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APPROACH FOR BIM IMPLEMENTATION: A VISION FOR THE BUILDING INDUSTRY

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ABSTRACT

Building Information Modeling (BIM) has been widely studied in recent years. Most of these studies are dedicated to understanding the application of BIM to solve specific problems (e.g. clash detection and 4D simulation). Other studies are related to BIM implementation manuals to help companies with this process, considering different stakeholder perspectives (owners, contractors, subcontractors, architects, engineers and suppliers). Some previous studies concentrate on the technical and operational aspects of BIM while others focus on diagnosis of current BIM implementation worldwide. However, there is a lack of studies about strategic vision for the implementation of BIM when considering the construction industry. Therefore, the aim of this paper is to identify key issues related to strategic aspects of BIM in the building industry, focusing on political, procedural and technological facets, using the practical knowledge of lean implementation.

KEYWORDS

BIM, Lean Construction, Strategic Planning, Strategic Alignment.

INTRODUCTION

In general, the implementation of Building Information Modeling (BIM) has been slow and is concentrated in only a few companies. Such projects are developed internally without the in depth participation of designers (architects and engineers). Many of these projects adapt CAD designs to 3D designs, using software related to the BIM platform (e.g. Revit), and technological resources for things like clash detection and quantity take off, emphasizing technical knowledge.

Previous studies (CIC 2011; FIATECH 2013; Jung and Joo 2011) present implementation manuals or guides that show a detailed step-by-step methodology to help companies work with BIM in the future. In turn, Eastman *et al*. (2008) discusses the BIM implementation process, considering the different visions, issues, and needs of owners, general contractors, contractors, designers and suppliers.

Bernstein *et al*. (2013) presents a study about the maturity of BIM in different countries, considering aspects such as: client satisfaction, financial investment and the technological information level. Additionally, potential improvements for each country

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are discussed. Smith (2014) explains the implementation processes within different countries, concluding that public empowerment has an imperative role in this process.

In addition, Succar (2009) presents a framework for the BIM implementation process, divided into three aspects: policy (rules and patterns), process (phases for implementation, based on time and cost) and technology (infrastructure to support the implementation process). Moreover, Succar (2009) proposes stages of BIM application (Pre-BIM, Modeling, Collaboration and Integration). At the end of these stages, the company would obtain the Integrated Project Delivery (IPD) level. In another paper, Lindblad and Vass (2015) highlight the importance of owner mindset for the success of organizational change.

Furthermore, the use of BIM must involve a wider approach, due to the increase in the complexity of projects and the potential of BIM to support improvements in the design, construction, operation and maintenance of building projects. Hence, these improvements increase productivity. For this reason, companies need to understand that BIM has a close relationship with productivity.

Moreover, there is a high appreciation of the operational vision, emphasizing aspects like worker skills to use software related to BIM, but not a deep or extensive use of BIM's modeling aspect. This process needs time and resources to prepare people, define rules and patterns and obtain infrastructure (software and hardware). Because of this, it is important to have discussions about strategic approach (long term vision), when considering BIM implementation with an innovative process, and all building stakeholders related to industry (contractors, designers and suppliers), government (national, regional and local) and academy (technical labor schools, colleges and universities) need to be involved.

In some countries, the BIM implementation process is just beginning. Only a few building companies and design offices (mainly architectural) are using it regularly. Many companies are waiting for the results from these first steps before deciding to invest in this new reality. This is a reactive approach, like most organizational change processes. It's also important to note that the public sector has not taken the first steps towards using BIM in public projects yet. Academia, in turn, is beginning the process to include BIM methodologies in curricula, particularly in architectural courses.

These discussions have shown little emphasis on the strategic vision of the implementation process of BIM in the building industry. Consequently, a research question is presented: How can we increase the strategic vision of the implementation process of BIM in the building industry? The aim then of this paper is to discuss guidelines for increasing the strategic approach in the implementation process of BIM, considering its relationship to lean philosophies, because both lean and BIM are directed towards waste reduction, rework reduction and increased productivity (Sacks et al. 2010a). Lean construction has been implemented since the 1980's and its background could very well help the implementation process of BIM.

