doubled competencies what has an obvious effect on rise of maintenance costs.

Summary

The transformations of housing policy occurring recently in Poland are aimed at improvement of living standards but, above all, at quick privatisation of housing resources. The change of organisation of management of municipal buildings as well as future introduction of integrated management systems will reduce the costs of maintenance and will contribute to the improvement of the comfort of these housing resources so neglected in the past. Solutions aimed at better arrangement and improvement of maintenance of dwellings by commercial companies are in the phase of further tests and bringing to perfection.

The new solutions appearing at the interface with existing structures of management of co-operative housing resources stimulate and force in result of competition from administrators the offer of more and more better service of inhabitants and lowering the prices of services. Despite of presence of some drawbacks, introduction of the reform is a positive step of extreme importance to the housing policy of the cities and the country. The gradual improvement of technical state of existing resources will allow to improve in the planned manner the living standards, to establish the necessary service centres associated with housing estates as well as to improve the system of sale, purchase and renting of dwelling protecting thus the cities from the process of avalanche devastation and formation of slums.

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Fig. 1 Municipal buildings erected in the 19th century awaiting for repair and modernization (photo W. Szarejko)

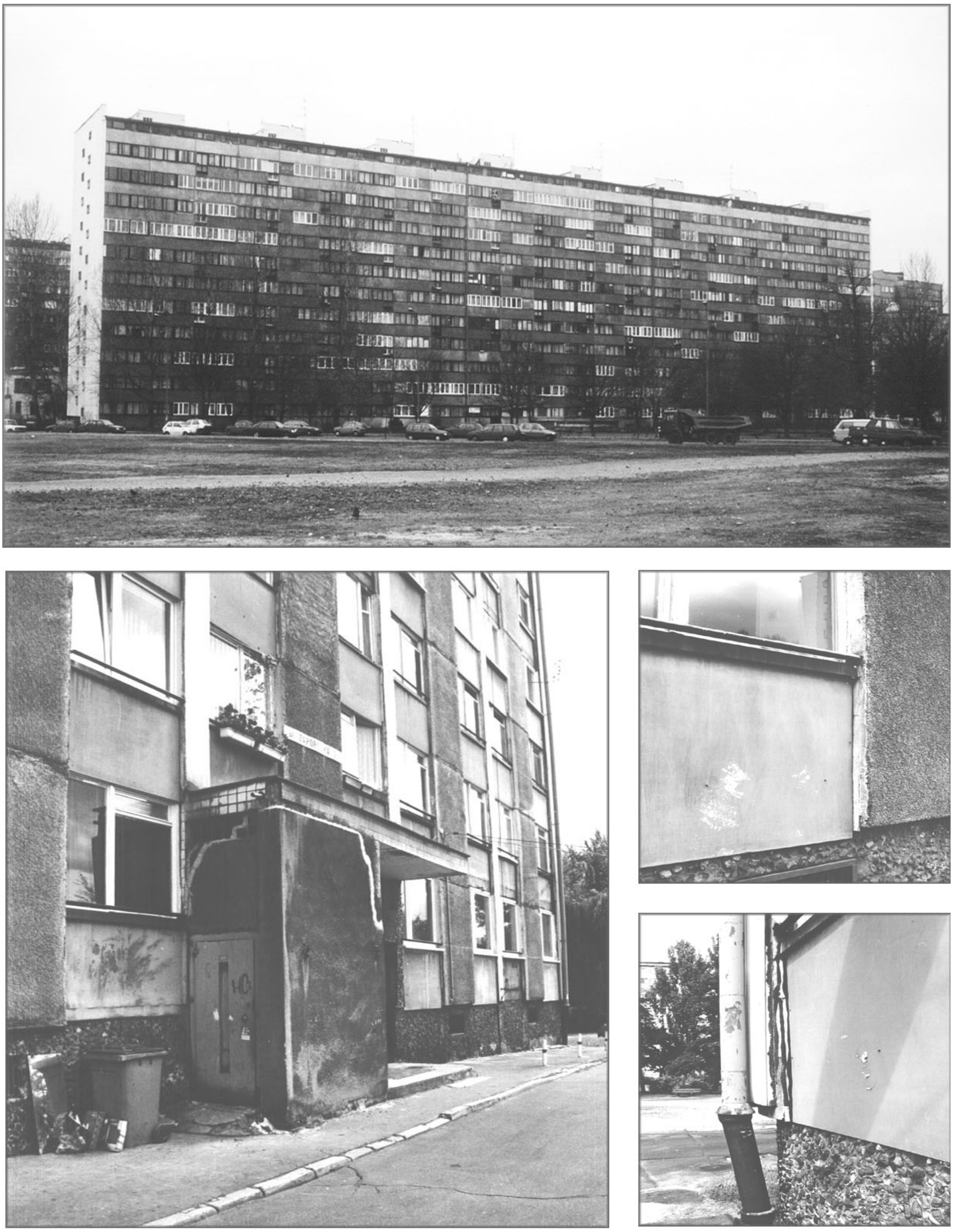

Fig. 2 Multi-family, large-panel houses of co-operative housing estate "Anna" from 60s and 70s in Wroclaw (the oldest three houses with 500 occupants each) before complex thermal renovation coupled with change of aesthetic appearance (1999-2001) (photo W. Szarejko)

Fig. 3 Multi-family, large-panel houses of co-operative housing estate "Anna" from 60s and 70s in Wroclaw (the oldest three houses with 500 occupants each) after complex thermal renovation coupled with change of aesthetic appearance (1999-2001) (photo W. Szarejko)

Fig. 4 The complex thermal renovation made in 2001 of buildings of co-operative housing estate "Anna" erected in 70s with modernized fire protection systems and repaired roofs (photo W. Szarejko)

Building Deterioration Investigation System

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Abstract: *Organizations that own and utilize a large number of facilities must practice the total management of the properties in its possession by engaging in facilities management (FM) that utilizes an FM database when executing such tasks as strategizing and planning, project management, facility operations and maintenance, and evaluations. In addition to information on land, buildings, and facility operations and maintenance, this FM database should contain current building performance and functionality data as well as facility operating cost figures. Building deterioration information is particularly important.*

This paper describes the building deterioration investigation services performed by NTT Facilities, Inc. and our methodology for evaluating building performance, FM sheets, and an investigation case study to compile FM database.

Keywords: FM , investigation , diagnosis , system , method , database

I. Overview of building deterioration investigation services

Capitalizing on its experience in FM for NTT Group properties, NTT Facilities offers FM consulting services to clients base that include government offices and other public-sector institutions, financial firms and other businesses in the private sector, and educational institutions. Our building deterioration investigation one of the main FM service can be broadly divided into the following three categories.

