4th Construction Specialty Conference
4e Conférence spécialisée sur la construction

Montréal, Québec
May 29 to June 1, 2013 / *29 mai au 1 juin 2013*

Development of a model to select BIM implementation strategy with respect to the BIM maturity level of an organization

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Abstract: Building Information Modeling (BIM) is considered as one of the growing needs of current Architectural, Engineering and Construction (AEC) industry because it provides a wide variety of facilities to help AEC projects execution. AEC companies invest in BIM tools to reduce their costs and increase the quality and integrity of their projects. BIM implementation needs to be evaluated continuously to find the progress and possible problems and re-plan the adoption process and making new strategy. To succeed in BIM implementation in an organization, an effective strategy should be formed with regard to the current situation of an organization in BIM utilization and its level of BIM maturity. Different BIM maturity models have been developed to meet the needs of AEC organizations in BIM performance assessment. Also, there are different BIM implementation plans and strategies to increase the use of BIM in companies. However, assessment models and planning process are working separately and there is a lack of an efficient integrated "assessment and planning" model because any planning should be based on current situation. This paper aims to merge two processes of assessment and planning to a model to select BIM implementation strategy with respect to maturity level of an organization. The model defines different maturity levels and for each level, there is a proposed strategy including a set of recommendations to achieve a higher level. At this stage of research, an extensive literature review is finished. The next steps to complete this model will benefit from opinion of experts.

1 Introduction

Architectural, Engineering and Construction (AEC) organizations have found Building Information Modeling (BIM) very helpful to overcome many of their problems in projects. Using BIM, these companies will increase their competitiveness. BIM tools help them to reduce the costs of projects by identifying the conflicts before the construction phase. The errors will be eliminated and reworks are decreased. By reducing the number of conflicts and errors and avoiding modifications in the design and construction phases, many delays in projects are eliminated. Then the project will proceed faster and in the scheduled time (Eastman et al., 2008). McCueb et al. (2012) believe that BIM improves productivity in the design and construction processes and is based on collaboration between stakeholders and providing a data-rich model of the facility. Arayici et al. (2011) stated that by BIM adoption, efficiency is obtained through the piloting projects and the design process is improved by elimination of wastes and value generation. The virtual model of building will be updated during all phases of project and works as a building data base at the operation phase of building and makes better control and checking of building possible (Eastman et al., 2008).
The benefits obtained from BIM implementation depend on level of BIM competency and progress of AEC companies. To achieve a higher level, BIM maturity level of AEC organizations should be measured and an appropriate strategy should be developed to plan for BIM implementation with regard to the current level of BIM maturity and the needs and conditions of each company.

"Successful BIM adoption needs an implementation strategy" (Arayici et al., 2011). Jung and Joo (2011) believe that strategy and policy lead all activities of an organization and specify different requirements of information systems. Sebastian and van Berlo (2010) recommended that more research is needed "[…] to develop the most effective BIM take-up strategy based on the current performance level". For BIM organizational strategic planning, "the maturity of the aspects of an organization or BIM planning elements", that are important for its BIM implementation, should be measured (BIM planning facility owners).

Azhar (2011) understood that there is no clear consensus for BIM implementation or utilization. It's needed to standardize the BIM process and to develop guidelines for BIM implementation. Researchers and practitioners have to find appropriate solutions to overcome these challenges and other associated risks. Also, "BIM adoption would require a change in the existing work practice" (Gu and London, 2010). At operational level, " […] professional guidelines are required as part of the implementation strategy" (Arayici et al., 2011).

This paper reviews some of the current BIM maturity models and BIM implementation plans in AEC organizations and proposes a conceptual framework that integrates two processes of BIM maturity assessment and BIM implementation planning. Finally, the suggested conceptual framework supports a model that it's structure is presented.