BACKGROUND

BIM implementation can be divided into project based, organizational based and industry based processes. Additionally, there is an organizational change process, linked to a strategic fit and innovation process. These three phases can be presented as concentric circles (Fig. 1), showing that the industry level depends on both organizational and project levels.

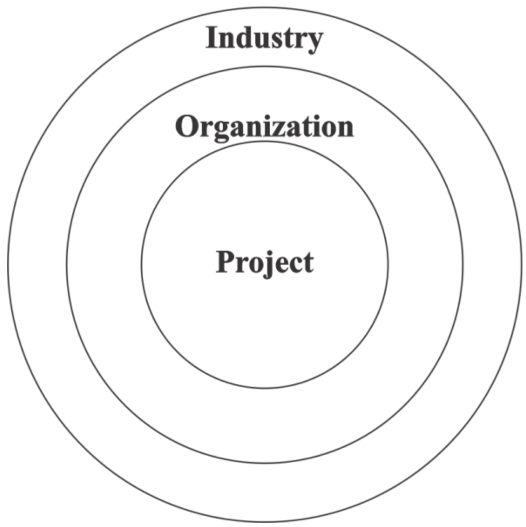

Figure 1: Different levels of implementation of BIM (e Lean)

PROJECT-BASED BIM IMPLEMENTATION

Many studies discuss guidelines for the implementation process of BIM in specific projects. CIC (2011) presents procedures for the planning and execution of a project by applying the BIM platform. In this, four points are discussed: identification of the aims and usage of BIM; mapping of the BIM implementation process within the specific project; definition of the information exchange process among stakeholders; and a definition of the infrastructure that supports the implementation process of BIM. On top of this, there is a discussion related to organizational questions that would influence the implementation process: definition of a mission for the project; definition of a leader for the implementation process; partner commitment; direct involvement of the project leader; discussion about the collaborative process; and appreciation of team work. This publication is one of the most important references for the implementation process of BIM in specific projects.

FIATECH (2013), in turn, presents a comparative study among some examples of the implementation guide of BIM. 28 proposals are shown (eight related to third party institutions and 20, for private and public institutions, including governmental agencies and universities). 22 proposals were developed by American institutions, and the remaining six were developed by Norway, Hong Kong, Finland, Australia, Singapore and the United Kingdom). All of them present means and procedures of the implementation process of BIM in specific projects, with a strong operational approach.

Jung and Joo (2011) also present a framework to help in the implementation process of BIM in specific projects which concentrates within three dimensions: technology (T), perspective (P) and business (B). Each one is divided into categories: T (data property, the relationship between data, data patterns and data use); P (industry, organization and project); and N (planning, R&D etc).

Gu and London (2010) present four fundamental steps to support the implementation process of BIM: definition of scope, purposes, roles, collaboration and phases of the project; development of task processes; identification of technical requirements; customization of process and evaluation of skills, knowledge and capacities of people. These authors reinforce the importance of people to the implementation process of BIM, according to Khosrowshahi and Arayici (2012).

Finally, Eastman *et al*. (2008) introduce guidelines for the implementation process of BIM, considering the different visions of stakeholders (owner, contractor, subcontractors, engineers, architects and suppliers). They discuss the BIM process from each point of view, emphasizing the technical aspects of the implementation process for each stakeholder and their peculiarities.

ORGANIZATIONAL-BASED BIM IMPLEMENTATION

NIBS (2007) discusses patterns, politics and rules related to BIM, aiming to give orientations in the implementation process of BIM for American companies. He states, project stakeholders should use the same language, thus improving the use of BIM. To do this, it is necessary to solve the problem of the information exchange between different kinds of designs. The solution is the development of Industry Foundation Classes (IFC), a conceptual data schema and an exchange file format for BIM data (ISO 16739:2013) that enables a solid data exchange between different languages and software. For example, national standards are discussed to help companies in the process of exchanging information, as well as rules and orientations related to security and information storage. Finally, NIBS (2007) is interesting because it presents guidelines to support the long-term use of BIM in organizations.

