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BIM MATURITY ASSESSMENT AND CERTIFICATION IN CONSTRUCTION PROJECT TEAM SELECTION

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Abstract: To implement BIM in a construction project successfully, all the project participants as BIM users must have minimum BIM capabilities. Before any project starts, assessing BIM capabilities of project stakeholders is a concern for construction clients. The main problem of public clients regarding BIM is that they have no mechanism to ensure that the key participants, they hire for a BIM project, have the minimum capabilities (i.e. BIM Infrastructure, processes and qualified resources) to participate in design and delivery of the project. The high variability of firms' readiness to work with BIM may impose a high cost for the client and other mature members of the supply chain. Therefore, construction clients need a way to ensure minimum BIM maturity of participants, such as a maturity audit to assess BIM competency of potential project team members. From a client's perspective, "minimum BIM qualification" means "minimum capability to use BIM". The current BIM maturity models try to assess BIM capabilities level of firms, but lack BIM uses assessment. This research proposes a prototype that focuses on capability of firms in specific BIM uses, while measuring their general BIM capabilities. The research methodology is based on an iterative literature review followed by focus group discussions. Through literature review, the researchers propose BIM platform maturity model. Then, BIM experts discuss on possible improvements. It is expected that by using this model, construction clients may achieve more BIM benefits, i.e. reduced cost, time, and increased quality of project, through selection of BIM-qualified project team members.

1 INTRODUCTION

The construction industry has been facing many problems and barriers, such as cost overruns, time delays, prolonged contractual claims (Liberda et. al., 2003), disputes (Musonda, 2011), and labor productivity decline (Teicholz, 2004), leading to low performance and productivity. In addition, the project-oriented nature of the construction industry and the uniqueness of every project (Wegelius-Lehtonen, 2001), multi-disciplinary, cross-organizational, and changing make-up of Architectural, Engineering, and Construction (AEC) project teams (Liston, 2009) with fragmented supply chain (Cox and Ireland, 2002) increases the complexity of working on large construction initiatives. To improve productivity of the construction industry, different solutions, such as digital construction, are observed. Digital construction aims to address the growing fragmentation problems and improve productivity by using technologies such as Building Information Modeling (BIM) for integrating processes throughout the entire lifecycle of a construction project. BIM proposes a consistent digital information platform to be used by the stakeholders throughout the lifecycle of the project. To date, many construction projects have reported benefits from the use of BIM technology and recommended it as a remedy for productivity issues (Mihindu and Arayici, 2008). According to McGraw-Hill (2009) the most notable reported BIM benefits of a project, include: reduced conflicts during construction, improved collective understanding of design intent, improved overall project quality, reduced changes during construction, reduced number of RFIs (Requests for Information), and better cost control/predictability.

To implement BIM successfully, in a project, and fully get the benefits, all the project members, as users of BIM should demonstrate minimum BIM capabilities. However public clients have no mechanism to measure the minimum BIM capabilities (i.e. BIM Infrastructure, processes and qualified resources) of the key suppliers to participate in the design and delivery of the project using BIM technology. High variability of BIM maturity level of project members may result in high cost for the client and the most mature members of the supply chain. Therefore, having members who obtain and provide an independent BIM maturity certificate beforehand would help in solving this issue.

This paper reviews the current BIM maturity models, which are developed for the purpose of BIM qualification assessment in project team selection. Since there is a lack in development of maturity levels of BIM Uses in the current BIM maturity models, it proposes a practical BIM maturity model in order to evaluate both general BIM capability and specific 'BIM Uses' capability of firms, which are two main concerns of construction clients. Finally a hypothetical sample part of this model, namely 3D Coordination, is developed at maturity level 1, to demonstrate the potential evaluation process used with the proposed maturity model.