2 Current practice

There are different BIM maturity matrices that have been developed for specific purposes such as BIM performance measurement and improvement (Succar, 2010b), assessment of the organization's maturity of the planning elements and planning to achieve desired level of maturity (BIM planning facility owners), qualification assessment of consultant and contractor in Indiana University (BIM Indiana University), BIM implementation strategic management (NIBS). All the maturity matrices help AEC organizations to understand their current BIM maturity level. But only the maturity matrix developed by Pennsylvania State University (BIM planning facility owners) is using the maturity assessment tool as a basis for BIM implementation planning and the other matrices don't recommend what should be done next. However, the process of implementation planning is very time-consuming and needs an expert committee that requires investment from the company. This can discourage AEC organizations to use this method of planning which is not fast and is expensive. Here is where an integrated model that merges two processes of BIM maturity assessment and BIM implementation planning into a unified model with pre-defined maturity criteria and pre-defined set of planning recommendations can help AEC organizations. This model should be the result of many experts' experiences and work as a fast and economic solution for BIM implementation planning. In this model the user chooses only the level of BIM maturity and organization information in each pre-defined criteria and the model recommends what to do for improving BIM maturity level.

3 Literature review

Some of the important previous efforts for evaluating BIM performance and assessing the BIM maturity levels are reviewed in this part. Then, to understand the available BIM implementation plans and strategies, the current models and frameworks are presented.

3.1 BIM maturity assessment

Taylor and Bernstein (2009) research revealed that the most of firms that implement BIM in their organizations will take a route in the adoption process and with increasing their experience. They use BIM firstly for visualization of their models and design. Then, they get benefits of coordination. Finally, BIM helps them to analyze the projects. BIM is also useful in integration of supply chain.

Succar (2010b) defines “BIM capability” as a basic ability to do a task, service or product. Three stages of BIM capability called “object-based modeling”, “model-based collaboration” and “network-based integration” are presented by Succar (2010a). According to Succar (2010a), “BIM Capability Stages (or BIM Stages) define the minimum BIM requirements - the major milestones that need to be reached by teams or organisations as they implement BIM technologies and concepts”. Succar (2010b) indicates the evolutionary improvement of BIM fields within these capability stages by a set number of maturity levels called “BIM Maturity Index”. According to Jung and Joo (2011), maturity shows the degree of advancement of BIM utilization. “Maturity Levels reflect the extent of BIM abilities, deliverables and their requirements as opposed to minimum abilities reflected through Capability Stages. A collation of process maturity levels from ‘immature’ to ‘highly mature’ is typically referred to as a ‘Maturity Model’” (Succar, 2010b). Succar developed a BIM Maturity Matrix that “is a knowledge tool which incorporates many BIM Framework components for the purpose of performance measurement and improvement” (Succar, 2010b). Succar (2010a) identified five metrics to measure BIM performance accurately and consistently. These metrics are: BIM capability stages, BIM maturity levels, BIM competency sets, Organizational Scales and Granularity Levels. The assessment process starts with selecting organizational scales and end with generating a capability and maturity report. Succar (2010a) defined five levels of BIM maturity: (a) Initial/ Ad-hoc, (b) Defined, (c) Managed, (d) Integrated and (e) Optimized. The ability to choose accuracy level of assessment is available only in BIM maturity matrix developed by Succar (2010b) among the other matrices in this paper. But working with this model is very time-consuming and highly skilled experts are needed. “However, since BIM capability stages are established when the minimum requirements are met, they cannot assess the abilities (or the lack of them) beyond these minimum requirements. BIM capability stages cannot detect variations in level of experience and modelling quality between two organizations that are both at the same BIM stage” (Sebastian and Van Berlo, 2010).

Ahuja et al. (2010) suggested a “benchmarking framework” to measure the extent of ICT adoption for building project management by small and medium enterprises (SMEs) in the construction industry. Their benchmarking framework is also “[…] a performance measurement tool, which measures efficiency of the organizations in implementing their strategies for ICT adoption for building project management”(Ahuja et al., 2010).

Indiana University has assigned a series of requirements for its construction projects with more than 5$M or greater and for the construction projects which have already used BIM. The design team has to use BIM in Indiana projects. BIM models must include geometry, physical characteristics and product data. Drawings and schedules needed for assessment, review, bidding and construction should be extracted from this BIM model. The project team including designers and construction team must use the Indiana University’s electronic project collaboration environment (BIM Indiana University). The “IU BIM Proficiency Matrix” must be submitted to the university by the design team before the contract award. This matrix is scored by the consultant based on the examples of previous projects which were using BIM. The IU can understand the BIM level of expertise and experience of the consultant by this maturity matrix. Interested contractors can submit an “IU BIM Proficiency Matrix” to the university at the bid submittal stage (BIM Indiana University). According to Succar, B., (2010b), “the matrix focuses on the accuracy and richness of the digital model (as an end-product) and has less focus on the process of creating that digital model”.

