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# Building Information Modeling implementation through maturity evaluation and Critical Success Factors management

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**Abstract**

Building Information Modeling has become a widely accepted tool used to overcome the many hurdles that currently face the Architecture, Engineering and Construction industries. However, implementing such a system is always complex, and the recent introduction of BIM does not allow organizations to build their experience on acknowledged standards and procedures. Moreover, data on implementation projects is still disseminated and fragmentary. The objective of this study is to develop an assistance model for BIM implementation. Solutions to evolve towards a better integrated and better used BIM are proposed, taking into account the different maturity levels of each organization. Indeed, based on the widely recognized Critical Success Factors, concrete activities helping implementation are identified and can be undertaken according to a previous maturity evaluation of an organization.


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*Keywords:* Building Information System; Project management; Critical success factors; Information systems; Maturity.

## 1. Introduction

Building Information Modeling by its very nature falls into the category of collaborative tools that aim for data interoperability and life cycle management. Integrated information management has become an increasing matter of concern despite the fact that ERP solutions exist since the seventies. At the same time, numerous studies on 3D modeling have shown its benefits; these are especially noteworthy in the aircraft industry [1]. After a couple decades of efforts focused on 2D-modeling from the Architecture, Engineering and Construction (AEC) industry, interest in a new way of leading projects finally grew in the late nineties, and the BIM initials first appeared in 2004 in the normal AEC vocabulary [1].

BIM has now proven its potential in terms of solving some of the major problems encountered in the AEC industry. Surprisingly, the latter has seen its productivity stagnate and even shrink a little from 1964 to now, whereas other industries have performed much better [2]. Explanations for this can be found in the high amount of small firms in this sector, unable to invest to improve their practices, or in the complexity of setting up an appropriate environment


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for numerous stakeholders to work together. Another relevant figure puts to light the fact that interoperability deficiencies increase construction costs by $6.12 per square foot [3]. Arayici and al. sum it up, declaring that the AEC industry needs to find a way to raise productivity, efficiency, quality and sustainability and lower lifecycle costs, lead times and duplication [6].

As a result, considering the range of hurdles that the AEC industry is facing, BIM seems to be a tool that is able to provide some solutions to overcome them. Thanks to the mandatory business process reengineering that BIM introduces, firms can save time and money, produce more accurate and exhaustive building models and keep track of the information created during their projects. BIM indeed allows real-time communication based on a multidimensional model and permits some additional analysis such as quantity takeoffs or clash detection. Authors precisely examine the benefits of a BIM adoption [1,4,5,20] and simultaneously legitimize an interest in BIM by the industry.

Despite this promising progress, however, BIM tools have not yet fully delivered their capabilities to professionals in this sector. The explanation for this limited introduction can be found in several factors, such as stubbornness in some firms about keeping the old CAD ways of working alive [7], change management [6,8] or the need to adapt existing workflows in a lean oriented manner [6]. Consequently, a transition, as well as technical mindset, is compulsory to achieve the benefits of BIM. Another barrier to the widespread use of it among the AEC industry is the lack of guidance for this transition and the poor amount of studies rooted in reality to support firms in their adoption [6]. The most successful companies in this kind of project are the ones that have paid particular attention to having a clear strategy to rule them [9]. By extension, implementation and adoption projects are smoother when ruled by a detailed plan and well-defined objectives, and progress needs to be made on that [19]. Thus, researchers can take part in a common trend towards the establishment of industry standards and best practices in that context and bring their support to a better integration of BIM in the industry.

Recognizing this need, the objective of this paper is to propose a support model for BIM adoption based on the BIM maturity of a company. The remainder of this article is organized as follows. Section 2 presents a brief review of the studies on the existing implementation procedures and how it can be assisted. Section 3 describes the model; the three different elements in the model and the linkages between them are depicted. After some consideration about how the model will be validated, we conclude with limitations and improvements that could be made.

## 2. Background work

As successful implementation needs to be framed by a well thought-out strategy, it is of interest to look into the literature to find out which studies have been realized so far and in which way it could assist projects. BIM integration is undoubtfully a complex objective to achieve and involves multiple issues that have to be taken into account differently according to each organization context.