2 BIM CAPABILITY MATURITY ASSESSMENT FOR PROJECT TEAM SELECTION

A "maturity model" can be defined as "… a conceptual framework, with constituent parts, that defines maturity in the area of interest. […] In some cases, […], a maturity model may also describe a process whereby an organization can develop or achieve something desirable, such as a set of Capabilities or practices" (OPM3, 2003). The term 'BIM Maturity' refers to the quality, repeatability and degrees of excellence of BIM services (Succar, 2010b). Current BIM maturity models in construction were developed for different purposes. Reviewing three of these models, which were developed for the purpose of BIM qualification assessment in project team selection stage (i.e. BIM Indiana University, 2012; CIC, 2012; Sebastian and Van Berlo, 2010), can help researchers in a) understanding what the construction client expects from a BIM maturity assessment tool during the project team selection and qualification, b) what BIM topics should be assessed for such a process, and c) how a BIM maturity assessment should be done in practice. The authors believe that an industry guardian (evaluator) can alleviate burdens from the client by independently conducting such a process beforehand.

Sebastian and Van Berlo (2010) developed the BIM Quick Scan tool to benchmark current BIM performance level of AEC organizations for the Dutch construction industry. The purpose was to justify qualification of project parties to be involved in projects and to "… raise awareness and establish a common strategy for innovation through BIM" (Sebastian & Van Berlo, 2010). In this approach, a certified BIM consultant carries out the assessment upon request of an organization and produces an assessment report. This approach combines quantitative and qualitative assessments of the 'hard' and 'soft' aspects of BIM at a) corporate level, b) ICT infrastructure level, and c) model/modeling level. Four main chapters of an organization, including organization and management, mentality and culture, information structure and information flow, and tools and applications, are assessed by the BIM Quick Scan tool. Each one of these chapters contains a number of Key Performance Indicators (KPIs) "… in the form of a multiple-choice questionnaire. (KPIs). […] With each KPI, there are a number of possible answers. For each answer, a score is assigned. Each KPI also carries a certain weighting factor. The sum of all the partial scores after considering the weighting factors represents the total score of BIM performance of an organization" (Sebastian & Van Berlo, 2010, pp. 258 and 259). KPIs are assessed using a percentile scale and the chapters are assessed in a five-level scale of 0 to 4 (Sebastian & Van Berlo, 2010). The tool asks about presence of 'BIM Uses' in the firm, but there is a problem associated with categorization of BIM Uses. While some of these BIM Uses are specific, such as planning (4D) and quantities/costing, the others are very general, such as simulations, design, architectural, construction, etc. In addition, although it asks for presence of a BIM Use, the maturity level of a specific BIM Use is not evaluated by the tool. For example, if a firm has BIM 4D planning, this assessment tool cannot assess how well the firm is using BIM for planning (4D) in a scale.

According to CIC (2012), it is suggested that the BIM maturity level of applicants must be evaluated during the team selection stage, namely during Request For Qualification (RFQ) and Request For Proposal (RFP). At the project team selection stage, to enable the owner to assess the BIM maturity level of applicants, a BIM capability and maturity model is needed. The owner asks about BIM experience and expertise of applicants in RFQ. Applicants must provide proof of qualifications they claim to have. In RFP, the applicants must propose the BIM services that they can provide for the project. After reviewing the BIM qualifications and BIM proposed services of all applicants, they will be scored in a BIM maturity matrix. Considering the results of BIM maturity assessment, the owner selects the applicants who best match with the required criteria. The categories in "BIM Qualifications Scoring Matrix" and "Proposal Scoring Matrix" are shown and presented in Table 1, according to CIC (2012).

Table 1: BIM qualification and proposal assessment categories (CIC, 2012)

BIM Qualifications Scoring Matrix (CIC, 2012)	Proposal Scoring Matrix (CIC, 2012)
1. BIM Project Execution Planning Experience: Experience the team has with planning for BIM on projects. **2. Collaboration Experience:** Willingness of the team to collaborate with others and their experience collaborating. **3. BIM Tools:** Competence of the project team in implementing various BIM tools. **4. Technical Capabilities:** Abilities of the organization to preform BIM	**1. Price:** What is the total price for the listed services **2. Additional BIM Uses:** What additional BIM services are proposed **3. Project Team Qualification:** How much experience and success has the proposed project team had **4. Collaboration Procedure:** What collaboration procedure is included in the proposal **5. Deliverables:** What are the deliverables proposed

Although this model (CIC, 2012) considers the proposed BIM Uses of applicants, it fails to measure the maturity level of a firm in performing specific BIM Uses, such as 3D Coordination, 4D Modeling, etc. The BIM assessment categories of 'BIM tools', 'Technical Capabilities', and 'Deliverables', are general in BIM maturity assessment. The authors of this paper believe that clients should not have to expend effort on a case-by-case basis to do this assessment every time. Having an independent certification body where BIM maturity certification is obtained, managed by independent certified assessors (i.e. like ISO) would be simpler for the clients and would better control quality of assessment for the whole industry.