Pennsylvania State University has developed an organizational BIM assessment profile (BIM maturity matrix) for the purpose of assessing the organization’s maturity of the planning elements. This maturity matrix evaluates current and target strategy, BIM uses, process, information, infrastructure and personnel, and shows the level of BIM maturity by scoring the evaluation parameters (BIM planning facility owners). Expert committee must be employed for maturity assessment and then, BIM implementation planning by using the maturity matrix. This makes this model costly and time-consuming.

Sebastian and Van Berlo (2010) believe that the current BIM maturity assessment tools don’t work well “[…] as a standard benchmarking tool that is objective (i.e. perform qualitative and quantitative analyses), comprehensive (i.e. evaluates the model, modelling process and organization) and collective (i.e. commonly accepted in the construction industry)”. To solve this problem, they have developed the “BIM Quick Scan tool”. The unique specifications of this model are a combination of quantitative and qualitative assessments and getting benefit from expert, ability to compare two organizations and benchmarking the

performance of numerous organizations over time and considering "[…]'hard' and 'soft' aspects of BIM at corporate level, ICT infrastructure level and model/modeling level" (Sebastian and Van Berlo, 2010).

The National Building Information Model Standard (NBIMS) Capability Maturity Model (CMM) is developed for the strategic management in the BIM implementation of an organization (McCuen et al., 2012). CMM helps "[…] users gauge their current maturity level, as well as plan for future maturity attainment goals through a commonly accepted, standardized approach" (NIBS). The model evaluates 11 capabilities or area of interest based on their weighted importance (McCuen et al., 2012). Expert users are able to work with this matrix and it imposes time and cost to organizations for working with such a model. Sebastian and Van Berlo (2010) believe that CMM "… is an internal tool to determine the level of maturity of an individual BIM as measured against a set of pre-defined weighted criteria. CMM is not intended to be used to compare different models or BIM implementations. It is designed to measure the maturity of the model (including the modelling process), but not to measure the BIM maturity of the organization".

Each model is developed for a specific purpose. However, some factors such as accuracy and simple organization of assessment can encourage AEC organizations to use the current models more. Some factors such as long time of assessment or the need to highly skilled experts can make AEC firms reluctant to use such assessment tools. According to Ahuja et al. (2010), "the key to any successful measurement system is simplicity, both in the nature of the individual measures and in the means by which it is unified into a coherent focused whole".

It can be understood that there is a gap for BIM maturity assessment tools that incorporate accuracy and quickness and don't need trained experts.

3.2 BIM implementation plans and strategies

To understand BIM implementation planning, it's necessary to know BIM planning elements. BIM planning guide for facility owners v1.02 (2012) identified BIM planning elements including 'strategy', 'BIM uses', 'Process', 'information', 'infrastructure' and 'personnel'. 'Strategy' explains why BIM should be implemented. 'BIM uses' include BIM application "[…] for generating, processing, communicating, executing, and managing information about the facility" (BIM planning facility owners). 'Process' indicates the means and methods of BIM implementation that assess the current status and develop new processes and transition route. 'Information' element explains the required information from facility. 'Infrastructure' identifies required software, hardware and workspace for supporting the BIM infrastructure. 'Personnel' clarifies the roles and responsibility of people involved in the BIM implementation process.

BIM implementation plan and strategy is determining for the success of BIM adoption in an AEC organization. Jung and Joo (2011) emphasize on the managerial issue that influence the successful BIM utilization. They believe that strategy and policy lead all activities of an organization and specify different requirements of information systems.

Liu et al., (2010) through a survey understand that 'perceived benefits', 'external forces' and 'internal readiness' are the important factors that affect AEC industry in BIM adoption.

"The success of BIM depends on many factors, such as the size of the project, team members' BIM proficiencies, the communication of the project team, as well as other organizational external factors" (Barlish and Sullivan, 2012).

The computer integrated construction research program of Pennsylvania state university developed two guidelines for planning and executing BIM (BIM planning facility owners & BIM execution planning).

