

PROCESS MODELING FOR BIM

Jiří KAISER^a

^a *Czech Technical University in Prague – Faculty of Civil Engineering / Department of Applied Informatics, Prague, Czech Republic, jiri.kaiser@fsv.cvut.cz*

Abstract

In the recent years Building Information Modeling (BIM) has been finally widely recognized as the next evolutionary step in the architecture, engineering and construction (AEC) industry and also as a step towards the sustainable construction. Organization of work on creation and using building information model during its whole life cycle is a key to get desirable effects of BIM approach. Specification of data that should be included in the model on which level of detail, responsibility for data acquisition and specification of data users is important part of building information modeling process. For the effective work with BIM models process models for various stages of information modeling are needed. Process models showing activities and data exchanges during Building Information Modeling are often part of BIM Execution Plan (BEP) and Information Delivery Manual (IDM). Used modeling languages are usually based on Business Process Model and Notation (BPMN) standard but not making full use of its potential.

Keywords: *Building Information Modeling, BIM Execution Plan, Information Delivery Manual, Process Modeling, Business Process Model and Notation*

1 Introduction

In the recent years Building Information Modeling (BIM) has been finally widely recognized as the next evolutionary step in the architecture, engineering and construction (AEC) industry and also as a step towards the sustainable construction. [1] “Building Information Modeling (BIM) is ideally suited to the delivery of information enabling improved design and building performance. Two major beneficial features of BIM in relation to sustainable building design are those of Integrated Project Delivery (IPD) and Design Optimization.” [2] BIM is able to eliminate the extra cost of design changes during the subsequent phases of construction process. BIM is also capable of enhancing the project delivery culture and can contribute to the selection of best solutions to reduce energy and resources consumption. [2] However for design optimization and effective work with BIM models process models for various stages of information modeling are needed.

2 Current state in process modeling for BIM

Models showing activities and data exchanges are used mostly as a part of BIM Project Execution Plan (BEP) and Information Delivery Manual (IDM). Methods of process modeling that are used are usually based on Business Process Model and Notation (BPMN) standard. Used adoption of BPMN standard has often modified syntax [3]. Moreover process

models often handle BPMN standard in a way that is in contradiction to the BPMN formal definition [4] and process models don't contain important information. Processes are often presented using models with misused or missing elements and/or connectors. This causes that meaning of created models can be interpreted in various ways. Many steps of the process may be unclear or sequence of these steps is not fully defined. These problems may result in important information insufficiency of models or misunderstandings of models. It can be assumed that increasing amount of more complicated and automated tasks like automatic classification processes [5], which can be performed on BIM models for various purposes, will require more complicated and accurate process models with clear activities, sequences and data associations specifications.

3 Process modeling for BIM Project Execution Plan

A well-documented BIM Project Execution Plan will ensure that all parties are clearly aware of the opportunities and responsibilities associated with the incorporation of BIM into the project workflow. A completed BIM Project Execution Plan should define the appropriate Uses for BIM on a project (e.g., design authoring, design review, and 3D coordination), along with a detailed design and documentation of the process for executing BIM throughout a facility's lifecycle [6].

Principle of creation of BIM Project Execution Plan is based on definition of BIM Goals that are achieved through application of BIM Uses.

There are BIM Project Execution Plan guides and templates [7], [8] that don't use BIM process map description at all and use only text description of BIM processes. On the other hand Building Information Modeling Execution Planning Guide [6] can be considered as very comprehensive and uses process maps that are based on BPMN standard.

Process modeling in BIM Project Execution Plan has two goals. The first one is to present BIM Overview Map. Another one is to present detailed BIM Use Maps for each BIM Use.