BIM implementation can be seen from several “views”, depending on what the project owner’s aim is [10]. Technological issues can be the main concern [6,11,12,13], as well as the new functionalities allowed by the implementation [11,12] or its maturity [14]. Hartmann and al. [10] also note that the industry suffers from a poor amount of practical experiments led on theoretical basis and insist above all on the need to adapt BIM to the company’s requirements, and not the opposite, in order to trigger the least resistance to change possible, and to disrupt the existing workflows as little as possible [18]. It also implies that studies often focus only on very aggregate levels and that firms lose from the lack of concrete advice. The point is reinforced by Davies and Harty [15] and their approach toward on-site implementation.

In addition to the definition of the expectations about BIM use, it is also relevant to assess its maturity in the organization with levels depicted in [7, 14]: object-based modelling, model-based collaboration and network-based integration. This evaluation can be used to enlighten firms about their current situation so they can prioritize the jobs to be done. It is indeed a central aspect in order to evolve towards a wider integration of BIM in the industry, as demonstrated by [9] with a description of the *Capability Maturity Model* (CMM). This tool has been developed by the *National Building Information Modeling Standard* (NBIMS) and provides a maturity index through an organized assessment of BIM use and happening business processes in a company. The final mark obtained with the CMM is built from several criteria about the main issues of BIM.

Moreover, significant challenges can be clearly isolated, which can contribute to better preparation for the implementation if they are known in advance. Organizational culture, education and training, and information management seem to be three essential factors [7]. A roadmap then integrates every issue encountered during implementation. Furthermore, information management is often stated as a complex matter that has to be taken with much care, notably with the concepts of information stewardship, data responsibility and data accuracy [9]. The importance of the external stakeholders in the BIM leap forward [1,9] can also be cited.

Within the context of implementation procedures and recommended practices, Arayici and al., [6] propose an iterative model for adoption used in a case study and by mimicking the lean principle of Plan, Do, Check, Act. This strategy is, however, restrained to a single case and does not exhaustively describe the steps to follow. It has also been applied in the specific situation of an implementation for remote projects [16]. Migilinskas and al., [4] prefer to focus their research on the identification of benefits, obstacles and challenges of an implementation, through different case studies. On the other hand, the well-known Autodesk Inc. company produced a BIM deployment plan [17]. This plan tackles multiple issues of a BIM implementation project, even if some others like change management are completely left aside. Therefore, this proposal has the major drawback of being one-sided and Autodesk-centered. Another interesting approach constructs a BIM adoption framework, which integrates challenges that were pointed out by professionals in specific interviews [13].

Instead of trying to treat the matter of implementation fully, some authors stay centered on a particular problem so they can examine it in more depth. Selecting the right BIM tool that fits with the company expectations [6], change management during an implementation project [8] or workflow reengineering [18] are examples.

With regard to that article and its motivations, it is also relevant to investigate which factors could influence how well a BIM implementation goes. Due to the similarities between BIM and ERP software, a close look at the dedicated literature is of importance. Many research projects have been carried out on the Critical Success Factors (CSF), which are elements that are seen as essential and that facilitate achievement related to a BIM adoption project [21, 22, 23, 24, 25]. As far as BIM is concerned, studies have been conducted with a similar objective, but no broad consensus has been reached. Analysis on which points gave an edge to acknowledged projects [26], driving factors [11] or key issues [9, 13] tend to spread.

In conclusion, previous BIM related studies do not provide complete and concrete answers to the issues raised by BIM adoption and utilization. On one hand, exhaustive implementation procedures are relatively non-existent and case studies are, conversely, not general enough. On the other hand, critical success factors on those kinds of projects are poorly documented. With the significant role that maturity has to play in the ways to properly lead an implementation, the objective of this paper is to propose a model to support BIM adoption and further use based on a maturity assessment, linked to critical success factors, themselves finally linked to concrete actions, as imagined in Françoise's work [25].