1. Building deterioration investigations as an element of due diligence

Due diligence in real estate transactions is a detailed, multifaceted investigative process aimed at identifying sound investments. Three types of investigations are required: financial, legal, and physical. Our building deterioration investigation services that are carried out as physical investigations include evaluating the deterioration of buildings and their fixtures and equipment. We do this by performing building deterioration investigation services that examine, building's plans, an array of management documentation, and the maintenance, repairs, and renovations that have occurred up to the present time. We use the findings of the investigations, to evaluate conditions of locations, quake-resistance performance, the presence of harmful substances, and the current state of FM, and calculate facility operating costs and the estimated PML(Probable Maximum Loss) in the event of an earthquake and then compile an engineering report that furnishes information pertaining to future risks.

2. Diagnosis for the preparation of medium- to long-term maintenance plans

Many corporations are presently endeavoring to optimize their FM expenses for the buildings that they own and operate. To do this, they particularly need information in terms of planning what repairs, renovations, and update work to undertake, when to perform such works, and what approximate expenses will be required. Drawing on our many years of experience in the area of buildings planning and management, and our track record in terms of research and investigations, we have developed a system for investigating the deterioration of buildings and formulating proposals for facility improvement plans. With this system as our platform, we make diagnoses and propose medium- to long-term maintenance plans.

3. Building deterioration investigations for constructing FM databases

Building deterioration investigations for the purpose of constructing FM databases are not the same as those geared toward the detailed preparation of medium to long-term maintenance plans. When databases are to be constructed, the level of examination and the data compilation required are both different. There are at least three considerations for making diagnoses in such cases. First, it should be possible to use the investigation results for evaluating the status of management operations, developing policies for individual facilities, and establishing priorities for investing in facility improvements. Second, the periodic maintenance of data must be possible. Third, facilities managers should also be able to conduct investigations.

II. Simplified building deterioration investigation system

1. Aims to develop the system

As it developed its system, we aimed to address issues such as the following.

(1) Make the diagnostic process efficient and accurate

For the FM cycle, the conversion of diagnoses and their results into database form is a key point. But the process of preparing investigation forms, conducting on-site investigations, doing evaluations, and compiling reports is extremely efforts. This process needs to be made more efficient. Furthermore, the investigation methodology should be unified so that expected level of results from on-site investigation, which consists primarily of visual inspections, can be obtained regardless of the level of an investigator’s technical expertise.

(2) Set up a database

There is a need to obtain a unified grasp of investigation results and to ascertain problem points reliably.

(3) Provide displays of investigation results

There is a need to carry out simple investigations of a number of facilities in a short period of time and to display the results in the form of quantities in order to compare the findings obtained.

2. System functions

Figure 1 illustrates how the entire system works.

(1) Basic data management

The system manages information on building attributes, the composition of building elements, building equipment, and the findings of previous investigations.

(2) The selection of elements to be investigated

Our system prepares with standard investigation categories set as initial items for specific types of buildings: office buildings, training facilities, recreational facilities, multi-unit housing, and single-unit housing. The system is equipped with a mechanism that permits the inclusion of supplementary investigation categories in a case when there are categories that should be added at the time of an actual investigation.

(3) Evaluation levels

The system features three levels to describe the degree of deterioration present for each element designated as a category to be assessed as part of the on-site building investigation process. The system evaluates whether such deterioration is on a large scale or is localized.

(4) Investigation sheets

Investigation sheets are used for entering on-site investigation results for individual elements. This information is then stored in the system.

(5) Building investigation reports

A range of information is compiled and condensed into a single sheet. This information includes the status of the deterioration of individual elements in the small category, the evaluation scores for individual elements in the mid-sized category, and the evaluation scores for large-category items (including a building's exterior, interior, and equipment). The sheet also indicates elements that have deteriorated, shows the overall balance (a radar chart), and features comments on the status of deterioration.

(6) Investigation master report

Our system produces a report that enables the assessment of evaluation results for facilities as a whole according to building type, geographic region, or a particular facilities manager.

(7) Entry of data on forms for subsequent investigations

The system generates investigation forms in a format whereby information references results of previous investigation is incorporated as part of a building's history.