Succar (2009) presents three fields for implementation of BIM: Policy, related to regulations, building standards, contractual agreements and benchmarks; Process, related to the stages of model creation, drawing up documents and components, considering time and cost; and technology, definitions about BIM software, communication systems, equipment and peripherals, database technologies and model servers to support the implementation process of BIM. In sequence, he divides these fields into steps, indicating the required decisions for each step. For technology, the steps are software, hardware and network, while for process they are leadership, infrastructure, human resources and products & services. For policy, steps are contractual, regulatory and preparatory. An adequate interaction of these fields enables a successful implementation of BIM. The author presents maturity stages of BIM implementation: Pre-BIM, Modeling (based on object development), Collaboration (based on collaborative works among stakeholders), and Integration (based on net integrated works among stakeholders). In the end of this process, companies will be working in an IPD approach, when all three fields are strong and BIM is being used across the board.

For Miettinen and Paavola (2014), a great challenge for companies is to consider the implementation of BIM as an organizational change process that must make an impact on management and contractual processes. At this moment, a strong resistance to change will come up in most companies, mainly in the building industry. Miettinen and Paavola (2014), also advocate BIM as a strategic resource that impacts different areas in companies and, consequently, leaders need to change their minds about this. Moreover, they must have an integrated vision about the implementation process of BIM that has been emphasized as a collaborative process among all areas of companies, creating a knowledge generation process. Government also has an important role in this process because it could define aims and deadlines to use BIM in society. Governments could also incentivize the use of BIM in construction of public buildings, therefore creating a BIM culture. Aranda-Mena et al. (2009) and Khosrowshahi and Arayici (2012) reinforce this discussion, claiming fragmentation and calcified processes inhibit widespread change in the building industry. For them, technology alone cannot support the implementation process of BIM in the long term. The business process models need to change. And so, the implementation process of BIM is directly related to an organizational change.

Succar and Kassem (2015) argue that BIM implementation refers to the set of activities undertaken by an organizational unit to prepare for, deploy or improve its BIM deliverables (products) and their related workflows (processes). For them, BIM capability is achieved through well-defined revolutionary stages (object-based modeling, model-based collaboration, and network-based integration) separated by numerous evolutionary steps. As well as this, BIM maturity (or post-implementation) is the gradual and continual improvement in quality, repeatability and predictability within available capabilities. Then, there are five maturity levels: [a] Ad-hoc or low maturity; [b] Defined or medium–low maturity; [c] Managed or medium maturity; [d] Integrated or medium–high maturity; and [e] Optimized or high maturity. Companies change their maturity stages with considerable investment in human and physical resources. Each new stage needs new organizational abilities and deliverables not available in previous stages. Each stage requires its own readiness ramp, capability jump, maturity climb, and point of adoption.

INDUSTRY-BASED BIM IMPLEMENTATION

A study developed by McGraw-Hill (2014) presents an overview of the use of BIM in different countries (the United States, Brazil, South Korea, Japan, Australia and New Zealand), analyzing different metrics (e.g. Contractor's perception of BIM proficiency, Impact of BIM expertise on team formation, BIM benefits, Contractor's current perception of ROI, BIM investments etc.). There are some discrepancies among countries. The United States are at a superior level in relation to Brazil and Australia/New Zealand, but the use of BIM is increasing in these countries more than any others. An important point when looking at Brazil and some other countries, is a lack of clear leadership of the coordination of the implementation process of BIM linked to government, as we see in Finland (Smith 2014).

