RISK MODEL FOR CONSTRUCTION PROJECTS RISK REGISTER SYSTEM

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One of the first phases of research on risk register was dealing with risk itself and resulted with risk model for construction projects risk register system. The model was developed based on research on existing risk models, risk management process and research and development of construction projects risk management system. After extensive research and testing on case studies we developed the risk model together with construction project risk register system. During this research we found that for better understanding of risk in construction projects and improvement of risk identification in practice we found useful to introduce a term uncertainty level as characteristic of risk to distinguish risk from planned event. This term is used to define risk as uncertain future event with uncertainty level higher than one of planned event which, if activated by driver, will cause consequence which will impact on project success.

KEYWORDS: risk, components, characteristics, risk register.

INTRODUCTION

The recognition of poor knowledge and practice of risk management in construction in Croatia initiated research into the topic at the University of Zagreb, Faculty of Civil Engineering in 1996. It was conducted under two research projects financed by Ministry of Science and Technology[i]. Initially the research was focused on the overrun occurrence. The aim was to get knowledge of qualitative position of construction industry in transition economies regarding the problem of planned budget and time overrun. The research included key project participants who provided initial perspective of the most frequent overrun sources resulting in risk breakdown structure (RBS). Later, the research was oriented towards linking RBS logic and risk drivers. We were investigating which event, issue, or other driver, turned on the risk from the passive to active position, and how the potentially successful project became less successful.

Today, risk management in construction is acknowledged as a very important part of project management and a very interesting subject to write about as well. It is frequently discussed, but the practice is still at an inadequate level. Reasons vary from case to case, from the lack of knowledge to implementation of risk management, or the lack of resources. However, the reasons are mostly related to a poor knowledge of risks per se. Just as humans learn and gain experience from their mistakes and the mistakes of others, so must companies be capable to do so by the use of a "permanent brain" of the company. Among other things, the risk register

is considered as a repository of knowledge on risks; therefore aim of our last research phase is to come up with a risk register structure design to be used in construction companies.

One of the first phases of research on risk register was dealing with risk itself. There are many different approaches to risk and it was very important to determine what risk model will be used that is what concept is the most appropriate for construction projects risk register. It was the crucial part of this research since risk register structure directly depends on used risk model.

WHEN RISK IS A RISK?

Term risk is used in different ways, depending on context and purpose. Literature research resulted with conclusion that use of term risk is inconsistent and it is used to be described and explained with other words, such as hazard, danger, threat, uncertainty, probability, likelihood or chance. It has different meaning to different people.

However, the aim of this paper is to determine what risk is for project management, especially construction project management i.e. project risk.

Summarizing most definitions of project risk (Hillson, 2006; Barnes, 1983; Al-Bahar and Crandall, 1990; Kerzner, 2003) we can conclude that it is *future event*, *uncertain*, which can, if happens, have *impact on achieving project objectives* in terms of scope, quality or specifications, time and cost. It is considered as *event* it self, exposure, also with *probability* or product of expected consequences and probability of occurrence. For describing risk authors are using terms as probability, likelihood, chance, frequency and possibility.

Definitions by PMI (2000) and PRAM (Bartlett et al, 2004, p.5) are also focused on uncertain events, conditions or circumstances which is not in line with one of Chapman and Ward (2003) because it does not match when one discuses variability due to lack of clarity or ambiguity. Their definition tries to clarify that project risk management starts with management of sources of uncertainty on the project and state that “risk is an implication of uncertainty on level of performance .....”.(p.48) Risk defined in this way is only one criteria of *risk efficiency*, while other *expected value* is one to determine performance outcome that can be expected. Main difference between this approach and other two previously mentioned is that opportunities and threats as well as uncertain events, conditions or circumstance are considered to be parts of uncertainty source and not risk it self.

Smith and Merritt (2002) have defined three main risk directions, which can serve as criteria for determining weather risk “candidate” is controlled or not: *uncertainty*, *possibility of loss* and *time* .(p.8) They argue that without *uncertainty* “candidate” is issue, *possibility of loss* is one of the main reasons of risk management existence, even in situations where real consequence can be turned into gain and *time* determines when danger of risk starts and when it stops otherwise is considered to be more of a permanent issue or nag.