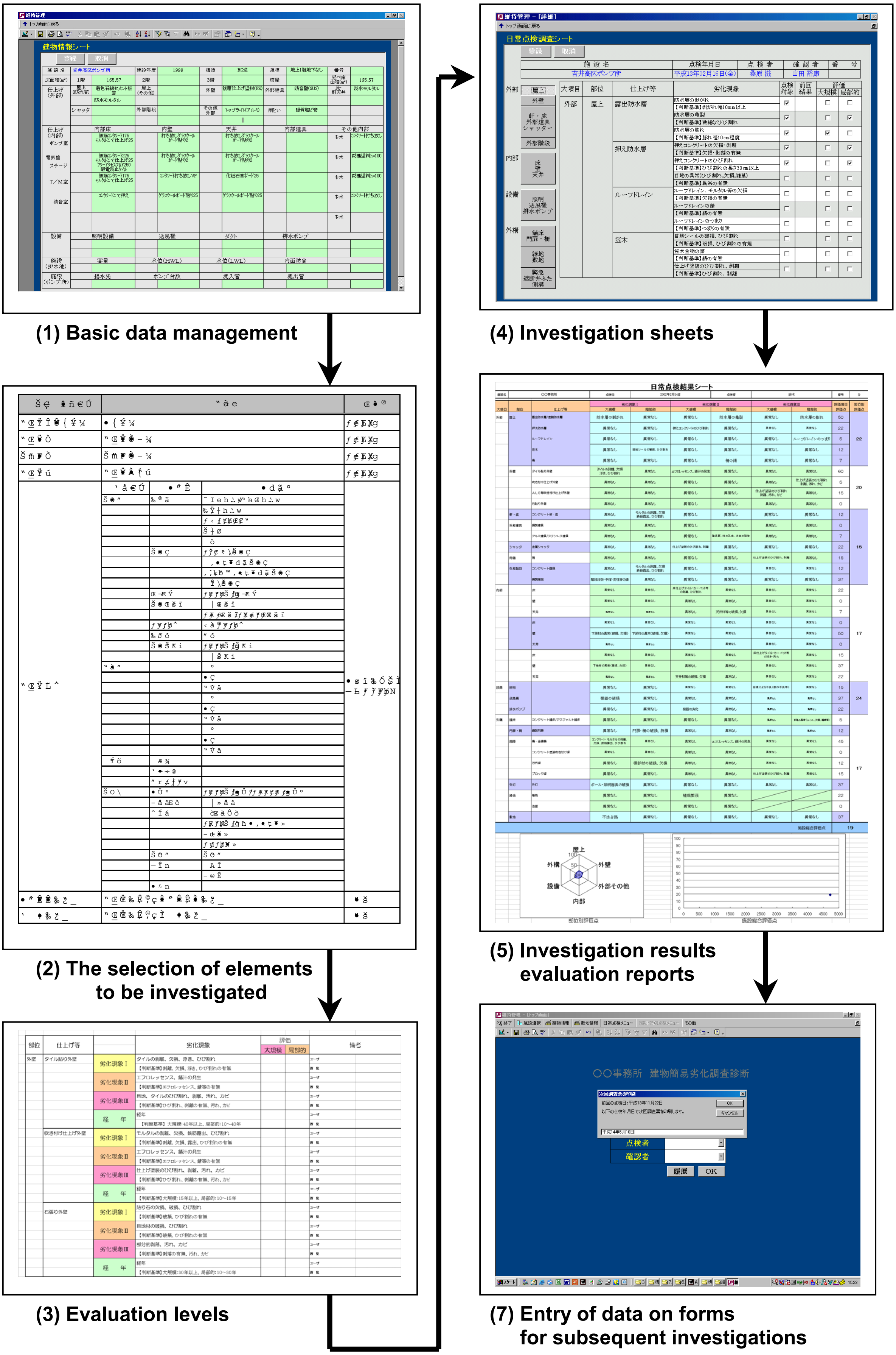

Figure 1. Building deterioration investigation system works.

III. Case study of a building deterioration investigation

This section presents a case study of building deterioration investigation services for the construction of an FM database. The general details of this investigation are shown below.

Facilities investigated:	210 facilities in locations around Japan (office buildings, welfare facilities, multi-unit housing, and single-unit housing)
Project time frame:	May to September of 2001
On-site investigation period:	June and July of 2001
Investigators:	Investigators with expertise pertaining to buildings as well as fixtures and equipment (facilities managers)

1. Objectives

The investigation had the two following objectives.

(1) Collect data for the construction of an FM database

Our client had decided to simultaneously construct an FM database system, and the system is intended to manage current data pertaining, for example, to land, buildings, and building equipment. We carried out this project in order to ascertain, through building deterioration investigations, the extent of deterioration in the entire group of facilities being managed and to provide updated data on deterioration conditions for buildings and their equipment as one segment of the current data.

(2) Collect information for selecting buildings to be included in investigations for the purpose of preparing medium- to long-term maintenance plans

If companies want to utilize buildings effectively for an extended period of time and preserve building performance and functionality, then they must take a planned approach to maintain and improve the performance and functionality while carrying out their business operations. This client in this case was an organization that owns and operates a large number of buildings, and it needed to plan and implement renovations in a planned, rational manner over the medium to long term.
The investigation is carried to select the buildings that ought to be included at this time in the preparation of medium- to long-term maintenance plans.

2. The facilities investigated

(1) The buildings investigated

The investigation involved a total of 210 buildings. They included four types of structures: office buildings, welfare facilities, multi-unit housing, and single-unit housing. Table 1 provides a detailed breakdown.

Table 1. The facilities investigated

Building type	No. of buildings
Office building	40
Welfare facility	30
Multi-unit housing	80
Single-unit housing	60
Total	210

(2) Diagnostic categories
The diagnostic categories encompassed the status of the deterioration of buildings, their equipment.

3. Diagnostic methodology

The building deterioration investigation was carried out with visual inspections and interviews, in accordance with a unified methodology and utilized the investigation form shown in Table 2.

The diagnostic process can be summarized as follows.

(1) Investigators make a general classification of the building elements covered by the deterioration investigation as well as finishing materials and the configuration of building equipment. On the basis of a diagnostic methodology that NTT Facilities has used in the past, they classify these elements and so forth as exterior elements, interior elements, structures, and equipment in accordance with the way the client's buildings are configured.

(2) The forms of potential deterioration of individual building elements, finishing materials, and building fixtures and equipment include the following three: deterioration occurring in the surface layer, deterioration that penetrates into finishing materials, and deterioration that extends to basic materials. Investigators focus on representative signs of these three forms of deterioration when making a diagnosis.

(3) Another diagnostic category, the number of years since the buildings were constructed, is added with respect to rooftop weatherproofing, exterior walls, and building equipment.

(4) Investigators evaluate the level of deterioration at two stages: localized occurrences of deterioration and the large-scale occurrence of deterioration.

(5) Using the diagnostic results, investigators quantify the degrees of soundness of the finishing materials, the individual building elements, and the building equipment and perform an intercomparison. For this quantification, they assign weightings for the extent to which the finishing materials and the building fixtures and equipment have an impact on building performance, the extent to which the deterioration that has occurred affects building performance, and the level of deterioration that has occurred. The following formula is used to calculate the degree of soundness.

$$\text{Degree of soundness} = [1 - (\text{detected defect incidence} / \text{estimated maximum defect incidence})] \times 100$$

(6) Additionally, deterioration is expressed qualitatively by dividing the degree of soundness into five levels, which are shown in Table 3. The action that is required in response to the levels of deterioration that appear in that table is roughly as follows.

III	Deterioration has progressed somewhat: It is necessary to plan repairs and renovation over the medium to long term.
II	Deterioration has progressed considerably: Repair and renovation work will be required within three years.
I	Deterioration has progressed markedly: Repair and renovation work is required immediately.

(7) The diagnostic results for each building are compiled in a building investigation sheet, such as the one that is shown in Figure 2. A description of the facility, the diagnostic findings, observations that were made, and other details are consolidated into this single sheet.

Table 2. Investigation form (abbreviated format)