Another BIM maturity model, in form of a matrix, was developed by the Indiana University (IU) to evaluate BIM expertise and experience of construction project participants (consultants) (BIM Indiana University, 2012). "IU BIM Proficiency Matrix" must be submitted to Indiana university by the design team before the contract award for its construction projects of 5$M or greater and for the construction projects which have already used BIM. For other projects, it is encouraged but not required to submit. The consultant scores the matrix based on the examples of previous projects with use of BIM. The IU can understand the BIM level of expertise and experience of design team by evaluating the maturity matrix. Interested contractors can submit an "IU BIM Proficiency Matrix" to the university at the bid submittal stage (BIM Indiana University, 2012). This matrix contains eight categories, comprising of four sub-categories. A total of thirty-two subcategories are scored with a score ranging from 0 to 1. A maximum total score of thirty-two can be achieved based on this mechanism. The achieved total score locates the BIM maturity level of firm on a defined range: total score of 0 to 12 is assigned for "Working Towards BIM" category, 13 to 18 for "Certified BIM", 19 to 24 for "Silver", 25 to 28 for "Gold" and 29 to 32 is assigned for "ideal". The problem with this scoring system is that for each subcategory a value from 0 to 1 is earned based on subjective judgement from maturity level. This approach is not very accurate. For example, although a score of 0.45 represents a higher maturity level than a score of 0.4, it is not defined clearly how to justify this scoring and its performance measurement. This model considers some BIM Uses, such as ‘Design side collision detection’, ‘Coordination modeling’, in maturity assessment. However, lack of development of capabilities within different maturity levels, is a deficiency. According to Succar (2010a), “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”. In addition, the matrix has very little consideration for BIM resources. For example, the sub-category of “Model managers role defined” asks about the presence of a model manager for each discipline. However, the level of BIM expertise, experience, and knowledge of model managers are not considered in the scoring. The matrix also has other weaknesses, for example in BIM technological resources assessment. Although delivering a rich and accurate digital model is the focus point of this model, the required technological infrastructure was not considered in maturity assessment.

It is important for construction clients to measure how well a potential project member can use a specific BIM application. All the reviewed models have a common problem, which is lack of development of capabilities in maturity levels of BIM Uses. There is a need to address this issue.

3 PROPOSED BIM MATURITY MODEL FOR INDEPENDENT CERTIFICATION

As mentioned in section 1, construction clients need a way to ensure that the participating firms of project meet minimum BIM requirements in order to qualify for a project. From the perspective of a client, “minimum BIM qualification” can be translated to “minimum capability to use BIM” and this is practically what is wanted by a certification: ‘how well does this participant uses BIM technology in a construction project’. This is accepted as a principal assumption of this study. Clients want to know whether a firm is capable of using BIM, and if yes, to what level. This perspective offers an opportunity to adapt existing BIM maturity models to reach that goal. There is a lack, in the current BIM maturity models, to look at BIM through this lens. The existing BIM maturity models provide a rich base of information to achieve this goal. However, no model has focused on development of maturity levels of ‘BIM Uses’. “A BIM Use is a unique task or procedure on a project which can benefit from the integration of BIM into that process” (CIC, 2011). This paper proposes a new approach in assessing BIM capability maturity of firms in performing specific BIM uses, while measuring their general BIM capabilities at the same time. This approach represents the clients’ expectation of a maturity model. They want to know how well a project stakeholder uses BIM to delivers a BIM product or service. Therefore, the authors propose a BIM platform maturity model that provides information about maturity of BIM Uses that will meet clients’ expectation.