3.1 BIM Overview Map

The Overview Map shows the relationship of BIM Uses which will be employed on the project. This process map also contains the high level information exchanges that occur throughout the project lifecycle [6]. An example of BIM Overview Map is presented on fig. 1 [6]

In process diagram data objects should be connected by data associations – not by sequence flows. “A Sequence Flow is used to show the order that Activities will be performed in a Process.” [4] but “Data Associations are used to move data between Data Objects, Properties, and inputs and outputs of Activities, Processes, and GlobalTasks.” [4]. Thus data associations should be used to connect data objects with activities.

Connectors of data objects should be connected to activities – not to sequence flows. “Data Objects MAY be directly associated with a Sequence Flow connector to represent the same input/output relationships. This is a visual short cut that normalizes two Data Associations one from an item-aware element (e.g., an Activity) contained by the source of the Sequence Flow, connecting to the Data Object; and the other from the Data Object connecting to an item-aware element contained by the target of the Sequence Flow.” [4] Connecting data object to sequence flow must be done using data association and is possible to represent that data object is produced by activity at the start of sequence flow and used in activity connected to the end of the sequence flow. In this case data association connector must be without an arrow.

Process model can be enriched by specification of data inputs for activities. Process map shows only data objects produced by activities but there is no specification which data are required for activities execution.

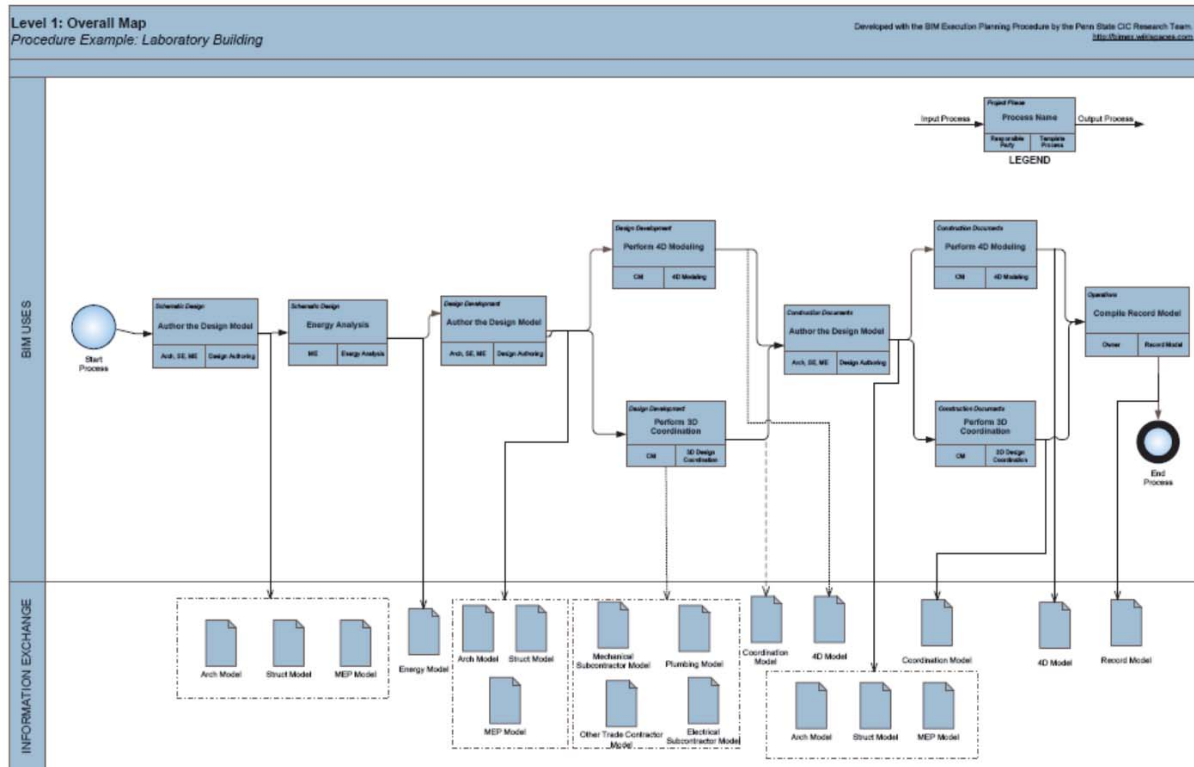


Fig. 1 BIM Overview Map Example [6]