BIM project execution planning guide v2.1, (2010) "provides a structured procedure, […], for creating and implementing a BIM Project Execution Plan" (BIM execution planning). This procedure includes four

steps. At first, the values that BIM application will bring during project planning, design, construction and operational phases are identified. In the second step, the BIM execution process is designed by creating process maps. By the process map, the team will understand the overall BIM process and various processes of identified BIM application and will identify information exchanges between multiple entities. The process map also identifies the contract structure, BIM deliverable requirements, information technology infrastructure, and selection criteria for future team members. In the third step, information exchanges between project processes are defined by helping Information Exchange worksheet which is completed after designing and mapping the BIM process. Finally, the required infrastructure for developed BIM implementation plan is identified and defined "[…] in the form of contracts, communication procedures, technology and quality control to support the implementation" (BIM execution planning).

After the BIM project execution planning guide v2.1 (2010), BIM planning guide for facility owners v1.02 (2012) was presented "[…] to more effectively plan the integration of BIM throughout the organization and the lifecycle of a facility" (BIM planning facility owners). This guide has a different perspective and focuses on an organizational level of BIM planning for facility owners. Three additional planning procedures are presented to develop a cohesive strategy of BIM implementation. Firstly, 'BIM organizational strategic planning' evaluates the current organization status and provides BIM goals and visions, and it prepares a transition plan for the BIM implementation. Then, 'BIM organizational execution planning' develops detailed BIM implementation plan. Next, 'BIM project procurement planning' addresses the contractual issues and creates requirements and BIM planning template, and finally, BIM project execution planning guide v2.1 (2010) is employed to maximize the value of BIM (BIM planning facility owners).

BIM planning guide for facility owners v1.02 (2012) of Pennsylvania state university (BIM planning facility owners) considers the current and desired level of maturity and advancement strategy. Multiple sessions and workshops are required for the development of a detailed roadmap (BIM planning facility owners). It can be time-consuming and this method doesn't work as a fast BIM implementation planning model.

From the literature, it is understood that for an efficient BIM implementation planning, presence of expert committee and trained personnel for diagnosing the organization status and needs is required. In the other word, a massive project must be carried out to develop BIM in an organization. There is a gap in BIM implementation planning models that reduces the time of planning and decrease the need for expert committee by using pre-defined solutions that can be proposed based on the status of organization in BIM maturity level. Also, it is important for this solution to clarify how to move from current level to a higher level.

Although, some efforts have been done in BIM maturity assessment to develop maturity models with pre-defined measurable items that can be scored based on their maturity level, but most of them have been stopped in evaluation phase and are not developed to planning stage. Although the guideline developed by Pennsylvania state university (BIM planning facility owners) goes beyond the assessment phase and suggests BIM planning based on maturity level, however, the complicated process of planning takes huge amount of time and expertise and cannot be employed easily by AEC organizations. In addition, this model doesn't provide information on how to achieve a target level of maturity. This is the point that BIM implementation planning ties with maturity assessment and pre-defined structure of maturity models can be developed to pre-defined sets of BIM planning recommendations.

4 Integration of BIM maturity assessment and BIM implementation planning

The level of BIM maturity differs company by company and even among different players of a company (Grilo and Jardim-Goncalves 2010). According to Mayo et al. (2012) research, BIM execution maturity of the building owners is still in its infancy.

To work with BIM efficiently, all players must have a minimum level of BIM maturity and collaborate in an integrated environment. They can identify their deficiencies and level of BIM maturity by using different maturity models. However, to overcome the problems and achieving a higher level of maturity, AEC

organizations need to agree on a shared workflow and dataflow. It is suggested to document these and other project issues in a BIM implementation plan.

For BIM organizational strategic planning, the maturity of the aspects of an organization or BIM planning elements that are important for its BIM implementation should be measured (BIM planning facility owners).

Sebastian and Van Berlo (2010) recommended that more research is needed "[…] to develop the most effective BIM take-up strategy based on the current performance level". Jung and Joo (2011) believe that strategy and policy lead all activities of an organization and specify different requirements of information systems.

"Successful BIM adoption needs an implementation strategy" (Arayici et al., 2011). However, at operational level, professional guidelines are required as part of the implementation strategy (Arayici et al., 2011).

Azhar (2011) understood that there is no clear consensus for BIM implementation or utilization. It's needed to standardize the BIM process and to develop guidelines for BIM implementation. Researchers and practitioners have to find appropriate solutions to overcome these challenges and other associated risks. Also, "BIM adoption would require a change in the existing work practice" (Gu and London, 2010).

By reviewing the literature, it is understood that there is a lack of a decision making tool that incorporates BIM maturity assessment and BIM implementation planning processes to help AEC organizations with developing BIM implementation plan.