RISK COMPONENTS AND CHARACTERISTICS

For the purpose of better understanding of risk it is necessary to determine and clarify its components. When researching literature it is noticed that different concept and views on risk

result in different outlook on components hence different terminology, definitions and clarification.

Main risk component is considered to be **uncertain event**. When we discuss event as project risk component, Risk Management Committee (1992) has definition of risk as any specific identified activity or natural event, which can occur or impact on project outcome or results (pp.20-25). Event is incident or situation, which occurs in specific area and in specific time interval. (Standards Australia, 1995) **Consequence**, second component, is defined as result of event it self. Consequences of risk event in project are expressed depending on project objectives, including time, cost, scope and performance (quality). Third risk component is **cause**, which according to Carter at al (1994) observing from risk management aspect is the most important risk component, because only by influencing causes one can actively manage risk. (p.) Most commonly used risk components are shown in model in Figure 1.

Figure 1: Basic risk model

Two *main characteristics* for risk measurement, which have major role on risk assessment and decision on treatment, are **probability of event** occurrence and nature, **intensity and duration of effects** (CUT, 2000). For the purpose of estimating a possibility for event of risk it is necessary to identify risk drivers, which are defined as specific project characteristics, which can trigger risk event. According the Berkeley and other (1991) risk drivers are observable phenomenon, that are likely to drive possibility of risk consequence which depends, at least in part, on occurrence of this phenomenon.(pp.5-17) Possible risk drivers are identified as project size, location, duration, news, technical conditions, client characteristics etc. By identifying possible drivers it is possible to predict and actively manage project risk.

Risk models, which show basic entry data, way in which they affect and shape risk, consequence manifestation, mechanism and chain of events and finally enable systematic project management, make it possible to completely understand risk and its components.

Smith and Merritt (2002) have shown 4 risk models: simple, standard, cascade and Ishikawa risk model. (p.17-25) I this paper only two will be presented due to paper length limitation.

Standard risk model authors consider the best one for understanding project risk (Figure 2). This model consists of following components:

- *Risk event*– condition or event which causes loss
- *Event driver* – something that exists in project surrounding that can lead up to believe on risk event probability
- *Probability of risk event* – event occurrence probability
- *Impact (risk)* – consequence or possible loss, which can result in case of risk event
- *Impact driver* – something that exist in project environment, which can lead up to a believe in risk impact probability
- *Impact probability* – probability of activity with condition that risk event already occurred

- *Total loss* – size of a real value loss, which appeared when event occurred; measured in days, currency or other measure.

According to authors, this model represents essence in dealing with risk. By changing the event drivers one can reduce probability of event occurrence. Likewise, part related to impact enables development of total loss reduction concept by changing impact drivers, even in case when risk event can not be prevented. According to authors, model's advantage is that it supports relations of cause and consequence, while disadvantage is fact that it allows large time difference between event and action, which should be avoided. It is important to emphasize, regarding this model, drivers as critical information for planning risk mitigation.

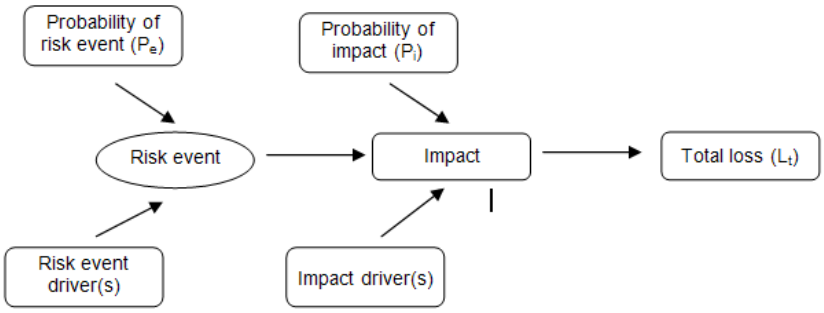

Figure 2: Standard risk model (Original source: Fastrack Training Inc. training material) (Smith and Merritt, 2002, p.)