In process maps activities usually don't contain information about responsible party – for this purposes are usually used lanes. “Lanes are used to organize and categorize Activities within a Pool. The meaning of the Lanes is up to the modeler. BPMN does not specify the usage of Lanes.” [4] On the other hand for some activities there may be more than one responsible party. It should be taken into consideration to set responsibility to one particular party which also make possible to put each activity to particular lane of the process model. Situation may be complicated because of many responsible parties on the process map.

Project phase can be modeled using intermediate events that can be used to give information about milestones of the project. Diagram can be also divided to sections using vertical lines and activities for each project phase can be placed in particular section.

Activity in BIM overview map may contain information about responsible party and information about detailed maps as shown on fig. 2. “A Sub-Process is an Activity whose internal details have been modeled using Activities, Gateways, Events, and Sequence Flows.” [4] But if we can consider each activity on overall process map as a sub-process then detailed BIM use map can have the same name as the activity on overall process map and information about “Detailed Map” is redundant.

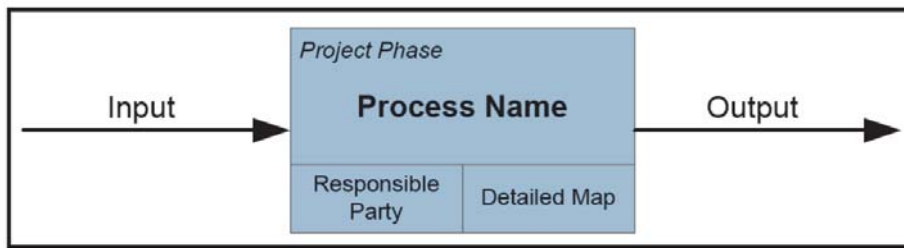


Fig. 2 Notation for a Process in the Overview Process Map [6]

3.2 BIM Use Maps

The second goal of process modeling in BIM Project Execution Plan is to present detailed BIM Use map which define the sequence of the various activities to be performed within the BIM Use.