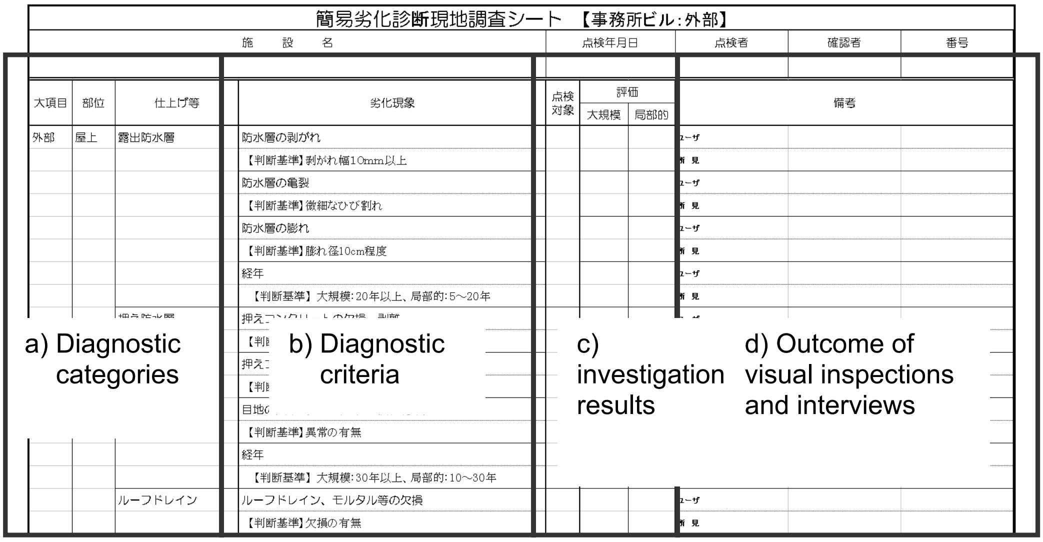

Table 3. Levels of soundness according to evaluation scores

	Level of soundness	Building element	Building equipment
V	Sound	90 or higher	90 or higher
IV	Basically sound	80 - 89	80 - 89
III	Deterioration has progressed somewhat	60 - 79	60 - 79
II	Deterioration has progressed considerably	40 - 59	40 - 59
I	Deterioration has progressed markedly	39 or lower	39 or lower

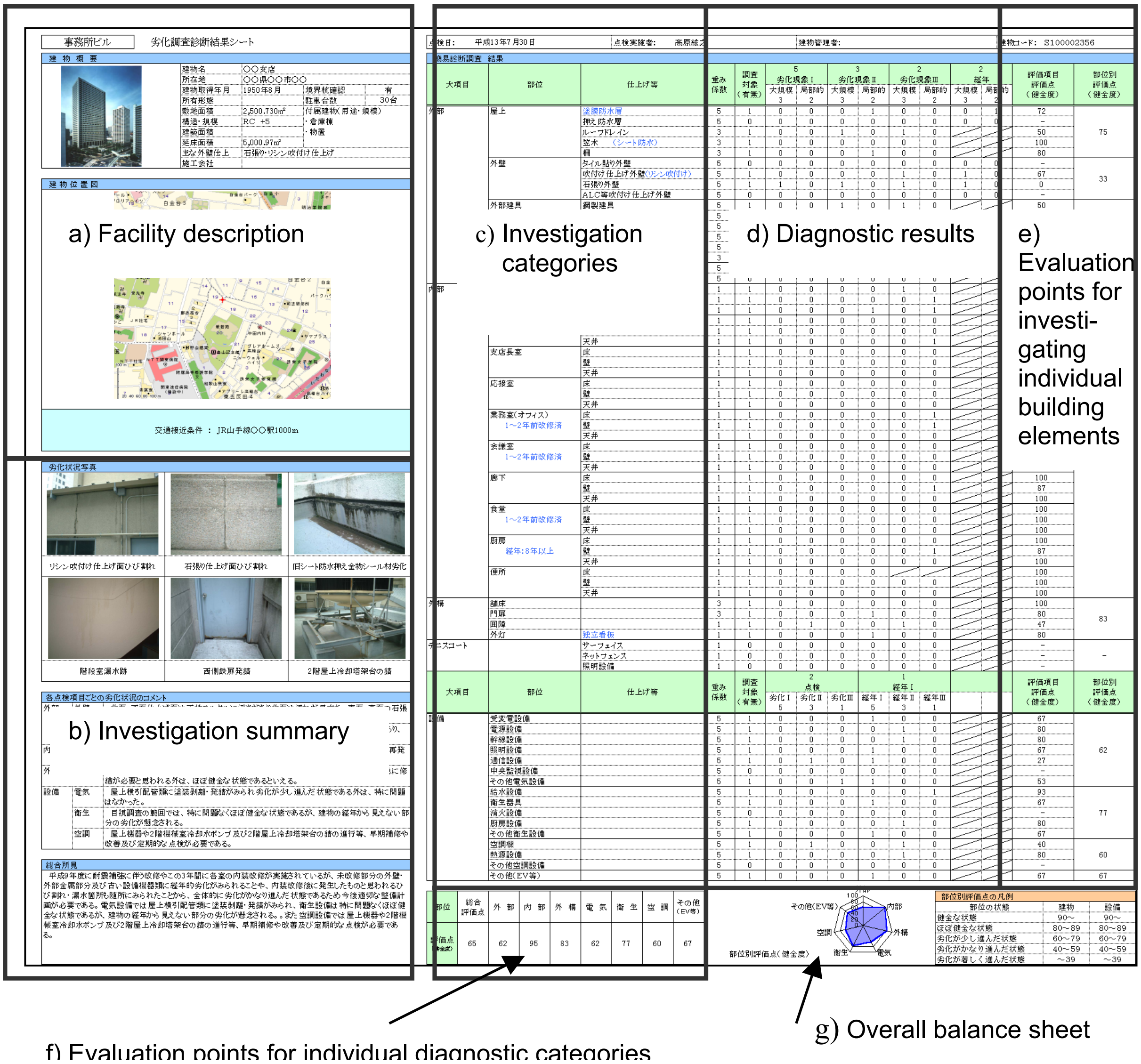

Figure 2. Building deterioration investigation results sheet

4. Summary of the results

The outline of the result by the case is shown below.

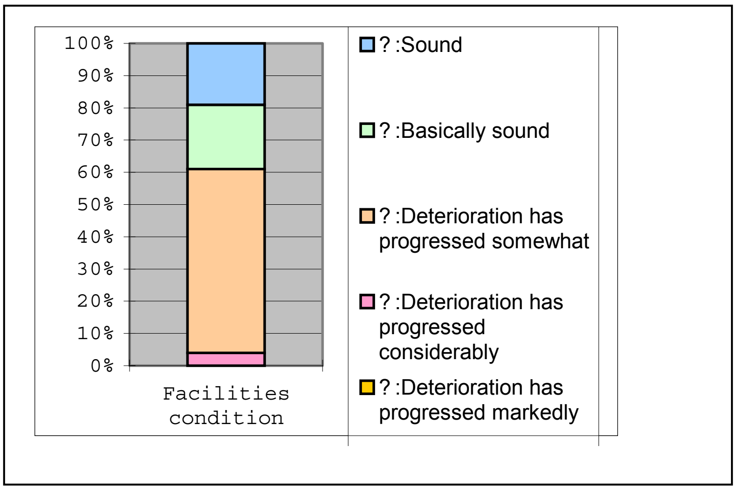

Figure 3. The condition of the client's facilities

If we look at the condition of the client's facilities as a whole according to the overall evaluation of all of its buildings, we can first see that there are not any facilities whose deterioration has progressed markedly (I), and that buildings whose deterioration has progressed considerably (II) account for no more than 4% of the total. For 57% of the buildings, however, deterioration has progressed somewhat (III). (Figure 3)