Cascade risk model is multiphase model in which event causes consequence, which leads up to risk impact, in its simplest form has three phases (Figure 3). This model shows well way in which project risk unwraps because in practice it rarely happens that impact is direct result of risk event. Smith and Merritt consider this model useful when it is needed to analyze several risks due to complexity of links between them or need for detailed analysis.

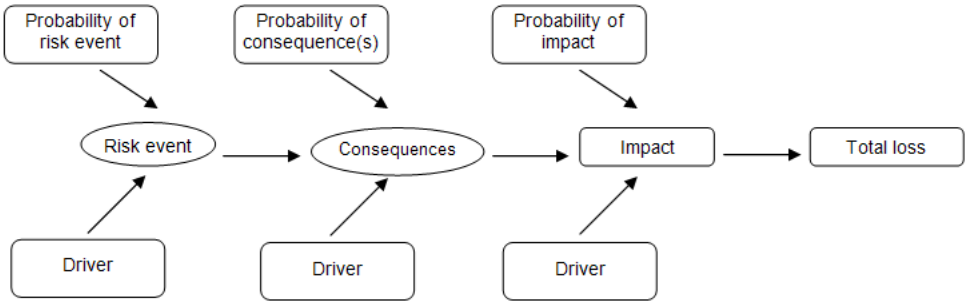

Figure 3: Cascade risk model (Smith and Merritt, 2002, p.)

Next to the source and event, as main three risk components, PMI (2000) sets also trigger sometime called the symptom or warning sign, which represent indicates that a risk has occurred or is about to occur. (p. 133) Risk sources are defined as possible risk categories, which can impact a project in good or bad sense. Usual risk sources are listed as request for change, errors, omissions or misunderstandings regarding documentation, bad defining or misunderstanding the role and responsibility, bad judgments, lack of professional staff. When describing risk sources following data are involved:

- Risk event probability from that source,
- Range of possible outcome,
- Expected time of event,
- Presumed frequency of risk event from that source.

Other component is risk event defined as event which can have impact on project, and described with:

- Probability of risk event,
- Possible alternative outcomes,
- Expected time of event,
- Assumed frequency of event.

Third component is considered to be risk symptoms, also known as triggers and defined as indirect manifestation of real events.

This way of risk modeling is very confusing due to the fact that consequence is included, that is outcome as data with which an event is described with and is not used as separate component. Also, defining probability and risk event frequency is questionable, because describing with one value excludes describing with other. By describing risk source with range of possible outcome it goes over to an area of identification of different risks, which have the same source, other three data are not in line with previous risk source definition.

Hillson (2006) has different, more simplified view on risk. (p.2) He uses basic model consisted out of three components cause, risk and effect. Causes are defined as events or sets of circumstances which exist in the project or its environment, and which give rise to uncertainty. Causes themselves are not uncertain since they are facts or requirements. Risks are uncertainties which, if they occur, would affect achievement of the objectives either negatively (threats) or positively (opportunities). Effects are unplanned variations from objectives, either positive or negative, which would arise as a result of risks occurring. They are contingent events, unplanned potential future variations which will not occur unless risks happen.

Risk model by Carter at al (1994) is shown in Figure 4. This model shows that one risk cause can have more impacts, but also one cause can lead to several risks and impacts attached. (p.17)

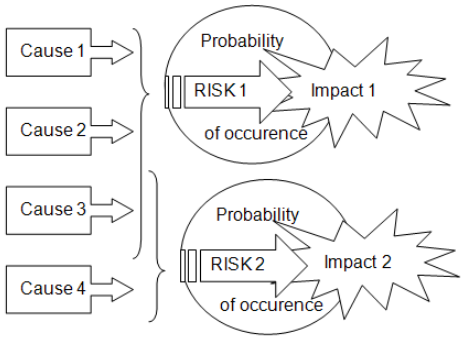

Figure 4: Risk model according the Carter at al (1994)

By levelling driver and cause, this model can be compared with simple risk model (Figure 4) because it does not make difference between probability of risk event and impact that is consequence. In this approach risk life cycle is emphasized as important component, which determines time interval when possibility of risk exists, starting with trigger event till the end of its impact and it consists from generating and active period, which can also overlap.