Client perspective in maturity assessment

The software industry has considerable experience in adopting capability maturity model from quality management field to software industry processes (i.e. Capability Maturity Model Integration (CMMI)). Although processes in the software industry are quite different from processes in the construction industry, but the notion of process maturity is the same. To develop our proposed model in this study, we have studied a maturity model from the software industry, namely Software Maintenance Maturity Model-$S3^m$ (April, 2005), which is based on the client perspective and is designed from using both industry references, and national and international standard practices. This model helps software “maintainers identify their process maturity level and guide them to higher maturity processes…. The maintenance maturity model was developed to address the uniqueness of software maintenance” (April, 2005, p. 143). $S3^m$ uses the architecture of the CMMI (SEI, 2010a) and draws practices from two international software standards: ISO12207 and ISO 14764. The reason that $S3^m$ is studied is that the relation of our proposed maturity model to the other BIM maturity models (i.e. IU and CIC) is a similar relation of $S3^m$ to CMMI. $S3^m$ maps practices from CMMI and ISO standards in the same way our proposed model maps to several BIM maturity models (i.e. Succar, 2010a,b; Succar et al., 2012; Sebastian and Van Berlo, 2010; CIC, 2012; BIM Indiana University, 2012; NIBS, 2007, 2012) to cover unique expectation of client (BIM uses).

3.1 Proposed architecture of the BIM Platform Maturity Model (BIMPMM)

April (2005) organized software maintenance activities in a hierarchical architecture from the most general definitions to most specific practices. The first level of this hierarchy (less specific) to fourth level (most specific) includes respectively “process domain”, “Key Process Areas (KPAs)”, “Roadmaps”, and

“Practices”. Our proposed BIM platform maturity model is inspired from $S3^m$ architecture while using the processes and activities that are BIM specific, as shown in Table 2.

Table 2: Proposed architecture of the BIM Platform Maturity Model (BIMPMM)

BIM Domain	Key Process Area (KPA)		Practices
Process	BIM Uses	3D Coordination	… (level 0-5)
		Design Reviews	… (level 0-5)
		Design Authoring	… (level 0-5)
		Other BIM Uses …	… (level 0-5)
	General BIM Capability	Project Management	… (level 0-5)
Resources		Infrastructure	… (level 0-5)
		Human resources	… (level 0-5)

3.1.1 BIM domains

Various domains are defined for BIM in the literature. This first study just focuses on the domains of “BIM Process” domain and “BIM Resources” domains as they pertain to the construction industry to address the construction clients concern regarding assessment of minimum BIM capabilities of applicants in their project. The “BIM Process” domain considers BIM capabilities regarding specific “BIM Uses” and the maturity level of BIM project management. This domain is very important as a client wants to know how well a firm is using and managing BIM technology in this area. The “BIM resources” domain evaluates the required resources to perform the BIM Processes in general. The available resources of applicants are an important factor for project team selection from the perspective of the construction clients.

3.1.2 Key Process Areas (KPAs)

In this study, KPAs of the “BIM Process” domain include BIM uses and project management. BIM uses are about specific applications of BIM in construction projects. Top three most frequent uses of BIM, which include “3D Coordination”, “Design Reviews”, and “Design Authoring” according to Kreider et al. (2010) study, are selected to introduce example of BIM Use specific KPAs in the proposed BIM platform maturity model. The proposed ‘project management’ KPA refers to the quality of management in using BIM. We know that BIM project management can include various activities, such as designing BIM execution plan in project, defining and procuring required BIM resources, defining BIM collaboration processes, etc. The proposed “BIM Resources” domain includes KPAs related to BIM “infrastructure” and “human resources”. In the other words, the allocated infrastructure and human resources to BIM at the organization/project levels will be assessed in this domain and within these KPAs. The proposed maturity model, considers BIM infrastructure as the technological aspects of BIM (i.e. software, hardware, network, ...). We also know that human resources relates to the personnel roles and responsibilities, and the level of knowledge, skill, and experience that they posses, in using BIM technologies. The training and educational programs of an organization to improve BIM competency of personnel will be evaluated in this category. In the proposed maturity model, KPAs are also categorized according to their general and specific BIM capabilities. Since a ‘BIM Use’ is about specific application of BIM in a doing a task in a project, KPAs of ‘BIM Uses’ are considered as specific BIM capabilities. But KPAs of “Project management”, “Infrastructure” and “Human resources” don’t reflect any specific BIM application and are defined, in the proposed maturity model, to be part of a ‘General BIM capability’ category.