This paper suggests a conceptual framework of integration of BIM maturity assessment and BIM implementation planning. The framework can support an integrated model of assessment and planning. The purpose of this unified model is to evaluate the maturity level of AEC organization and to consider the identified maturity level in BIM implementation planning. This model works as a decision making tool that asks entry data and calculates the BIM maturity level. Then, based on the entered information and calculated maturity level, the model proposes a set of recommendations for BIM implementation planning. To produce this model, three sets of information must be identified:

- First, BIM maturity factors and entry factors such as organization specifications like organization scale, financial afford of organization, external essentials of organization like client expectations and regulations, targeted level of maturity.

- Second, the relations and relative importance of these factors.

- Third, BIM implementation programs that can be recommended based on the entry factors and their relations and BIM maturity level.

The factors and working mechanism of this model will be developed by getting benefits from literature review and collecting data from experts to determine the entry data that are criteria of a decision making tool. Based on these criteria, the maturity level of an organization and optimum level of maturity will be identified. The relations and relative importance of these criteria affect the recommended BIM implementation plan. After finding all the criteria, their relations and relative importance are asked from experts by data collection methods such as interview and questionnaire. Then, they recommend that by considering the maturity level and specifications of each organization, what plans should be carried out to achieve an optimum level of BIM maturity. The optimum level depends on the organization's conditions. The expected contribution is a decision making model with predefined input criteria and recommended output plans. The identification of criteria and their relations and plan recommendations are the result of experience of many experts that are collected in a decision making tool. Finally, the model is validated by studying real case studies. A schematic model of this framework is shown in Figure 1.