Second, the percentage of office buildings for which the deterioration of their electrical equipment has progressed is 65%. The percentages of those identified as structures whose sanitary installations and air-conditioning equipment show signs of deterioration are 70% and 50%, respectively.
Third, if we look at the connection between the year a building was constructed and its degree of soundness, we can see that soundness tends to be lower the longer a building has existed. (Figure 4)

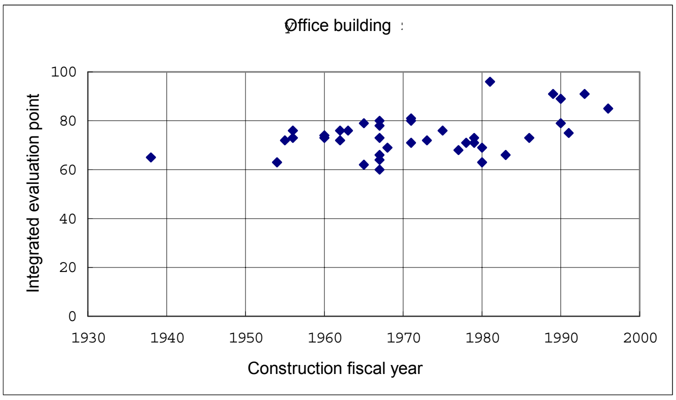

Figure 4. The connection between the year of construction and soundness

5. Utilizing diagnostic results

• Data for FM database

In order to use diagnostic results as facilities management data, we input the information as data for the construction of an FM database.

• Selection of buildings to be included in the diagnosis for the preparation of medium- to long-term maintenance plans

Many of the office buildings were identified as structures whose deterioration has progressed somewhat (III). It was concluded that there is a need to plan future repairs and renovations over the medium to long term. Among these buildings, we selected 10 for which the need for medium- to long-term maintenance plans is particularly urgent.

IV. Conclusion

Businesses have recently been showing interest in the preservation and improvement of the value of their assets, including buildings. The provision of databases and building deterioration investigations are required in order to obtain a unified grasp of information concerning these buildings and their operation and management. Through the development of our system, we have made progress in terms of standardizing the diagnostic methodology, making evaluation results more concise and simplifying the extraction of data from records of past investigations, and upgrading the development of databases.

Reducing Waste in Social Housing Maintenance

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Abstract
This paper outlines a project to produce a more accurate predictive model of maintenance needs as part of a broader research initiative to identify and reduce waste within the maintenance process for social housing. The research is set within the broader context of sustainability in the built environment.

The paper establishes the current position regarding planned and responsive maintenance in the field of social housing, with particular reference to the deficiencies and problems inherent in planned maintenance systems at the moment. The paper considers the key problem to be the inability of maintenance management systems to accurately forecast or predict maintenance requirement which, together with other deficiencies in the maintenance management system lead to the conclusion that significant waste is probably inherent in the system. The research project aims to develop a more accurate predictive model for planned maintenance that will reduce waste in the maintenance process. The research has adopted the 'lean' definition of waste in its search for inefficiencies and optimisation in the system.

The project adopts a theoretical approach that integrates planned and responsive maintenance into a single, generic information model that utilises advanced Artificial Intelligence techniques to interpret very large data sets. This paper outlines the key issues being addressed by the research team and describes the research programme. Finally the paper describes the inter-relationship between this project and the more general work into sustainable building being undertaken by the research team.

Keywords: maintenance, sustainability, process, social housing, forecasting, management systems

Introduction

This paper presents for discussion a new direction in research that has recently commenced; its objective is to develop a new and fundamentally more robust, less wasteful maintenance management system for social housing and possibly beyond. It postulates that a different approach to the identification of maintenance needs and the planning of maintenance actions to the one that currently exists, using traditional condition based surveys, will be more accurate, efficient and therefore less wasteful. This new maintenance management system forms part of a broader set of studies being undertaken within the University of Greenwich and by others into the issues of sustainability of social housing, both new and existing. It stems directly from the work of Jones (2002) who identified sustainability of the built environment as a key challenge facing Property and Facilities Managers and of the RICS (1999) who identified significant opportunities to improve the way information and communication technologies were used for built asset maintenance planning.

Background to the Current Study

The need to reduce waste in the maintenance process has been increased by a number of initiatives from the Government, worldwide changes in attitudes to the environment and developments in technology.

Political Initiatives – A Boost for Social Housing Maintenance

The importance of social housing and social housing maintenance has been raised significantly by the Government in recent years. The amount of money allocated to the provision of new social housing and to the maintenance of social housing has increased dramatically. Raising the standard of Social Housing and providing a decent home for all has been a part of UK Governments' agenda since the mid 1990's. In April 2000, the Deputy Prime Minister, John Prescott, launched a Housing Green Paper 'Quality and Choice: A Decent Home For All, 2000' in which the Government presented a comprehensive review of the state of UK housing and outlined its strategy to provide everyone in the UK the opportunity to have a decent home. The paper outlined the Government's view that by improving the quality of homes and by giving people greater involvement in, and control over their housing (across all types of housing, owned or rented, private or public) self-dependence would improve and would become an integral part of the wider agenda to revitalise urban and rural areas and tackle social exclusion. One of the key proposals within the Green Paper was the commitment to raise the quality of social housing provision to a decent standard over a 10 year period. In order to achieve this a major repairs allowance of £1.6 billion was allocated to cover the cost of maintaining council housing in sound condition. Additionally, the recommendations of the Construction Taskforce (Egan 1998) for the development of new technologies for the construction of large numbers of social houses are receiving strong and continued government support.

The deduction from earlier studies that inefficiencies exist in the maintenance management system becomes more significant in the light of the increased spending outlined above, but accompanied as always by demands for continuously improving best value; to meet government demands the maintenance of social housing will need to show efficiency improvements.

To facilitate the Government's initiatives in social housing and as part of the conditions for receiving the financial assistance provided by the Government, Local Authorities (and by implication Registered Social Landlords) have been encouraged to carry out proper needs assessments and stock condition surveys to underpin their housing strategies. However, the ability of the stock condition survey process to accurately predict maintenance/refurbishment needs, or to become the basis for an effective maintenance management system has been questioned (DTI 2001, Jones 2002). Alternative assessment methodologies, based around more reliable measures of building component performance supported by advanced information and communication technologies have been suggested as an alternative approach which could provide a more effective and efficient maintenance management system. The need to predict maintenance needs more accurately is recognised as a fundamental part of reducing waste within the overall maintenance management process and ultimately the development of an improved maintenance management system.