3.1.3 Roadmaps and practices

A Roadmap is defined “ … as a set of linked practices that can often cover many levels of maturity” (April 2005). Each KPA contains a number of roadmaps. Practices are defined within the roadmaps. “In a given roadmap, the sequencing of the practices is organized based on the sequencing of the pre-requisites required to move from an initial beginner's implementation of a process up to its mastery. Practices required to initiate the implementation process are positioned at the initial level (e.g. level 1), while more sophisticated practices are ordered progressively up to level 5." (April, 2005). In the proposed BIM platform maturity model, the practices are mapped from current BIM maturity models (Succar, 2010a,b; Succar et al., 2012; Sebastian and Van Berlo, 2010; Computer Integrated Construction Research Program, 2012; BIM Indiana University, 2012; NIBS, 2007, 2012) and other relevant resources. Finally, the practices that represent capabilities with the same topic, construct a roadmap. BIM experts meet to discuss the position and the rationale of each practice in the maturity levels, and possible improvements. Based on the obtained feedback, an iterative development of the proposed maturity model (iterative model development/improvement and experts' feedback) is carried out by the researchers.

3.2 Proposed maturity scale

As many maturity models use five-level scale of maturity (see Succar et al., 2012, p. 134), our model also proposes a five-level scale. We adopted the maturity scale of BIM Planning guide for facility owners (CIC, 2012), which used BIM maturity level definitions inspired from the Capability Maturity Model Integration (CMMI) for Services (Forrester et al., 2011) (Figure 1). Each KPA can be assessed by a maturity scale of five level (levels 0-5). Reaching a maturity level requires the achievement of all practices of that level.

Maturity Level	Description
(0) Non-Existent	At this maturity level, a process has not yet been incorporated into current business processes and does not yet have established goals and objectives.
(1) Initial	At this maturity level, a process produces results in which the specific goals are satisfied, however, they are usually ad hoc and chaotic. There is no stable environment to support processes with the inability to repeat such and possible abandonment in time of crisis.
(2) Managed	At this maturity level, a process is planned and executed in accordance with policy; employs skilled people having adequate resources to produce controlled outputs; involves relevant stakeholders; is monitored, controlled, and reviewed; and is evaluated for adherence to its process description.
(3) Defined	At this Maturity level, a process is tailored to the organization's standard processes according to the organization's guidelines; has a maintained process description; and contributes process related experiences to the organizational process assets
(4) Quantitatively Managed	A this maturity level, a process is managed using statistical and other quantitative techniques to build an understanding of the performance or predicted performance of processes in comparison to the project's or work group's quality and process performance objectives, and identifying corrective action that may need to be taken.
(5) Optimizing	At this maturity level, a process is continually improved through incremental and innovative processes and technological improvements based on a quantitative understanding of its business objectives and performance needs and tied to the overall organizational performance.

Figure 1: BIM Maturity levels (CIC, 2012)

However, a BIM maturity assessment measurement is inspired from ISO15504 recommendation in four categories: N,P,L and F. The $S3^m$ (April, 2005) and many other maturity models conform to this ISO recommendation that defines partial maturity of a practice, when it is not fully achieved or not achieved (ISO/IEC15504):

N: Not reached – 0 to 15%

P: Partially reached – 15%-50%

L: Mostly reached – 51%-85%

F: Fully reached – 85%-100%

3.3 Evaluation process of proposed BIM platform model

To make it easy to assess the BIM maturity level of a participant, an assessment tool can calculate the threshold rating, and a BIM entry level to be eligible to participate in a construction project. The applicants must be eligible in BIM and show their maturity certificate to apply in a construction project bidding. A certified BIM maturity assessor (i.e. an assessment body) would issue the certificate using a class 1 assessment process (this will be presented in another paper). The BIM maturity assessment could take place at any time independently from projects. Based on the type of firm, i.e. architect, engineer, contractor, the KPAs and questions of a questionnaire are filtered and adapted by the assessor to be included in assessment of that firm. For example, within a project an engineer may not be evaluated in KPA of 'Design reviews', because the client doesn't expect the engineer to perform 'Design reviews' in that project. The independent assessor would plan the assessment and then distribute a questionnaire to the interested firms. The results of their questionnaire will be evaluated based on their specialty. The questions ask the firms if they have the practice in their organization. As shown in section 3.2, based on utilization level in the firm, a respondent can choose an answer from four options of "Not reached", "Partially reached", "Mostly reached", and "Fully reached". For a Class 1 assessment, a minimum of four process instances shall be identified for each process within the scope of the assessment. To achieve a maturity level, all practices of that level must be "fully reached" where process attributes are assessed and validated. Finally, the third party reports the BIM maturity assessment results and can issue a certificate.