Murphy (2014) considers the implementation of BIM as an innovation process (product and process). Besides this, he emphasize that one of the most important problems of BIM implementation is a short term vision of those responsible for the process, because they do not consider the big picture. This includes some stakeholders and their several competencies (information and communication, cost management, human resource management, technical expertise, time management, strategy and political, culture and values) to be developed according to the objective of each one. Coordination and collaboration among stakeholders is fundamental for the success of the implementation process. Hence, the main problems of implementation are management focused rather than focused on the technical side. This vision of knowledge and improvement of competencies from stakeholders is endorsed by Succar *et al*. (2013). They advise that first step for a good implementation process is to analyze the competencies of each stakeholder, define the competencies for each stage of the implementation process of BIM, comparing to stakeholder competencies, analyze this gap and, finally, provide alignment between them. Everything reinforces the strategic vision of the companies.

Khosrowshahi and Arayici (2012) claim a fragmented consideration of actual BIM implementation is opposed to the complete and complementary strategic planning approach. Besides this, a lack of business process models has contributed to BIM being used only at a very basic level. Consequently, the implementation process of BIM is influenced by three factors: organizational culture, education and training and information management. These require a contribution of business strategy from a strategic fit between business strategy and the external domain, with an alignment among the factors presented above. As such, different BIM technologies that are available may provide different organizational capabilities; requiring stakeholders to assess currently available technologies on the market. So, the selection of suitable technology must be aligned to the future strategy of the company. For them, the main barrier for BIM implementation is a potential lack of knowledge about marginal utility, risk and benefits of implementing BIM. Therefore, collaboration among stakeholders is fundamental to increase the benefits of an in-depth vision and to spread the investment risk. Support of ongoing training and consultancy help is needed in this process too. Finally, they present a roadmap to implement BIM in the third stage (Succar 2009).

RELATIONSHIP BETWEEN BIM AND LEAN

Sacks *et al*. (2010a) present a seminal paper with a matrix relating lean principles with BIM functionalities, resulting in 55 interactions. Besides this, Sacks *et al*. (2010b) reinforce this interaction presenting the KanBIM, that uses resources of BIM (mainly visualization) to help the implementation process of the Last Planner System. This would be more interactive for users.

Hamdi and Leite (2012) applied in a case study, the framework of Sacks *et al*. (2010a), confirming many interactions. For example, use of visualization and standardization of the reduced time cycle and clash detection of the reduced time cycle too. Thus, the standardization supported by BIM helps the increase of predictability and efficiency of the building site.

Oskouie *et al*. (2012) applied Sacks's matrix too and observed that the database of BIM could support a better control of the life cycle of cost and environment; BIM facilitates the reduction of the time cycle for facility implementation and increased efficiency of the maintenance process; BIM improves the future maintainability of buildings using the integration of construction, operation and maintenance and increased agility and reliability of the process; The use of augmented reality to train operational workers reduces rework on the building site.

Khosrowshahi and Arayici (2012) present examples of what issues can be overcome by BIM implementation such as: reduced error, rework and waste for better sustainability for design and construction; improved risk management; removal of waste from process, construction and design; whole lifecycle asset management, better facility management/asset management; ability to better deal with client made changes to the design and the lifecycle implications of these; gaining supply-chain support in producing documentation and a supply-chain skill set; and construction management appreciation of the use of technology. Such solutions are similar to the results presented by the lean methodology. Consequently, there is a relationship between them and one can help another in an ongoing exchange of knowledge. In addition to this, they are complementary to companies.

Arayici *et al*. (2011) argue that the implementation process of BIM is complex where it involves process flow, competence training and a new business models. For them, the implementation process of lean needs these too and, consequently, the experience in lean implementation could be help companies implement BIM. Gu and London (2010) reinforce the importance of process flow too.

DISCUSSION

The above discussions show that BIM must be considered as a strategic process that involves organizational change and innovation, beyond technical aspects. However, many publications (technical and academic) are concentrated solely on technical aspects, explaining how to use software related to BIM or how to develop BIM in a specific project.