## 3. Model

### *3.1. Literature review strategy*

The approach used to perform the literature review involved several steps. At first, in order to look at the problem as a whole, research was centered on works related to BIM implementation and not only BIM implementation methodologies. As the results highlighted the weakness of representation of adoption procedures, the focus has progressively shifted to this particular matter as well as on how to help industry integrate BIM into their practices. The significant amount of data scattered in case studies has pointed out that efforts to rationalize it should be made. The objective of the literature study thus has become twofold: on the one hand, to clarify factors that have a strong influence on implementation projects, and on the other hand, to harness several concrete examples of BIM adoption and practical advice to expose actions to lead in that context. Furthermore, each action can be connected to a success factor, reflecting the fact that it specifically fosters the mastery of this factor, as Françoise designed the relation in his work on ERP [25]. Consequently, the literature exploration turned towards defining critical success factors for BIM adoption and collecting empirical studies or proposals for actions to be undertaken in such projects. However, the decision of staying focused on factors deeply influencing both implementation and utilization was made. Indeed, companies suffer from those two matters and it is wise to bring to the table solutions that best bridge these gaps. The resolution of adding maturity in the model has also been taken, the assumption that is revealed through literature being that it plays a determining role in implementation. The CMM tool presented previously appeared immediately as a relevant answer because of its ability to assess maturity in an organization.

### *3.2. Capability Maturity Model*

The *Capability Maturity Model* as introduced above is conceived to assess building an information model and the processes associated with creating and maintaining it [9]. It originates from the *National Building Information Model Standard* (NBIMS), an American organization working for the adoption of standards and best practices among the AEC industry to make it more productive, and has proven its reliability in terms of variance of the results (study led by NBIMS Testing Team [9]). It is a measure of the quality of a BIM implementation and an indicator of how profound BIM implementation is in the industry [28]. It has been applied in different engineering domains before being adapted for construction. Though it is not really a model, it provides a maturity index through an organized assessment of BIM use and happening business processes. This evaluation is distributed into eleven criteria, as presented in Table 1, themselves marked from one to ten, each rank describing a particular condition of the company for the assessed criteria. Then, a global mark of one hundred eleven is obtained. The organizations willing to use the CMM to get an overview of their use of BIM can therefore be aware of their global performance as well as their abilities in each of the issues, so that they can react according to their weaknesses. In this regard, an analysis took several successful BIM implementation projects to see in which criteria they were good or poor [28]. A brief description of the ten levels included in the first category, Data Richness, is shown in Table 2.

### *3.3. Critical Success Factors*

As explained above, the model developed is grounded in the research conducted by Françoise [25] and on the relationship between success factors and actions that he imagined, with the difference that this is applied to BIM implementation projects, with an additional focus on factors also having an impact on utilization only, and that maturity is deliberately involved in it. Then, one first thing to obtain was a precise list of critical success factors. With literature guiding the thinking process for this task, the set of CSFs retained is presented in Table 3.

Table 1. Capability Maturity Model categories (adapted from [9,27])

| CMM categories |
|---|
| Data Richness |
| Life Cycle Views |
| Roles or Disciplines |
| Change Management |
| Business process |
| Timeliness/Response |
| Delivery Method |
| Graphical Information |
| Spatial Capability |
| Information Accuracy |
| Interoperability/IFC Support |

Table 2. Description of the CMM criteria: Data Richness (adapted from [9,27])

| Data Richness Maturity Level | Description |
|---|---|
| 1 | Basic Core Data: BIM has been introduced in the company but there is no data or little basic data to load. |
| 2 | Expanded Data Set: Some more data can be entered, but it is still early in the maturity. |
| 3 | Enhanced Data Set: The model is reliable for basic data. |
| 4 | Data Plus Some Information: Data becomes information. |
| 5 | Data Plus Expanded Information: Data begins to be authoritative and the primary source. |
| 6 | Data with Limited Authoritative Information: Metadata is introduced, so that information is best available. |
| 7 | Data with Mostly Authoritative Information: Data is seen as reliable and authoritative, data checking progressively becomes useless. |
| 8 | Completely Authoritative Information: Metadata is entirely linked to the information, which is the authoritative source. |
| 9 | Limited Knowledge Management: Knowledge Management strategies are set up and information is beginning to be linked. |
| 10 | Full Knowledge Management: Authoritative information is completely linked to Knowledge Management strategies. |

As the literature study was going on, several other success factors were identified, such as the essential need for a clear strategic vision to achieve BIM benefits [1, 9, 17, 21, 22, 25]. However, it did not appear as though those factors clearly had any effect on the utilization of BIM, whereas the model intended to include this aspect. Further examination with CSFs correlated to CMM will bring more clarification.