Political Initiatives - Urban Sustainability

In addition to the initiatives relating to social housing and decent housing, the UK Government has also begun to press ahead with an environmental agenda with initiatives in sustainable development and construction. These initiatives follow on from undertakings given by the Government at a series of international environmental summits, such as Rio, Kyoto and Ottawa, together with a general rise of environmental issues in the political agenda. In terms of maintenance and social housing the Government has adopted a sustainable development approach.

The UK Government defined sustainable development as (DETR 2000):

- Social progress which recognises the needs of everyone;
- Effective protection of the environment;
- Prudent use of natural resources; and
- Maintenance of high and stable levels of economic growth.

In attempting to achieve sustainable development the Government has recognised that a reduced environmental impact caused by buildings and the process of their construction will be provide a common starting point for many organisations that wish to address sustainability issues. By way of practical guidance the strategy identified 10 themes for practical action that construction organisations could take, these included amongst others:

- Re-use of existing buildings.
- Design for minimum waste (both during construction and throughout building life cycle).
- Aiming for 'Lean' construction (continuous improvement, waste elimination, value for money.
- Minimise energy in use.
- Reduce pollution from buildings.
- Preserve and enhance bio-diversity.
- Conserve water recourses.
- Have respect for people.

Examination of these actions clearly shows that the decisions of property and maintenance professionals will significantly influence how sustainable a building can become over its whole life cycle. This is particularly true for planned maintenance programmes where, if effectively planned and efficiently delivered, maintenance/refurbishment can provide the opportunity for a step changes to the environmental performance of the building. With the extent of social housing and the determination of the Government to implement this initiative provides a substantial incentive for the improvement of maintenance management. Thus the second issue facing this project is to examine how environmental improvements can be integrated into the planned maintenance programme for social housing.

The Built Environment – Protection of an Inherited Legacy

Environmental issues have achieved increasingly greater political prominence over recent years, stemming largely from greater public and governmental recognition of the environmental problems, particularly global warming and pollution, that have developed over the past 200 years and which are now approaching crisis. According to the UK Construction Foresight Panel, (DTI 2001) the majority of the UK's built environment be required for the next 20 years is already in existence, however, if existing buildings are to remain (or indeed in many cases become) sustainable then the majority will have to be extensively modified or upgraded. In housing alone it is estimated that over the next 20 years less than 20% of the current stock will be replaced by new build, leaving the remainder in need of refurbishment, firstly to accommodate the changing household patterns and needs that will inevitably occur (changing use, home working, an aging population, etc.), and secondly to reduce the impact that the buildings have on the environment and improving their sustainability. Indeed the regeneration, refurbishment, repair and maintenance of the existing building stock was explicitly identified as one of the most effective means of achieving a sustainable built environment in the medium term (DTI 2001). Whilst identifying this approach, the panel recognised the limitations of current modelling systems for building whole life and challenged those involved in the construction industry to develop broader based assessment methods and sustainable indices that address the impact of the built asset on its environment (both internal and external) as well as its cost components. This challenge provides an integrating factor for the current project, in which a newly developed more reliable maintenance model, could be extended to address the broader sustainability issues (economic, environmental, social) and examine their effective integration into the strategic maintenance / refurbishment process.

New Technologies and Improved Processes

Whilst Information technology has been applied to maintenance management since the late 1970's its impact on the fundamental processes that support maintenance actions has been limited (Jones & Collis 1996, Jones, Burrows & Collis, 1999). A major study of UK maintenance managers showed that whilst the financial aspects of computerised maintenance management systems were working satisfactorily, the maintenance planning and forecasting aspects were not.

In more recent years the rapid development of ICT (information and communication technologies), including the ability to accommodate miniaturised sensors within the building fabric and to apply advanced Artificial Intelligence tools to the interpretation of extremely large data sets have begun to influence maintenance and refurbishment process (DTI, 2001). Currently in many larger prestigious buildings, building performance is routinely monitored and the data fed directly into computer-based maintenance and refurbishment needs models. Further, as e-commerce systems become more commonly used, it is likely that the repair and maintenance department (whether an internal department or external organisation) will be aware of a building maintenance needs before the owner/occupier is. The continued development and application of technology provides a further driver for this project. In essence exploring the application of advanced IT to change processes to answer the question of whether IT can provide a better solution.

The Research Project – Problem Statement

In summary, building maintenance and refurbishment is currently a significant issue within the UK. The combination of the Government agendas to improve the quality of the UK social housing stock and to address the sustainability of the urban and rural built environments pose a number of challenges to property and maintenance managers. This project is one of a number being undertaken by the research team to improve the sustainability of the built environment through effective and efficient maintenance and refurbishment of the existing building stock. This project specifically aims to address the challenge of reducing waste, in all its forms, associated with the maintenance of social housing by re-designing the social housing maintenance process to improve the reliability of maintenance planning and the efficiency of maintenance practices. The remainder of this paper outlines the research project in more detail.

Details of the current research project

The current project is divided into 4 phases, the identification and quantification of inefficiencies (waste) associated with current social housing maintenance practices; the application of management paradigms, drawn from within construction and production industries and an evaluation of their significance (appropriateness) to the social house maintenance process; the re-design of the social house maintenance process to address the causes of waste and improve the reliability of maintenance planning and the efficiency of maintenance practices; and the evaluation of the new social housing maintenance model against historic and current data sets. The project is a three year PhD project which is currently in its initiation phase.

Identification of inefficiencies (waste) associated with social housing maintenance process

Rethinking Construction (the Egan Report) (1998) clearly identified the inadequacies in performance inherent in current construction processes. Whilst the report examined the whole of the construction industry, it specifically focussed on problems associated with house-building and on the potential of the social house building sector to stimulate significant improvements in both building products and processes. In formulating their ideas the Egan committee drew heavily on the principles which underpin the 'Lean Manufacturing' debate and in particular in the need to re-design products and processes to reduce waste. The research team have drawn upon a number of the principles expounded by Egan in the search for inefficiencies in the maintenance process, applying these to the analysis of current social housing maintenance processes.

As a starting point Egan’s definition of ‘waste’ is being used to analyse the maintenance process, this includes analysis of the maintenance management processes, which are also considered to be a potential source of efficiencies. The seven types of waste defined by Egan are not all applicable to maintenance, however they demand a thoroughness and impose a discipline to the analysis that will contribute significantly to the validity of the findings. The deliberate use of a stringent basis for the analysis is expected to reveal the full extent of the process, identifying all activities and their real contribution to maintenance. The research uses the lean principles of waste to analyse the efficiency of the maintenance process at this point in time. It imbibes the principles of ‘value-added’ which is a primary guiding principle for the research. A clear distinction is being kept between the analysis and subsequent activities in the research, recognising that whilst the lean definition of waste is the most appropriate for the analysis, it may not be the most appropriate production process for carrying out maintenance itself.

