Building Information Modeling: An Informational Tool for Stakeholders

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Abstract

The evolving concepts of building information modeling (BIM) can serve as a vehicle for improving building design, as well as operability, maintenance, and safety. BIM aims to use computable data to capture and coordinate customer, user, and market requirements and to develop a cost-effective design and technical requirements. Its adoption, therefore, is contingent on the need for well-defined and widely applicable processes, particularly in the project definition phase, that will improve decision-making, reduce cost, and enhance stakeholders' involvement in building projects. The product definition phase of buildings and building assets determines their quality, cost, and reliability. However, often the definition phase depicted on drawings (pictorial non-aggregatable data) and in text or verbally is not clear to many stakeholders, and changes that they may want are difficult to visualize. With BIM, changes, like in a spreadsheet, can quickly lead to new visual outcomes that can improve and synchronize designers' and stakeholders' understanding of the initiative. BIM should also allow for stakeholders' ex-ante (before design) and ex-post (after design) virtual evaluations of building initiatives prior to implementation.

Introduction

Construction projects are often implemented in a fragmented way (Cyon Research, 2003; Chasey & Schexneyder, 2000); architects design, constructors construct, and building managers manage in isolation. However, as far back as 1962, Bovaird, Goldman, and Slattery attempted to gather into cohesive form concepts characterizing the field of operational support for complex systems. These concepts resulted from integrated studies on reliability, maintainability, and logistics problems. According to Bovaird et al. (1962), it was essential to evaluate operational support from an ex-ante (before the design) and ex-post (after the design) point of view. They noted that designers must take the interrelationships among characteristics such as reliability, maintainability, and supply into account relative to the mission. The evolving concepts of building information modeling (BIM) also seek to provide stakeholders with the ability to evaluate the design, construction, and management of buildings using digital mediums, in a virtual setting, before project implementation. BIM, therefore, if appropriately applied, could potentially revolutionize the building industry.

What is BIM?

Currently, BIM is envisioned as an approach to data integration (interoperability),[1] a central repository of continuously available up-to-date integrated information on building design, construction, and management. However, for BIM to be practical and replicable, agreement on the concepts must be achieved and codified within suitable computable technologies that are organic and adaptable to changing circumstances. It is incorrect to view BIM solely as a technical business system and force actors to comply with purely mechanical requirements (Morgan, 1997). Instead, as noted by Morgan, the design of organizations should be viewed from a systems approach, wherein the different building organizations are open to their environment and must optimally interact from a socio-technical perspective to be cost-effective.

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1 Interoperability is the ability to share and manage information between project stakeholders.

Cooper, Bruce, and Wootten (1999) used the term requirement engineering (RE) to define the interactive process that embeds the needs and requirements of project stakeholders. For them, requirement engineering deals with (a) customer, user, and market requirements, (b) design requirements, and (c) technical requirements. Accordingly, the concerns of RE are the goals, desired properties, and constraints of complex systems that involve information technology, organizations, and people (Arayici, Amed, & Aoud, 2006). Other sources such as Keil, Cule, Lyytinen, and Schmidt (1998), Carr (2000), CHAOS Reports (1995, 2000), Nikula and Sajaniemi (2002), Chao and Ishii (2004), and Arayici and Aouad (2005) also addressed RE risk factors. John, Clements-Croome, Fairey, and Loy (2005) noted that the traditional construction process contains four stages: conceptual design, construction, operation, and maintenance, which often are carried out by different organizations.[2] Arayici and Aouad argued that computer integrated construction (CIC) is important for the integration of all phases, including the supply chain. Furthermore, they noted that integration reduces project cost, removes non-valued-added activities improve collaboration and increase client satisfaction. However, like BIM, CIC concepts have not been standardized. Lack of standardization inhibits clarity and widespread acceptance. Efforts by the International Alliance of Interoperability (IAI) to create a standardized model called Industry Foundation Classes (IFC) have not found wide acceptance.

The Concepts

BIM, for some, is merely a form of computable 3D modeling or 3D modeling with "bolt-on" systems. Others, however, view BIM as an integrative process driven by 3D computable digitalized images and linked to Internet-based building cost information services (Smith, O'Keeffe, Georgiou, & Love, 2004). They envision reengineering the fragmented building industry to seamlessly integrate all building project phases within a BIM concept. Thus, the aim of BIM is to integrate, standardize, and codify best practices within all phases of the building industry. John et al. (2005) believe that the conceptual design phase includes the client brief, the initial model, and design services. Designers could use computable 3D to model the client's brief , which would allow for virtual assemble and disassemble of buildings and building components. Moreover, integrated logistic support (ILS) techniques (US DoD, 1983; Jones, 1994; El-Haram & Horner, 2003; John et al., 2005) could be used to develop a cohesive BIM process.

Integrated Logistic Support

Jones (1994) noted that ILS begins with acquisition planning for an item and continues through its useful life. The expectation is that design engineers would evaluate the brief (mission) requirements and develop, within available constraints, the required performance and operational availability, which would include reliability, maintainability, and supply effectiveness of the building. This critical phase of using optimum knowledge and experience in planning, design, procurement, and field operations to achieve the project objectives has been labeled requirement engineering, front-end-analysis, logistic engineering, constructability, etc. (Chasey & Schexneyder, 2000).