Table 3. Critical Success Factors for a BIM implementation project, with additional impacts on utilization

| CSFs list | Description | Literature references |
|---|---|---|
| Business Process Reengineering | Efforts invested to deeply review the current processes and reorganize workflows and ways of doing things in a BIM oriented manner. | [1,7,9,13,18,25] |
| Standardization | Introduction of standards and metadata to better handle information and to tend towards an industry wide paradigm about BIM use. | [1,9,13,17] |
| External stakeholders involvement | Ability to involve every business partner in the BIM dynamic and get them to facilitate the transition. | [1,9] |
| Education to Information Management | Awareness and education of the internal members of the organization to information management practices and philosophy. | [7,9] |
| Technical Education | Formation and education of the internal members on the use of the different tools composing the BIM and on the new processes. | [7,17,22] |
| System selection process | Proper selection of BIM tools fitting adequately the needs of the organization. | [1,7,17,21,22] |

### *3.4. Connections between CMM, CSF and actions*

Three entities constitute the model: the CMM, a CSF list and actions. CMM categories can be seen as some of the driving factors for using BIM successfully. However, because it has been designed to assess maturity and because the intention for the model was to generally tackle the hurdles met among the industry to adopt BIM, those categories have been transcribed into CSFs, which form the first relationship between the three parts. As a result, each CMM criterion is associated with one or several CSF(s), meaning that those CSFs can be used as levers to progress in the criterion in question. It is also relevant to note that one CMM criterion can be linked to several CSFs, which shows that multiple issues are included in each category of the formatted CMM tool and justify the linkage. Furthermore, this connection permits the amount of CSFs in the list to be lowered, some of them with only very limited influence, and in the meantime to highlight the significant ones.

The second pairing is made between CSFs and actions: for every success factor, a set of actions is proposed. Correctly implementing those actions is bound to make the organization better with the corresponding factor. Justifications for the actions are found in the literature among the different case studies and proposals from experts. Figure 1 summarizes the interrelations within the model.

The intended use for the model is plural. One hierarchical approach prescribes that an organization willing to implement BIM or to update the state of progress of a project that has already been started begins with the CMM evaluation. From there, this organization can identify its strengths and weaknesses and focus its work on the criteria where it performs poorly. This work can in turn be driven by different CSFs as defined in the model and linked to specific CMM categories. Finally, actions are proposed and can be undertaken according to the recommended CSFs. The result of that approach is expected to be an enhancement of the situation in the targeted criteria. Also, only some parts of the model can be used. CSFs and actions are interesting on their own, on the one hand to know the issues involved in a BIM implementation and the other to know what to do. The entire process introduced with the model does not necessarily need to be followed.

### *3.5. Actions*

Finally, there are the actions in the model. The purpose of these is to concretely assist BIM implementation projects. Case studies have been investigated in order to extract what did work for companies from different places in different environments, as well as recommendations made by expert authors on the subject.

As a result, a lot of information about things to do in certain contexts has been gathered and then rationalized through the connection to the CSFs from the list built earlier. The following table illustrates three possible actions for every proposed factor, which come from the previous literature study.