It is clear that identifying the optimum production system for maintenance will require the resolution of a number of fundamental questions, the most significant of which is that of whether maintenance is in fact a production process at all. There is sufficient logic and evidence to suggest that maintenance is essentially an ad-hoc undertaking rather than a planned process, which would be contrary to all the attempts to plan maintenance around a production process of one sort or another. Indeed, initial analyses carried out by the research team has characterise maintenance as a low volume, many products activity with a jumbled flow and loosely linked project segments. A result that raises a number of maintenance management challenges in respect of how to reliably schedule activities, materials and capacity, the lack of flow, ensuring effective delivery, flexibility. There is however also equally significant logic and evidence to suggest that it can be managed as a production process of some description. Ultimately, the research will determine the nature of maintenance and its management in terms of production as the first stage in developing a new optimised maintenance management system. Inevitably economics will be a major determining factor.

Secondly, viewing construction as a holistic process, maintenance can be considered as the penultimate stage of the construction process, followed only by demolition. Viewing it in this way allows analysis to see if the lean principles being developed for construction can be extended into the operational phase of the building life cycle. This stage of the research project will examine to what extent examples drawn from other industries that treat maintenance as an issue of initial design (e.g. defence and aerospace), can be applied to social housing. The research will examine the extent to which the principles underpinning reliability-centred maintenance can be applied to the social house maintenance process.

Currently, the social house maintenance process is being analysed and mapped using the seven types of waste outlined In Egan (1998) through a series of in-depth case study analyses of historic social housing maintenance processes in the UK. Once the initial mapping has been completed it will be presented to a number of Focus Groups (representing the different stakeholders to the social housing maintenance process) for further refining and for the establishment of a series of Key Performance Indicators that can be used to address the waste associated with each stage of the maintenance process. Once this has been achieved, and a level of agreement reached amongst the stakeholders, a questionnaire survey and extended series of case study analyses will be undertaken to gather KPI data and to establish initial benchmark performance data against which any changes can be assessed. The Key Performance Indicators are intended to provide the basis upon which the social housing providers can instigate and manage their programmes of improvement.

Development of a new model for social housing maintenance

Whilst the outcomes of the issues concerning social housing maintenance are important, in so much as they influence the form of the process that emerges and the degree to which the process may be 'leaned', they do not change the fundamental objective that this project seeks to address; the reduction of inefficiencies in the maintenance process. This research project aims to re-design the social housing maintenance process based upon the analyses and findings from the earlier stages of the research.

The re-designed maintenance model will be evaluated to establish its true performance. The model will be theoretically tested against the actual processes currently used by providers of social housing, secondly it will be evaluated against the Key Performance Indicators and benchmarks established earlier in the study by operating the re-designed model in parallel with the current maintenance systems of a number of social housing providers. Eventually, it is hoped that the re-designed maintenance system will be adopted by a number of social housing providers to allow live evaluation of the systems before widespread dissemination.

In re-designing the model advanced information and communication technologies will be integrated into the process that attempts to achieve reactive or 'just-in-time' solutions, in a model in which a better prediction of maintenance need (pull) is used to inform longer term (and more reliable) maintenance plans (production smoothing) resulting in a better flow of maintenance activities. (note; it may be that the flow will involve the movement of maintenance operatives between activities, rather than the flow of maintenance activities moving between operatives).

Although this stage of the project is still some way off, initial thoughts of the research team as they relate to the information model needed to support a reactive or 'just-in-time' approach have been outlined. The majority of maintenance management information models have been developed from manual systems in which the primary constraint on the model has been the difficulty of maintaining an accurate representation of the building's condition over time. To over come this problem, the majority of models have relied on obtaining a periodic 'snap shot' of the condition of the building elements, and of the cost of maintaining or replacing these elements, then using this information to predict maintenance budgets and to programme planned maintenance activities. The data once used is discarded. However, the main weakness with this model is the lack of a temporal base, which results in divergence between the data in the model and reality, thus reducing the effectiveness of the model for long term maintenance planning and making it impossible to accommodate responsive maintenance activities.

The objectives of the new information model will be to combine all the data necessary to define and control the building's maintenance needs. In particular the model will redefine the basic relationship between building element condition and maintenance needs using expert system techniques to dynamically link building condition and maintenance cost data with time. Once defined the information model will provide an accurate representation of the building's maintenance needs, allowing alternate short and long term maintenance strategies to be evaluated and major expenditure items to be programmed well in advance. Improved programming of works will lead to economies of scale and more effective use of maintenance funds. The consequence on building stock will manifest itself in the systematic improvement of the buildings and their environment.

The theoretical basis for a new information model is outlined in Figure 1. In essence the model is designed around a database which contains tables detailing building element condition (1) and maintenance/replacement costs (2). An initial survey is required to build these tables for any given building portfolio. From these tables a maintenance needs plan (3) and a financial needs plan (4) are developed. In an ideal situation these would then constitute the maintenance programme. However, in reality, the financial needs plan will invariably be in conflict with the budget available for maintenance works, with a series of 'what-if' scenarios being required to best match priority need with the available budget. The result of this process will be the annual planned maintenance programme (5). Up to this point the information model is very similar to many traditional models, however by applying two feedback loops, one that takes account of any maintenance actions taken and the other that decays the condition of any elements which have not formed part the current year's maintenance programme, the static information model can be converted into a dynamic model in which ALL the core data (i.e. Tables 1 & 2) is reset with time. The feedback loops work in the following manner.

Any maintenance work done is recorded onto a works in progress table (6). By periodically comparing the actual cost of work done with the estimated costs as predicted by the costs table (2), it is possible to identify any mismatch (7). If the costs are in agreement then no action is taken (8). If they are not in agreement, then the system will identify whether the observed differences are systematic or random (9). If they are random then the model identifies them (10) but does not modify the cost data table. If they are systematic (11) then the model adjusts the costs data table (2). In addition to cost attributes, the works in progress table (6) also contains details of any maintenance or replacement actions that have been performed on various buildings (12). This information is used to periodically update the appropriate entries in the building element condition table (1).