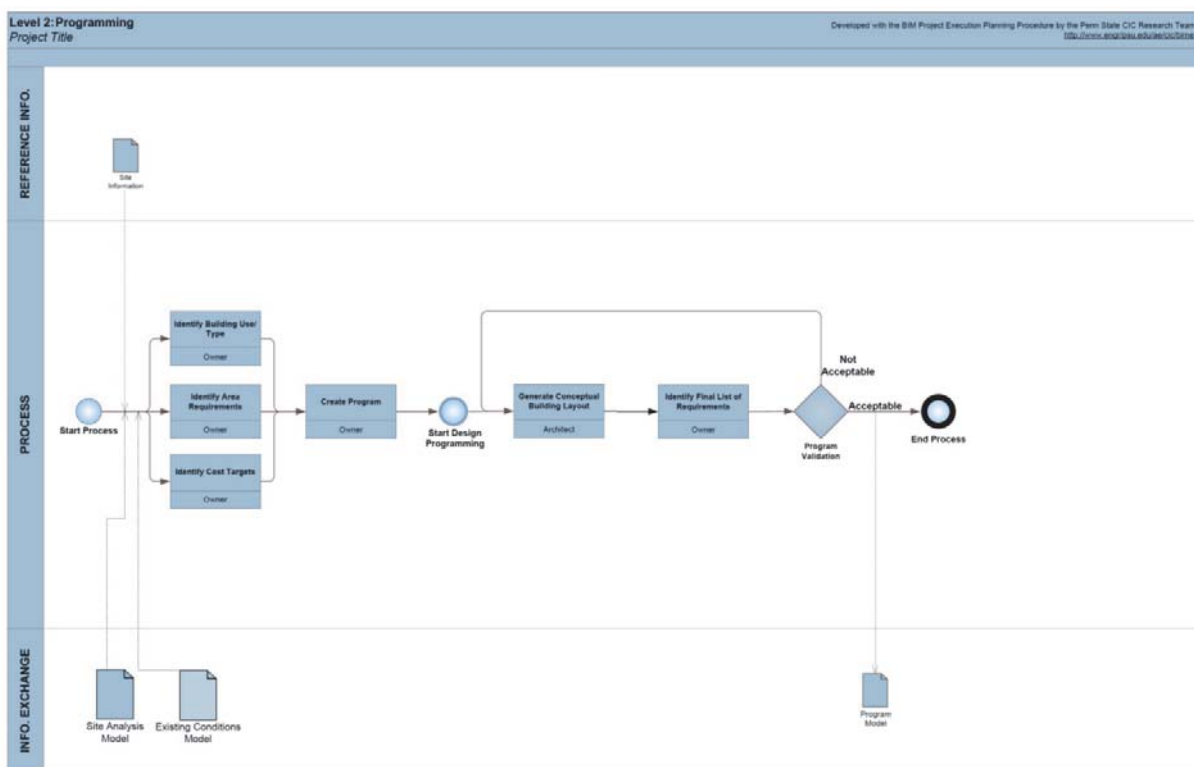


Fig. 3 BIM Use example – Building Programming [6]

BIM Overview Map should also have data objects connected to activities – not to sequence flows and activities may contain information about responsible party, but for this purposes are usually used lanes.

The activity (Create program) has multiple incoming sequence flows. The “Start Process” event has three outgoing sequence flows that activate three activities “Identify Building Use / Type”, “Identify Area Requirements” and “Identify Cost Targets”. After each of these three activities is finished sequence flows activate “Create program” activity. So this activity and also the rest of the process are processed three times. To prevent this situation is better to use parallel gateway to synchronize the process.

“Site analysis model”, “Existing conditions model” and “Site Information” data objects are connected to sequence flows at the start of the process (right behind the start event). It is

not clear which activities need these data object to be performed. Connecting these data objects to particular activities can give this information.

The same improvement can be made with connection of “Program model” data object to specify which activity produces this data object.

Clear specification of data inputs and outputs may improve the process model. Process model can also show states of data objects.

4 Process modeling for Information Delivery Manual

“The Information Delivery Manual (IDM) aims to provide the integrated reference for process and data required by BIM by identifying the discrete processes undertaken within building construction, the information required for their execution and the results of that activity.” [9] It will specify:

- where a process fits and why it is relevant
- who are the actors creating, consuming and benefitting from the information
- what is the information created and consumed
- how the information should be supported by software solutions

Information that should be included in IDMs is also specified by ISO 29481-1:2010 standard. “ISO 29481-1:2010 specifies a methodology that unites the flow of construction processes with the specification of the information required by this flow, a form in which the information should be specified, and an appropriate way to map and describe the information processes within a construction life cycle.” [10]

“ISO 29481-1:2010 is intended to facilitate interoperability between software applications used in the construction process, to promote digital collaboration between actors in the construction process and to provide a basis for accurate, reliable, repeatable and high-quality information exchange.” [10]

4.1 Process maps within Information Delivery Manuals

The preferred approach to developing a process map within IDM is to use the Business Process Modeling Notation (BPMN). The reasons for adopting this notation are [9]:

- It is supported as an emerging standard by the Object Management Group (OMG).
- It is increasingly being used in the specification of business processes within major projects.
- There are several available software tools that range from fairly simple, free applications that work with common industry solutions such as Visio to extensive industrial strength solutions.
- The notation has a conversion method to the Business Process Execution Language for Web Services (BPEL4WS) which is emerging as a standard XML based approach for workflow control

IDMs are used to map process of building information modeling on different levels of details. There are IDMs describing the process globally on lower level of detail [11].