Table 4. Actions associated with CSFs

| Business process reengineering | Literature references |
|---|---|
| Build models for "As Is" and "To Be" states, both for business processes and information flows. | [9] |
| Rationalize the production of data by assigning a unique role to get them, where it makes the most sense. | [9] |
| Track information by mapping out who the successive hosts are. | [9] |
| Standardization | Literature references |
| Introduce metadata to better manage the information. | [9,17] |
| Organize information so that users' access can be controlled. | [17] |
| Define standards for the components and exclusions of building models. | [17] |
| External stakeholders involvement | Literature references |
| Adapt contracts to include BIM skills and expertise. | [1] |
| Adapt deliverables to include BIM documents and BIM analysis. | [1] |
| Communicate regularly with the partners on the organization's information needs and formats for these data. | [1] |
| Education to information management | Literature references |
| Increase awareness of the fact that information has to be synchronized with workflows. | [9] |
| Educate about information stewardship and responsibilities about information. | [9] |
| Force electronic transfers of information and prohibit paper-based models to communicate. | [9] |
| Technical education | Literature references |
| List every current and needed skill, who and how many people master each skill, and their average level. | [17] |

| | |
|---|---|
| List training needs for each skill, who and the length of the planned training. | [17] |
| Set up a training program for new members in the organization. | [7] |
| Selection | Literature references |
| List which functions are priorities and make sure to adapt software and tools. | [6,17] |
| List which analysis the organization wants to be able to make and make sure to get adapted software and tools. | [6,17] |
| Develop test cases to assess each potential BIM tool. | [6] |