In truth, this is a myopic vision and will cause difficulties in the implementation process of BIM during its advanced stages, because many problems are organizational and innovationally related. Technical factors are not sufficient to support a deep and ongoing implementation process. Therefore, it is necessary to invest deeply in the organizational process and in people, the actual agents of change, because they affect organizational culture directly. The biggest challenges of all organizational implementation processes are related to the human aspects. Consequently, the chief executive office (CEO) must believe in it, because he or she must drive the process forward, convincing everyone of this new reality. This problem affects all the processes of organizational implementation such as lean, ISO 9000 etc.

Another important issue is the role of public power (government) as a catalyst of the implementation process of BIM in the industry through recommendations and rules, forcing companies to use BIM. Of course, it too must obey the use of BIM in all new constructions of public buildings.

To aid the facilitation of the implementation of BIM (Figure 2), a 3D matrix is presented to support a strategic planning of this process, considering a long term vision, the roles of the CEO and public power, and the lean experience (named Strategic Cube for the BIM implementation). In the X axis, fields (in their respective step types) are presented: technology, process, policy (Succar 2009) and people (Khosrowshahi and Arayici 2012). Here, human resources too (step type) has been transformed into a field, because it is an important agent for organizational change. In the Y axis, several stakeholders are listed: owner, general contractor, subcontractor, designers, engineers, suppliers, universities and government. Finally, in the Z axis, BIM stages of implementation (Succar 2009) are presented: pre-BIM, modeling, collaboration and integration. As well as this, it is necessary to consider the points of adoption (Succar and Kassem 2015) too, and their cyclic process of innovation and stabilization (PDCA cycle) in an ongoing evolution of the process of BIM implementation.

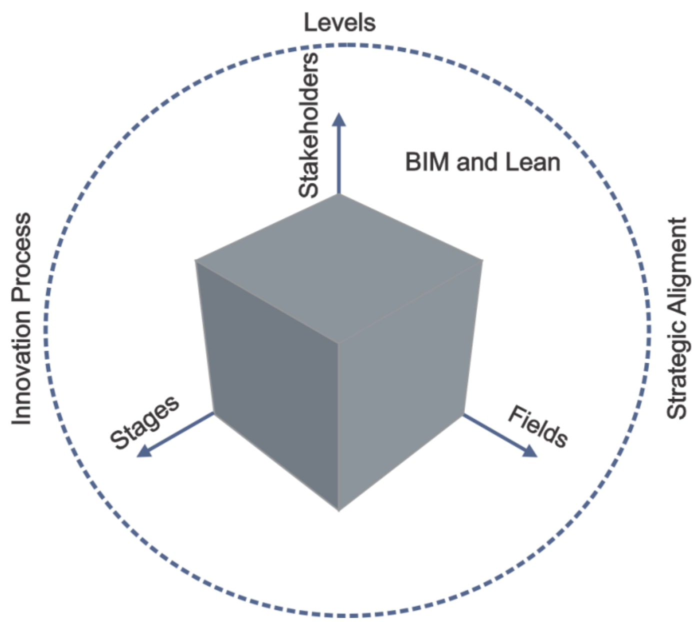

Figure 2: 3D Matrix of Strategic Planning for the Implementation Process of BIM

Accordingly, the idea is to build, in the forthcoming paper, questions to drive the strategic planning of BIM implementation, considering the axis crossing and the bottom-up (project to industry) sequence of the implementation process. Furthermore, aspects related to organizational change and the innovation process must also be considered.

For example, some questions that could be asked are: what training should sub-contractors receive in the pre-BIM stage? How much should owners invest in an IT infrastructure in order to move from the pre-BIM stage to the modeling stage? Finally, these questions will be offered as a theoretical proposal only, because the development of strategic planning to the implementation of BIM depends on characteristics and peculiarities of each industry, company and project. Thereby, in the future, a set of questions will be presented and they will be used according to circumstances.

CONCLUSION

This paper discusses the organizational and strategic aspects behind the implementation process of BIM, the reason for which is that few discussions have been made in literature. The main interest of researches is to study the applications of BIM (technical aspects). Nevertheless, this procedure is not sufficient for a long-term use of BIM as a strategic resource. As such, a 3D matrix of strategic planning for the implementation process of BIM was presented to open the debate about strategic aspects related to BIM.