Generating period is time of factors occurrence, which can lead to risk event, while active period is time needed to implement risk control. Each of them is set by start and finish period dates and project phases which are part of mentioned dates. By further risk defining, Carter et al (1994) state probability law, which describes risk event probability and/or its impact or consequence through time included in active period, which leads to fact that probability of risk event and risk impact can be viewed separately as in standard risk model (Figure 3). (p.52) In this approach term trigger is used, which is defined as event which can be determined by management that will initiate activities in risk management for the sake of diminishing potential impacts of risk event.(p.61) These are temporal events which held project manager to see that situation can lead to specific risk if appropriate measures are not taken. Table 1 enables a comparative view on main risk components with definitions and sources (if applicable).

Table 1: Risk components – terms and definitions comparison

Component	Definition	Source
Event	Any specific identified action or natural event which can occur and impact on outcome or project result	Risk Management Committee (1992)
Event	incident or event which occurred on specific location and in specific time interval	(Standards Australia, 1995)
Event	Condition or event which causes loss	Smith and Merritt (2002)
Event	One that can occur to cause damage or gain to a project	Al-Bahar and Crandall, 1990
Event	occurrence (event) which can impact a project	PMI (2000)
Risks	uncertainties which, if they occur, would affect achievement of the objectives either negatively (threats) or positively (opportunities).	Hillson (2006)
Consequence	Outcome of event itself and is defined in relation to project objectives, including time, cost, scope and execution (quality)	
Action (risk)	Consequence or possible loss which can result in case of risk event	
Effects	unplanned variations from objectives, either positive or negative, which would arise as a result of risks occurring	Hillson (2006)
Cause	one risk cause can have more impacts, but also one cause can lead to several risks and impacts attached	Carter at al. (1994)
Cause	events or sets of circumstances which exist in the project or its environment, and which give rise to uncertainty.	Hillson (2006)
Risk sources	Categories of possible risk event which can impact a project in good or bad sense	PMI (2000)
Risk symptom (trigger)	Indirect manifestation of real risk events	PMI (2000)
Triggers	Event, which can be specified by a management, which will initiate risk management activities	Carter at al. (1994)
Driver	Specific project characteristics which can trigger risk event	
Driver	Seen phenomena which can probably trigger possibility of risky outcome, at least partially, depends on this phenomena occurrence	Berkeley and dr (1991)
Driver	Specific project characteristics which and trigger risk event, such as project size, complexity, location, duration, news, technological conditions, client characteristics etc.	CUT, 2000
Event drivers	Something that exists in project surrounding which leads to possibility of risk event	Smith and Merritt (2002)
Driver	Turns risk from passive into active state	Radujković

RISK MODEL FOR CONSTRUCTION PROJECTS RISK REGISTER

During the research on risk management in construction projects we understood that the main problem to project managers is thinking about risks and understanding risks what it is. The main problem is that they cannot distinguish risk from issue and they cannot differ what is risk and what is source. The literature review showed that risks and models which are representing risks are understood very differently. There are no clear descriptions what risk components and characteristics are. Source and cause are treated as synonyms, as well as consequence and impact. When we talk about risks in construction projects, source and cause can be treated as synonyms which why we casted out cause from our concept. Consequence and impact, on the other hand, have absolutely different meaning and function in this risk model – consequence is component and impact is its characteristic.

Risk model developed during this research is consisted out of five main components which are representing risk mechanism are risk/event, source, driver, consequence and impact. (Burcar 2005) Each of these components is described with their characteristics and therefore together with components, is completely describing risk. **Risk model** arising from this approach is shown at Figure 9. *Event/risk* is central part of the model which represents uncertain event, action or advent which if occurs will cause the consequence. *Source* of risk is defined as human or nature act array from which risk arises, or generates possibility of risk occurrence. It can be within the project or project environment and its important characteristics is *owner* i.e. stakeholder which is why the source exists. *Consequence* is condition, advent or event which will occur only if risk/event occur and affects the project success. The consequence will induce *risk impact* which will affect project objectives. Its main characteristics are *nature, value* and *location* by which is described how the risk will impact project, what project objectives and which part of project, WBS or activity will be affected.