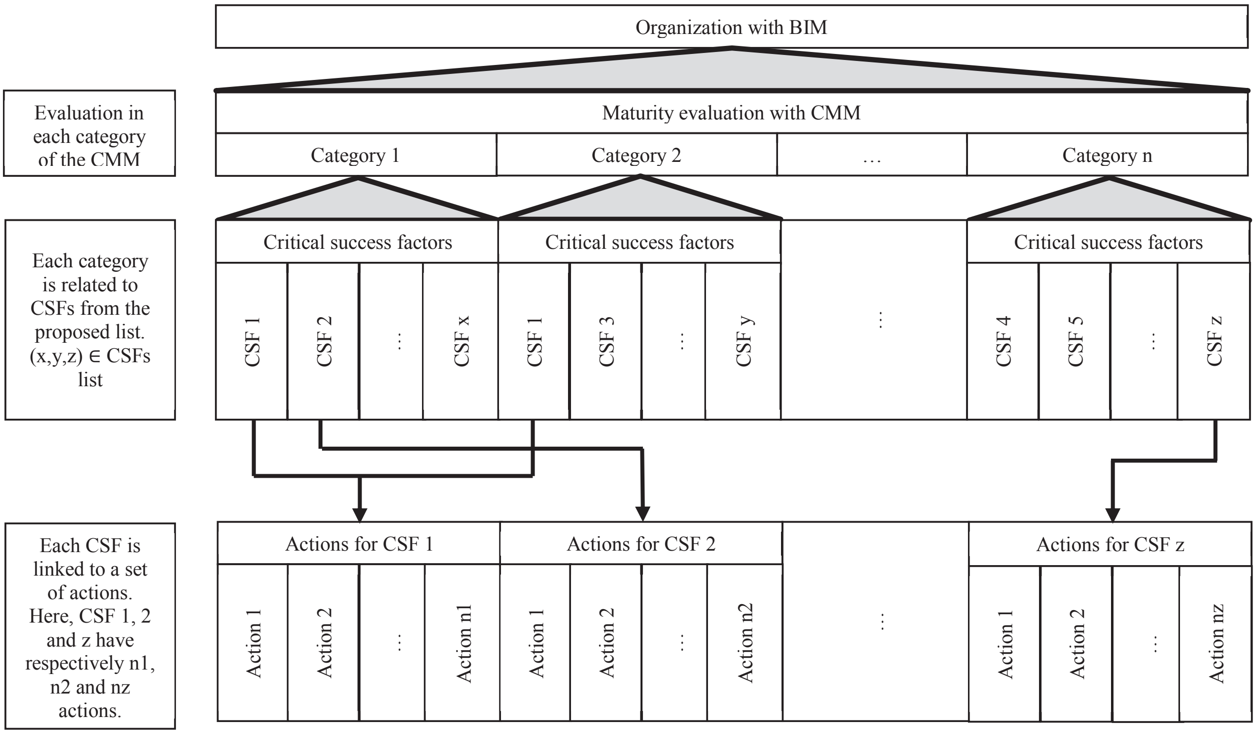


Fig. 1. Interaction model

### *3.6. Validation*

To legitimize the model and the related work, the planned validation is based on interviews with a panel of BIM experts from industry. These interviews will aim to evaluate how relevant the proposed success factors and actions are and whether some crucial issues are missing. To do so, the DELPHI method has been selected. A questionnaire has been built, that asks the responders to assess from one to five the significance of each CSF at first, and then of each action linked to the CSFs. In line with the method, once every responder has filled in the questionnaire, the results are added in the questions; i.e. an average evaluation of the relevance for each item. Then, the questionnaire will be filled up a second time and will provide the final result.

Through these interviews, it will be possible to determine what should be excluded from the model as well as what should be added. Notably, it is expected that because of their focus on implementation, some other factors will be considered important by experts.

As the links between CMM and CSFs and between CSFs and actions were quite obvious to imagine, the choice to not discuss that in a structured way has been made. However, informal debates about this particular point are expected to be made during the interviews.

## 4. Conclusion

In response to the difficulties encountered in adopting and efficiently using BIM in industry, this paper proposes a model that brings together BIM maturity, plays a preponderant role to approach implementation, critical success factors and practical actions, as depicted in the Françoise article for ERPs systems [25]. In addition to partly summarizing the existing literature on this subject, the contribution made was fulfilling the lack of guidance for BIM implementation projects by providing a structured approach to it.

However, several improvements could be imagined and applied to this work. Exhaustivity is a first limitation. In fact, as mentioned earlier, the emphasis is on issues that have a strong impact on both implementation and utilization. This choice was made because of the link between CSFs and CMM, which leaves out many implementation questions and assesses maturity and the current use of BIM. To stress critical success factors, it would be a great leap forward to determine and validate a list that entirely takes into account every issue implied in an adoption. This task has begun in the work presented in this paper, but is not the principal objective and no validation or any examination by experts was performed. Once again, taking a close watch on literature dedicated to ERPs would be one approach of interest, as much research deals with the subject and has proven to be realistic and complete.

Moreover, the model does not aim to provide a full methodology for adoption through its actions. They have been designed to be activities that permit an improvement in the concerned CSF, but do not drive an organization through the whole process of implementation. This defect is explained by the different situations organizations can be in when evaluating their maturity and the complexity involved in answering to each one of these states with a structured plan. Therefore, it would be an improvement to define precise things to do and to prioritize actions according to the CMM results.

CMM is also a matter of concern in keeping an accurate and updated model. Indeed, NBIMS regularly adjusts this tool to the AEC industry. The latest version describes the I-CMM, or Interactive Capability Maturity Model, based on the initial CMM, but involves users differently [27]. An alignment between the model and CMM seems to be necessary to keep pace with the trends in industry.

Several other additions could be of interest. For instance, adding a level of difficulty for the actions would indicate where to begin or the amount of effort that should be invested by the firms using the model.

Finally, validation stays in the remaining part of the research and is necessary to truly justify the content of the model. Further work will surely fill this gap. Expert panels will have to play a crucial role in this process. Above all, the amount of experts and their backgrounds will be determining elements in having accurate validation.

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## References

[1] Eastman C, Teicholz P, Sacks R, Liston K. BIM handbook: A guide to building information modeling for owners, managers, designers, engineers, and contractors. Second edition. Hoboken (New Jersey): John Wiley & Sons; 2011.

[2] Teicholz P. Bridging the AEC/FM Technology Gap. IFMA Facility Management Journal Apr/Mar 2004.

[3] Gallaher MP, O'Connor AC, John J, Dettbarn L, Gilday LT. Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry. Gaithersburg, MD, National Institute of Standards and Technology, U.S. Department of Commerce Technology Administration 2004.

[4] Migilinskas D, Popov V, Juocevicius V, Ustinovichius L. The Benefits, Obstacles and Problems of Practical Bim Implementation. In: Proceedings of the 11th International Conference on Modern Building Materials, Structures and Techniques: MBMST; 2013 May 16-17; Vilnius, Lithuania.