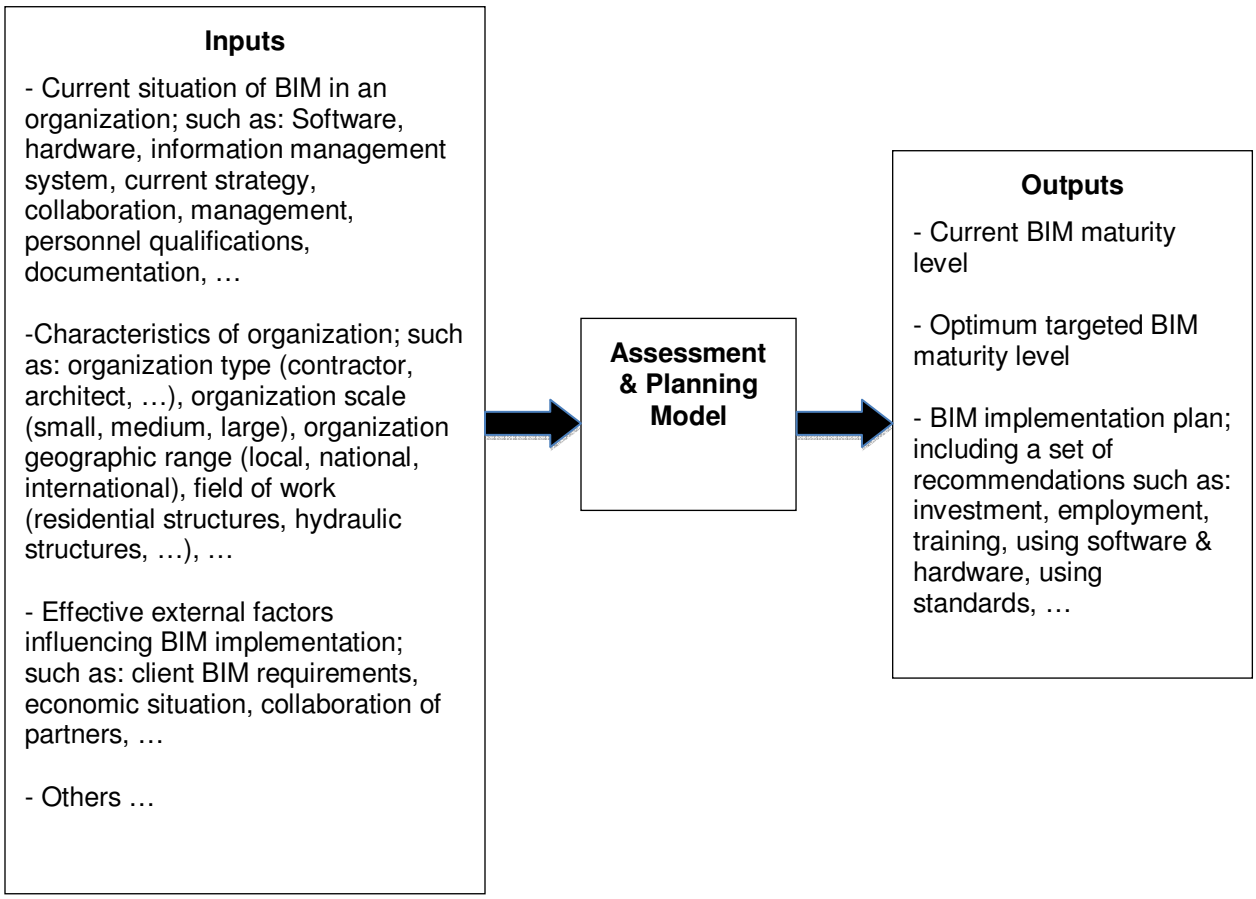

Figure 1: Schematic model of BIM maturity and planning model

To better understand the working mechanism of this model, a very simple hypothetical example of a report provided by this model is presented in Figure 2. It is noticeable that the final model will have a large number of input data and output recommendations. They will be identified through literature review and according to information provided from experts in interviews, questionnaires and other data collection techniques.

ex: input

If (X1<Maturity level of Criteria 1<X2)
and
(Maturity level of Criteria 7<X3)
and
(Maturity level of Criteria 22=X4)
and
(X5<company's turn over<X6 CAD)
and
(using software Y1 : yes)
and
(company type: contractor)
and
(field of work: highrise building)
and
.....
or
.....

X(1,2,...): variable number
Y(1,2,3): variable name
Z(1,2): variable number (0≤ Z(1,2) ≤45)
& (Z1 ≤ Z2)

output

then your total BIM maturity level is : Z1/45
your targeted total BIM maturity level should be : Z2/45
It's recommended to:
improve Criteria 1 by :
-developing a X7 years plan for BIM development
improve Criteria 7 by :
-investing up to X8 CAD in IT department
-employing X9 programers in IT department
-using e-documentation system Y2
improve Criteria 18 by :
-training IT personnel in software Y3 for X10 hours
.....

Figure 2: hypothetical example of model's report

5 Conclusion

AEC organizations use BIM to overcome many of their problems in projects. They reduce their costs and increase the quality and integrity of their projects. Many benefits are achieved by employing BIM tools. To increase the BIM utilization and efficiency in AEC organizations, BIM implementation needs to be evaluated continuously to find the progress and possible problems and re-plan the adoption process and making new strategy. Different BIM maturity models have been developed to meet the needs of AEC organizations in BIM performance assessment. Also, there are different BIM implementation plans and strategies to develop the use of BIM in companies. However, most of BIM maturity assessment models and planning processes are working separately and there is a lack of a fast and integrated "assessment and planning" model because every planning should be based on current situation. This paper suggests a conceptual framework of integration of BIM maturity assessment and BIM implementation planning. The framework can support an integrated model of assessment and planning. The purpose of this unified model is to evaluate the maturity level of AEC organization and to consider the identified maturity level in BIM implementation planning. To develop this model, three sets of information must be identified. First, BIM maturity factors and entry factors such as organization specifications like organization scale, financial afford of organization, external essentials of organization like client expectations and regulations, targeted level of maturity. Second, the relations and relative importance of these factors. Third, BIM implementation programs that can be recommended based on the entry factors and their relations and BIM maturity level. Developing such a model is a part of this research that gets benefit from literature review, opinions of experts and a decision making model. At this stage of research, an extensive literature review is finished. The next step is collecting data from experts to determine the entry data that are criteria of a decision making tool. These criteria identify the maturity level of an organization and optimum level of maturity. The relations and relative importance of these criteria influence the recommended BIM

implementation plan. After finding all the criteria, the experts identify the relations and relative importance of criteria in this model. Then, based on the maturity level and characteristics of each organization, the experts suggest that what plans should be carried out to achieve an optimum level of BIM maturity. The optimum level depends on the organization's conditions. The expected model is a decision making tool including predefined criteria as input data and recommended plans as output. The criteria and their relations and recommended plans are identified during data collection from experts. Finally, the model is validated by real case studies.

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