To describe the evaluation process of the proposed model, the first part of this model is presented in the next section. This portion of the proposed model only presents the "3D Coordination" KPA, its roadmaps and practices, and questions that are asked at maturity level of one. The description of the two other mentioned BIM uses, namely 'Design Authoring' and 'Design Review' are quoted from CIC (2011) in Table 3.

Table 3: 'Design Authoring' and 'Design Review' BIM Uses description (CIC, 2011)

BIM Use	Description
Design Authoring	A process in which 3D software is used to develop a Building Information Model based on criteria that are important to the translation of the building's design. Two groups of applications are at the core of BIM-based design process: designs authoring tools, and audit and analysis tools. Authoring tools create models while audit and analysis tools study or add to the richness of information in a model. Most of audit and analysis tools can be used for Design Review and Engineering Analysis BIM Uses. Design authoring tools are a first step towards BIM and the key is connecting the 3D model with a powerful database of properties, quantities, means and methods, costs and schedules
Design Reviews	A process in which stakeholders view a 3D model and provide their feedbacks to validate multiple design aspects. These aspects include evaluating meeting the program, previewing space aesthetics and layout in a virtual environment, and setting criteria such as layout, sightlines, lighting, security, ergonomics, acoustics, textures and colors, etc. This BIM use can be done by using computer software only or with special virtual mock-up facilities, such as CAVE (Computer Assisted Virtual Environment) and immersive lab. Virtual mock-ups can be performed at various levels of detail depending on project needs. An example of this is to create a highly detailed model of a small portion of the building, such as a facade to quickly analyze design alternatives and solve design and constructability issues

4 3D COORDINATION KPA

CIC (2011) describes BIM Use of '3D Coordination' as "a process in which Clash Detection software is used during the coordination process to determine field conflicts by comparing 3D models of building systems. The goal of clash detection is to eliminate the major system conflicts prior to installation". The design team must check collision against architectural, engineering and MEP models of project. The collision reports must be prepared, and then the project team or responsible members review the collision report and address the issues in the models (BIM Indiana University, 2012, category A.3). This process includes several activities, which must be mapped with their relationships in a detailed process map. The capabilities in a '3D Coordination' process are defined under four roadmaps of 'Process map', 'Information requirements', 'creating, transferring, and compiling information', and 'collision detection and solving'. These capabilities are explained as follows.

4.1 3D Coordination process map Roadmap

The responsible organization for performing '3D Coordination' must be capable to develop a detailed process map of this BIM Use. The detailed map must contain all necessary activities and connect them properly. The responsible party of each activity must be determined. According to CIC (2011), Eastman et al. (2011), BIM Indiana University (2012), the main activities of 3D Coordination can be concluded as defining information requirements, performing collision detection and solving collision problems. The required capabilities and questions are as follows:

4.1.1 Process map capability in Maturity Level 1

Practice 1. The firm is capable to develop a process map in order to identify 3D Coordination activities and their relation, responsible parties, and information requirements (CIC, 2011, p. 20&21).

Explanation: To initiate 3D Coordination in a project, the responsible firm needs to define the process map. The firm must identify the required activities, the relation and dependency of activities, responsible parties for the activities, and the required information and information exchanges for 3D Coordination in the project (CIC, 2011). Without a process map, the firm cannot carry out the process.