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2 Others, such as Tan & Lu (1993), include more phases: engineering planning, concept design, bid and proposal, engineering design, procurement, construction, acceptance and test, pilot run, etc.

The US Department of Defense (DoD), aviation and oil industries have used various ILS techniques, such as failure reporting, analysis, and corrective action system (FRACAS),[3] failure modes, effects, and criticality analysis (FMECA), reliability centered maintenance (RCM), level of repair analysis (LORA),[4] and life cycle costing (LCC) to improve project management. ILS is an engineering and management tool that when used correctly ensures that the owner and user will receive a project that meets their performance and support requirements (El-Haram & Horner, 2003). The construction industry, however, has not fully embraced ILS techniques. As a result, the industry has underperformed for several years, preferring cost approaches that do not account for LCC (El-Haram & Horner; John et al., 2005).

The movement towards design-build (D&B) may further restrict the incorporation of ILS techniques in the construction industry. Within the D&B framework, the contractor is responsible for both design and construction (Lam, Chan, & Chan, 2004). Moreover, often the entire project is turnover to the contractor at the 10% stage, which limits stakeholders' interactions and inputs. Lack of stakeholders' interaction reduces the flow of supportability inputs and adversely impact LCC. Additionally, critical success factors (CSF) for D&B projects are not widely known and D&B procurement has not been proven to be superior to traditional procurement (Lam et al., 2004; Smith et al., 2004). Thus, to ensure reliability, maintainability, and availability of buildings and building components, ILS techniques should be incorporated within the BIM framework. Moreover, contractors should be ILS pre-qualified, since the selection of contractors is also a CSF (Lam et al.).

Applying ILS to Construction Projects

ILS was developed by DoD and defined in MIL.STD-1388; its primary aim is to ensure that all elements of design are fully integrated to meet the client LCC requirements (El-Haram & Horner, 2003). However, like Jones' Integrated Logistics Support Handbook, MIL.STD-1388 does not lend itself to quick snippets of information that could be used as a template for construction projects. Lack of easy access to ILS templates will continue to dissuade designers from using the ILS techniques. Nonetheless, El-Haram and Horner, and Galloway (1996) have made significant contributions to the development of a streamlined version of ILS for the construction industry as well as for collecting LCC data for the building industry (El-Haram, Marenjak, & Horner 2002). From their work, it is possible to develop a codified version of a fully integrated BIM process.

ILS techniques are applicable from the design phase throughout support and disposal phases (El-Haram & Horner, 2003); it integrates the requirements for system performance with LCC optimization (Galloway, 1996). Galloway argued that the first approach is to develop the readiness and supportability objectives and conduct a logistic support analysis (LSA).[5] Tan and Lu (1993) stated that the quality of construction design leads to the quality of construction and the

3 FRACAS is a closed-loop reporting system; it requires the contractor to follow each reported failure with a report of the failure analysis and the corrective action required.

4 LORA is a process for evaluating maintenance action to determine if a task is economical and where it can be accomplished in the most cost-effective fashion. For example, LORA will decide if it is more economical to repair a failed item with in-house personnel, or contractor, on the equipment, off the equipment, discard, etc. and such determination leads to resource requirements (labor, spares, etc.).

5 Logistic Support Analysis (LSA) is the application of scientific and engineering efforts during the engineering, design, and acquisition process that will improve project supportability and other ILS objectives through the use of an iterative process of definition, synthesis, trade-off, test, and evaluation.

competitiveness of the engineering firms undertaken them. Teng and Ho (1996) noted that even the most advanced operations would not be able to improve product reliability over design reliability. El-Haram and Horner confirmed that two ILS techniques used in other industries, FMECA and RCM have achieved a significant reduction in costs. FMECA is a systematic way of identifying modes, causes, and effects of failures, and RCM identifies the most applicable and cost effective method for mitigating or eliminating failures. The level of repair analysis (LORA), and availability, reliability, and maintainability (ARM) are best applied at the design stage.

Jones (1994) indicated that there are three primary phases of logistics: functional requirements, physical requirements, and use. El-Haram and Horner (2003) highlighted the process of disassembling a building into physical and functional elements and also modeled the integration of physical and functional elements of a building. Furthermore, they noted that disassembling could continue to the lowest element, the part. For instance, on the physical side, a building could be disaggregated into superstructure, substructure, and services. Superstructure into walls, roof, doors, windows, and so on. Each sub-element could be further broken down into additional details, depending on criticality. A window, for example, could be disaggregated into frame, glass, putty, sill, and so on, to determine how and why each sub-element may fail and how to counteract that mode of failure. Today's 3D software can provide these levels of disassembling and more; some already provide the bill of material reports, and changes can flow seamlessly through the model. Unfortunately, building components, such as windows, knobs, and so on, are not current with all CAD software (Goldberg, 2006). Thus, linking CAD software via the Internet to commercial suppliers web sites will enhance the availability of building components.

Conclusion

The ILS and constructability literature can provide a cohesive framework for the development of an integrated BIM process that improves the quality, performance, and cost-effectiveness of building projects. More importantly, the literature can provide the basis for a template of ideal building information and a path to standardize the BIM process.

BIM, however, is merely an enabler, and although it may institutionalize process changes, it does not drive change; instead, people propel organizational changes (Spitzer, 1996). Therefore, the selection of project personnel will remain an essential component of building project implementation, as well as the interactions and clarity of communications between stakeholders.

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