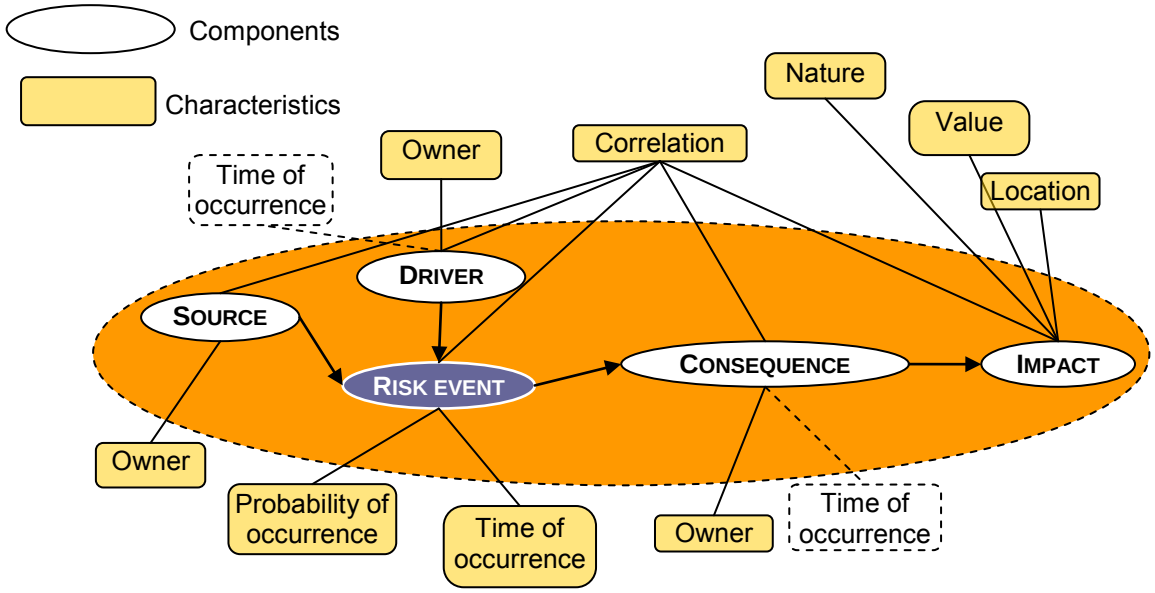

Figure 1: Risk model for construction projects Risk Register

The next risk component is *driver* which can be event or change of condition whose occurrence will activate risk mechanism. It will initiate the transformation risk into the actual

event. With its activation risk will stop being risk and start to be an actual event or issue which needs a reaction. Risk can be described as mechanism in latent condition which will be activated only by driver. Driver and consequence also need to identify *owner*, the subject related to these two events. As it is important for risk management process to identify who will be affected with consequence it is at least as that important to know who is owner of source and driver, which enables proactive approach to risk management. *Time* and *probability of occurrence* are characteristics most frequently connected with risk in general but in this model are attached to risk/event as central risk component. Both characteristics could be attached to the driver which activates risk mechanism and time of occurrence to consequence as well. However, time spans between these three components are short and their order is known (driver-risk event- consequence), therefore we didn't want to ballast the model with attaching time of occurrence for all three components. Moreover, it would be better to represent this mechanism with occurrence of the first i.e. driver which starts the whole mechanism, but because of insufficient understanding and utilization of driver in risk mechanism in practice, we decided to link this information to risk event.

The same approach is applied to probability of occurrence, with difference that probability of driver and consequence occurrence can be consider in case of alternative drivers and consequences, but this is done in risk analysis phase using decision tree. *Correlation* is very important part of risk model which characterize the interaction between two risks. In developing this model our intention was to link all risk characteristics with risk components, but in case with correlation we made the exception defining it on risk level instead of component level. Correlation between two risks can include any component of each risk and they together with their interactions are used to describe and define correlation type and mechanism.