Question 1. Does your firm develop a process map in order to identify 3D Coordination activities and their relation, responsible parties, and information requirements? (Choose answer from: No, Partially, Mostly, Yes)

4.2 Defining 3D Coordination information requirements Roadmap

Clash check is between specified building systems, i.e. mechanical and structural systems, because model components belong to a specific type of system (Eastman et al., 2011). Clash detection also can be done within one discipline. Therefore, 3D Coordination information requirements define intended building systems for conflict detection, including structural, mechanical, engineering, plumbing systems, and civil systems such as storm water systems, buried electrical systems (e.g. duct banks), rails, sewer systems, etc. After defining the required building systems' model, the level of detail of models must be defined for each model. The contractor must make sure the suitable Level of Detail (LOD) (Eastman et al., 2011). To define LOD at the beginning of project, the clash detection information requirements must be considered for future 3D coordination during the project.

4.2.1 Information requirements capability in Maturity Level 1

Practice 2. The firm carries out clash check for Architectural, Structural, and Mechanical, Engineering and Plumbing (MEP) building models (Eastman et al, 2011, p. 273; BIM Indiana University, 2012, category B.2).

Explanation: At this maturity level, the firm initiates to do clash check of Architectural, Structural, and Mechanical, Engineering and Plumbing (MEP) building models, against each other and within the disciplines, irregularly. At this level it is expected that the firm be capable of clash check for various building models and even irregular clash check satisfies meeting maturity level 1.

Question 2. Does your firm carry out clash check for Architectural, Structural, and Mechanical, Engineering and Plumbing (MEP) building models? (Choose answer from: No, Partially, Mostly, Yes)

4.3 Performing collision detection and solving collision problems Roadmap

The location and schedule for 3D Coordination meetings must be defined. In the meetings, the conflict problems must be addressed. Therefore, a protocol to address collisions is required before beginning coordination process (CIC, 2011). Clashes can be categorized into two groups. A group of them, which are small errors, can be defined as minor clashes. Minor clashes can be ignored in design phase and can be addressed during construction, on the site (Amiri, 2012). However, major clashes must be defined and be addressed during the 3D Coordination meetings.

4.3.1 Clash detection and solving capability in Maturity level 1

Practice 3. The firm defines the schedule and location of clash detection meetings in order to review and discuss on the clash problem and address it (BIM Indiana University, 2012, A.3; Succar, 2010a, p. 90).

Explanation: The organization assigns a responsible person to arrange a meeting to address the problem. In each meeting, the assigned responsible person prepare a collision report and the other involved project members review and discuss on the clash problem and how to address it. There is no protocol to address the clash problems in this level.

Question 3. Does your firm define the schedule and location of clash detection meetings in order to review and discuss on the clash problem and address it?

5 CONCLUSION

Construction clients need a qualifying mechanism to ensure that the participating firms of a project meet minimum BIM requirements. From the perspective of a client, “minimum BIM qualification” can be translated to “minimum capability to use BIM”. This perspective offers a new opportunity for a novel BIM maturity model and its independent certification process. The authors observed that there is a lack, in the current BIM maturity models, to look at BIM through this lens. This research, which is still in progress, focuses on the “BIM Process” and “BIM Resources” domains of the construction industry to address the construction clients concern regarding assessment of minimum BIM capabilities of potential project participants. This research proposed a new BIM platform maturity model presenting a hierarchical architecture, from most general definitions to most specific practices, namely ‘BIM domains’, KPAs, Roadmaps, and practices. The main contribution of the proposed maturity model is to focus the BIM maturity assessment of key ‘BIM Uses’. BIM Uses are considered as KPA in the proposed model, additional to general KPAs, namely ‘BIM project management’, ‘Infrastructure’, and ‘Human resources’. This BIM platform maturity assessment proposal, which is currently a prototype at concept of operation, proposes to set a threshold, a BIM entry level, to be eligible to participate in a construction project involving BIM. The interested firms to be eligible to participate in a construction project bidding, where BIM is required by the client, would need to be certified at certain BIM maturity level beforehand. A recognized third party assessment body would issue the BIM maturity certificate. By employing more BIM-qualified or BIM-certified firms in the construction industry, the industry will advance more rapidly and should gain more competitive advantages. BIM benefits, which bring most value to a project, include ‘Reduced conflicts during construction’, ‘Improved collective understanding of design intent’, ‘Improved overall project quality’, ‘Reduced changes during construction’, ‘Reduced number of RFIs (Requests for Information), ‘Better cost control/predictability’ (McGraw-Hill, 2009).

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