On the other hand there are information delivery manuals that focus on small part of building information modeling process like building programming [12] that shows only process map for building programming part of building information modeling process. Another example of information delivery manual that focuses on small part of building information modeling process is made for geographical referencing [13].

4.2 Common problems with process maps in Information Delivery Manuals

Examples of common errors in IDMs are already specified [14] as:

- Data objects should be linked with events or tasks using data associations, but in some cases in the existing PMs, data objects were connected using message flows.
- Regarding message events, when a message is outgoing from a task, a throwing-type message event should be used.
- Misuse of off-page connector symbols.
- When the start event is used, the end event must exist
- A process is a sequence of activities. Thus, activities in a process should be linked by the sequence flow from the beginning to the end.

Some of these problems can be also found in studied IDMs. Data objects are linked using message flows and activities in different lanes are not connected using sequence flows. Moreover Message Flows cannot connect to objects that are within the same Pool [4]. Using message flows is usually allowed for communication between processes in collaboration diagram.

Another found problem is using a start event without end event specification. If diagram is made as collaboration of processes there should be sequence flows definition in each pool. This issue usually comes from misunderstanding of process and collaboration diagrams. “In BPMN a Process is depicted as a graph of Flow Elements, which are a set of Activities, Events, Gateways, and Sequence Flows that define finite execution semantics” [4]. If whole diagram is modeled as a one process it may uses lanes within one pool. This assumes that there exists some control mechanism of whole process (within the pool) so activities should be connected by sequence flows from start to the end.

Another possibility is to make model as a collaboration of more processes. “A Collaboration usually contains two or more Pools, representing the Participants in the Collaboration. The Message exchange between the Participants is shown by a Message Flow that connects two Pools (or the objects within the Pools).” [4] Making the model as a collaboration of processes assumes that activities are connected by sequence flows in each pool and there is a communication between processes (pools, participants) that is modeled using message flows. Then activities in each pool should be connected using sequence flows from beginning to the end and meaning of different type of connectors should be clearly specified.

If there is need to model communication between participants it should be taken into consideration to make the model as collaboration or more processes and use message flows to show communication between them.

“Data Object elements **MUST** be contained within Process or Sub-Process elements.” [4] This means that data association can’t cross pool border. Another problem is also misuse of gateways. The problem may cause using inclusive gateways followed by exclusive gateways. In some cases this may result in creating multiple instances of the process during process execution without any synchronization. If condition flow outgoing from inclusive gateway is used there should be also condition definition. This means that there is no specification of cases in which the particular sequence flow is used.

Another problem in process diagrams for this Information Delivery Manual is not using gateways at all. “Gateways are used to control how the Process flows (how Tokens flow) through Sequence Flows as they converge and diverge within a Process.” [4]. It may result in problems understanding how the process flows.

5 Conclusion and discussion

Process maps for Building Information Modeling, which are used within BIM Execution Plan and Information Delivery Manuals, are usually based on BPMN standard. Process models often handle BPMN standard in a way that is in contradiction to the BPMN formal definition [4] or process models don't contain important information. The way of adaptation of BPMN standard often leads to simplification at the expense of process model accuracy. This may cause, that process models can be easily misunderstood.

Process models often contain problems. Some of them are in contradiction to the formal definition of BPMN standard. Typical problems are that data objects are connected by sequence flows, data object connectors are connected to sequence flows – not to activities, missing gateways for process synchronization or missing gateways in process diagrams at all, connecting objects by message flows within the same pool, missing sequence flows between lanes, missing end event and using data associations passing border of pool.

There are also some syntax inconveniences and information insufficiencies but it is up to the decision of process modeler if particular information will be added to the model or not.

Acknowledgement

This work was supported by the Grant Agency of the Czech Technical University in Prague, grant No. SGS16/200/OHK1/3T/11.

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