For those building elements that have not undergone any maintenance action in any given year, the second feedback loop is used to reset the building element condition data to maintain continuity between the actual condition of the building elements and the theoretical condition as contained in the database. This is achieved in two stages. A series of generic building element decay rules (13), that describe the decay profile (assumed non linear) of all the building element types are used to reset the condition data (12) in the building element condition table (1). After a period of time (e.g. five years), a small re-survey (e.g. 5%) is undertaken (14) and expert system techniques (probably based around neural networks) (15) used to identify any systematic and significant differences (16) between the actual condition of building elements and that predicted by the building element condition table (1). If no significant differences are observed then no action will be taken (17). If systematic differences are identified the decay rules will be modified (19) and the data re-decayed to bring the theoretical model into line with reality. If non-systematic differences are recorded these are reported but no action is taken by the system (18). By applying this second stage to the feed back loop the generic decay rules are customised to a particular building portfolio and the need for periodic re-survey diminishes, eventually to zero.

Once this information model is developed it will be integrated into and form a key component of the revised maintenance management system that will reduce the level of waste incurred in social housing maintenance. It is intended that the re-designed maintenance management system will be evaluated and optimised using an action research programme.

Summary

The project outlined in this paper is one of a number being undertaken by the research team into the impact that building maintenance and refurbishment can have on improving the sustainability of the existing built environment. Although its primary objective is to reduce waste associated with the maintenance of existing social housing, it has a secondary objective to address the role of building maintenance in achieving a sustainable built environment and to stimulate debate about this role. If an effective and accurate model can be found to predict a built assets performance over a realistic time period (5-10 years) then planned, rather than responsive maintenance could become the predominant mode of maintenance delivery. Further, if in the establishment of the built assets performance consideration was given to its sustainability (economic performance, social performance and environmental performance) then a predominantly planned maintenance programme could be used effectively to proactively improve the sustainability of the asset as part of the routine maintenance cycle. This would have the effect of systematically raising the standard of the existing built environment without the need to wait for the step opportunities currently associated with large scale refurbishment projects. It is hoped that the fundamental work being undertaken in this project will provide a sufficient level of reliability to the maintenance planning process to allow a more detailed consideration of the bigger 'sustainability' picture to be undertaken.

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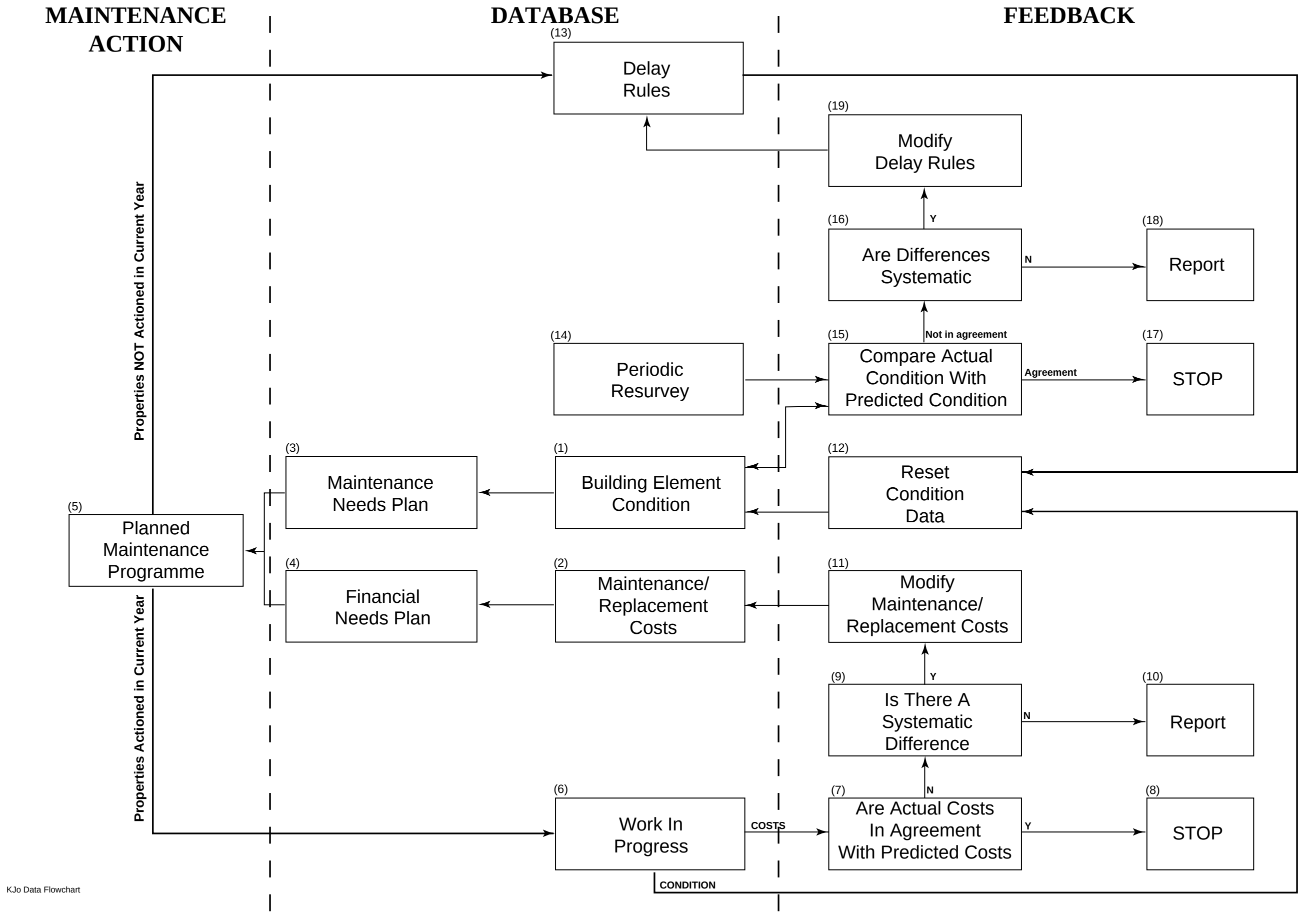
MAINTENANCE ACTION
DATABASE
FEEDBACK
(13)
Delay Rules
(19)
Modify Delay Rules
(16)
Are Differences Systematic
Y
N
(18)
Report
Properties NOT Actioned in Current Year
(14)
Periodic Resurvey
(15)
Compare Actual Condition With Predicted Condition
Not in agreement
Agreement
(17)
STOP
(3)
Maintenance Needs Plan
(1)
Building Element Condition
(12)
Reset Condition Data
(5)
Planned Maintenance Programme
(4)
Financial Needs Plan
(2)
Maintenance/ Replacement Costs
(11)
Modify Maintenance/ Replacement Costs
(9)
Is There A Systematic Difference
(10)
Report
Properties Actioned in Current Year
(6)
Work In Progress
COSTS
(7)
Are Actual Costs In Agreement With Predicted Costs
(8)
STOP
CONDITION
KJo Data Flowchart

Figure 1