During this research we found that for better understanding of risk in construction projects and improvement of risk identification in practice we found useful to introduce a term *uncertainty level* as characteristic of risk to distinguish risk from planned event. Each planned event has certain level of uncertainty which is usually ignored or transferred to determine event in some other way. During each project life cycle phase uncertainty level should be determinate as threshold data between risk and planed event. How? It is not measured only with probability of risk event occurrence, it is given by uncertain nature of event or level of unknown information i.e. limited knowledge on event or advent. Uncertainty level should be lower as project approaches to its closeout phase as knowledge in project rises and it should be subject of top management decision in risk management planning phase. Now we can describe risk as *uncertain future event with uncertainty level higher than one of planned event which, if activated by driver, will cause consequence which will impact on project success.*

APPLICATION AND CONCLUSION

As we mentioned at the beginning, we applied this model to develop risk register for construction projects. As the result we developed Risk Register System (RRS) consisting of two parts, Project Risk Register (PRR) and Central Risk Register (CRR). Project Risk Register has the role of a platform which enables recording risk data throughout the whole risk management process in order to collect data for each construction project and tool for project risk management and communication. Providing continuous risk tracking it can become a medium for communication between project stakeholders. Risk data from all projects are stored in the Central Risk Register. This part of RRS has a function of

"repository of knowledge" and a tool for project risk identification, and during long term utilisation it becomes a source for quantitative and qualitative risk data. As a source of data on risk response, tracking and controlling, it enables particular response efficiency evaluation as well as undertaking a consequence-based action.

Data and structure of RRS arise right from this risk model and risk management process; therefore, they involve all risk components and characteristics through all the stages of risk management process. From recording and structuring aspect there are two major groups of data: **project level data** describing project characteristics directly or indirectly related to risks, and **risk level data** describing *risk characteristics and components* necessary for generating information and needed for risk management process. Considering phases through which they are generated, risk data are grouped into three categories **planned (initial) data, monitoring data,** and **actual (final) data**.

Risk data are grouped into 3 groups so the application of the risk register can be performed in 3 stages which differ according to the extensiveness level of risk data and analysis application in risk management. **Required data** are including general data necessary for database functioning, basic, mostly *qualitative data on risk components and response* and all project level data. **Additional data** are closely determining *risk components and their characteristics,* while **advanced data** are including quantitative data for assessment and prioritizing risks, cost benefit analysis of responses and connection with monitoring data.

This RRS with data structure based on risk model enables to easily generate different project risk reports such as various project RBS reports, comprehensive check list for all risk components, risk monitoring reports etc. (Table 2, Table 3)

Table 2: Report example: List of drivers for given type of construction with information on type of work

TYPE OF CONSTRUCTION		
PROJECT CODE	**DRIVER**	**TYPE OF WORKS**
XXX	Driver X	Type of works X
YYY	Driver Y	Type of works Y

Table 3 Risk identification form

PROJECT CODE		PROJECT NAME				
ID	**RBS**	**RISK NAME**	**DRIVER**	**EVENT**	**CONSEQUENCE**	**IMPACT TYPE**
1.	**External**					
1.1.	*Legal*					
1.1.X.	Source X	Risk name X	Driver X	Event X	Consequence X	Impact T X
2.	**Internal**					
2.1.	*Project management*					
2.1.Y.	Source Y	Risk name Y	Driver Y	Event Y	Consequence Y	Impact T. Y

This flexible structure enables its application regardless of risk management level performed. It can be used in organisations with advanced as well as in those with lower risk management practice and knowledge, supporting and directing progress in risk management practice towards complete application. Other than the most common risk characteristics probability of occurrence of risk event and value of impact, identifying for each risk owner of source, driver and consequence will give us information for proactive risk management approach as well as for effective response development. Even at lowest level qualitative data on risk components and response are collected and recorded which are important and valuable data for future risk management actions.

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