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REFERENCES

Aranda-Mena, G., Crawford, J., Chevez, A., and Froese, T. (2009). "Building information modeling demystified: does it make business sense to adopt BIM?" *International Journal of Managing Projects in Business*, 2(3), 419–433.

Arayici, Y., Coates, P., Koskela, L., Kagioglou, M., Usher, C., and O'Reilly, K. (2011). "Technology adoption in the BIM implementation for lean architectural practice." *Automation Construction*, 20(2), 189–195.

Bernstein, H., Jones, S., Russo, M., Laquidara-Carr, D., Taylor, W., Ramos, J., Lorenz, A., and Terumasa, Y. (2013). *The Business Value of BIM for Construction in Major Global Markets*. New York.

CIC. (2011). *Project execution planning guide (version 2.1)*. Penn State University.

Eastman, C., Teicholz, P., Sacks, R., and Liston, K. (2008). *BIM Handbook: A guide to building information modeling for owners, managers, designers, engineers and contractors*. John Wiley, New Jersey.

FIATECH. (2013). *An Overview of existing BIM standards and guidelines: a report to Fiatech autocodes Project*.

Gu, N., and London, K. (2010). "Understanding and facilitating BIM adoption in the AEC industry." *Automation in Construction*, 19(8), 988–999.

Hamdi, O., and Leite, F. (2012). "BIM and Lean Interactions from the BIM Capability Maturity Model Perspective: A Case Study." *In: Tommelein, Iris D & Pasquire, Chrisitne L., 20th Annual Conference of the International Group for Lean Construction*, San Diego, USA, 18-20 Jul 2012.

Jung, Y., and Joo, M. (2011). "Building information modelling (BIM) framework for practical implementation." *Automation in Construction*, 20(2), 126–133.

Khosrowshahi, F., and Arayici, Y. (2012). "Roadmap for implementation of BIM in the UK construction industry." *Engineering, Construction and Architectural Management*, Emerald Group Publishing Limited, 19(6), 610–635.

Lindblad, H., and Vass, S. (2015). "BIM Implementation and Organisational Change: A

Case Study of a Large Swedish Public Client." *Procedia Economics and Finance*, Elsevier B.V., 21(15), 178–184.

Miettinen, R., and Paavola, S. (2014). "Beyond the BIM utopia: Approaches to the development and implementation of building information modeling." *Automation in Construction*, 43, 84–91.

Murphy, M. E. (2014). "Implementing innovation: a stakeholder competency-based approach for BIM." *Construction Innovation*, Emerald, 14(4), 433–452.

National Institute of Building Science. (2007). *National Building Information Modeling Standard*.

Oskouie, P., Gerber, D. J., Alves, T., and Becerik-Gerber, B. (2012). "Extending the Interaction of Building Information modeling and lean construction." *In: Tommelein, Iris D & Pasquire, Chrisitne L., 20th Annual Conference of the International Group for Lean Construction*, San Diego, USA, 18-20 Jul 2012.

Sacks, R., Koskela, L., Dave, B., and Owen, R. (2010a). "Interaction of Lean and Building Information Modeling in Construction." *Journal of Construction Engineering and Management*, American Society of Civil Engineers, 136(9), 968–980.

Sacks, R., Radosavljevic, M., and Barak, R. (2010b). "Requirements for building information modeling based lean production management systems for construction." *Automation in Construction*, 19(5), 641–655.

Smith, P. (2014). "BIM Implementation – Global Strategies." *Procedia Engineering*, 85, 482–492.

Succar, B. (2009). "Building information modelling framework: A research and delivery foundation for industry stakeholders." *Automation in Construction*, 18(3), 357–375.

Succar, B., and Kassem, M. (2015). "Macro-BIM adoption: Conceptual structures." *Automation in Construction*, 57, 64.

Succar, B., Sher, W., and Williams, A. (2013). "An integrated approach to BIM competency assessment, acquisition and application." *Automation in Construction*, 35, 174–189

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