[5] Bryde D, Broquetas M, Volm JM. The project benefits of Building Information Modeling (BIM). International Journal of Project Management

2013;31(7):971-80.
[6] Arayici Y, Coates P, Koskela L, Kagioglou M, Usher C, O'Reilly K. Technology adoption in the BIM implementation for lean architectural practice. Automation in Construction 2011;20(2):189-95.
[7] Khosrowshahi F, Arayici Y. Roadmap for implementation of BIM in the UK construction industry. Engineering, Construction and Architectural Management 2012; 19:610-35.
[8] Langroodi BP, Staub-French S. Change management with Building Information Models: A case study. Construction Research Congress 2012: Construction Challenges in a Flat World. Proceedings of the 2012 Construction Research Congress 2012:1182-91.
[9] Smith DK, Tardif M. Building Information Modelling: a Strategic Implementation Guide for Architects, Engineers, Constructors and Real Estate Asset Managers. New Jersey: John Wiley & Sons; 2009.
[10] Hartmann T, van Meerveld H, Vossebeld N, Adriaanse A. Aligning building information model tools and construction management methods. Automation in Construction 2012;22:605-13.
[11] Jung Y, Joo M. Building information modelling (BIM) framework for practical implementation. Automation in Construction 2010;20(2):126-33.
[12] Froese T. The impact of emerging information technology on project management for construction. Automation in Construction 2010;19:531-8.
[13] Gu N, London K. Understanding and facilitating BIM adoption in the AEC industry. Automation in Construction 2010;19(8):988-99.
[14] Succar B. Building information modelling framework: a research and delivery foundation for industry stakeholders. Automation in Construction 2009;18:357-75.
[15] Davies R, Harty C. Implementing 'Site BIM' : A case study of ICT innovation on a large hospital project. Automation in Construction 2013;30:15-24.
[16] Arayici Y, Egbu C, Coates P. Building information modelling (Bim) implementation and remote construction projects: Issues, challenges, and critiques. Electronic Journal of Information Technology in Construction 2012;17:75-92.
[17] Autodesk, Inc.. Autodesk BIM Deployment Plan: A practical framework for implementing BIM 2010.
[18] Tsai M, Matin A, Kang S, Hsieh S. Workflow re-engineering of design-build projects using a BIM tool. Journal of the Chinese Institute of Engineers 2014;37(1):88-102.
[19] Arayici Y, Ghassan Aouad G, Ahmed V. Requirements engineering for innovative integrated ICT systems for the construction industry. Construction Innovation 2005;5(3):179–200.
[20] Manning R, Messner J. Case studies in BIM implementation for programming of healthcare facilities. ITcon 2008;13:246-57.
[21] Motwani J, Subramanian R, Gopalakrishna P. Critical factors for successful ERP implementation: Exploratory findings from four case studies. Computers in Industry 2008;56(6):529-44.
[22] Umble EJ, Haft RR, Umble MM. Enterprise resource planning: Implementation procedures and critical success factors. European Journal of Operational Research 2003;146(2):241-57.
[23] Ngai EWT, Law CCH, Wat FKT. Examining the critical success factors in the adoption of enterprise resource planning. Computers in Industry 2008;59(6):548-64.
[24] Motwani J, Mirchandani D, Madan M, Gunasekaran A. Successful implementation of ERP projects: Evidence from two case studies. Int. J. Production Economics 2002;75(1-2) :83-96.
[25] Françoise O, Bourgault M, Pellerin R. ERP implementation through critical success factors' management. Business Process Management Journal 2009;15(3):371-94.
[26] Tsai M, Matin A, Kang S, Hsieh S. Lessons learnt from customization of a BIM tool for a design-build company. Journal of the Chinese Institute of Engineers 2014;37(2):189-99.
[27] buildingSMARTalliance, National BIM Standard. United States National Building Information Modeling Standard Version 1 2007.
[28] McCuen TL, Suermann PC, Krogulecki MJ. Evaluating Award-Winning BIM Projects Using the National Building Information Model Standard Capability Maturity Model. Journal of Management in Engineering 2012;28(2):224-30.