Accepted in Proceedings of Asia-Pacific Researchers in Organisation Studies - APROS/EGOS Conference
Sydney, Australia, Dec. 9-11, 2015

BIM Projects. Is it the end for the construction Project Manager?

Conrad Boton, École de Technologie Supérieure
Daniel Forgues, École de Technologie Supérieure
Article de conférence présenté dans le cadre de APROS/ EGOs 2016

Abstract

The design and delivery of construction processes are traditionally built around the theory and practices of Project management. However, the value of traditional project management and even the pertinence of project management theory have been questioned from pundits in Lean Construction. Building Information Modeling and related integrated practices are bringing more challenges to project management approaches, since the way the building project is designed and planned is much more related to processes and workflows. This paper, through a recent case study, explores the challenges of traditional project management approaches used in conjuncture with BIM.

1. Introduction

The Building Information Modeling (BIM) approach is dramatically changing the way information is managed in the architecture, engineering and construction industry. Information is considered as one of the critical and complex resources to be managed in construction projects.

Many interesting protocols and frameworks have been proposed to support BIM implementation in construction projects (Kassem et al. 2014). One important aspect of these works is related to formalizing the information delivery and exchanges in BIM (Eastman et al. 2010). The use of such protocols to formalize BIM-based collaboration through process maps has received increasing success in the industry. But recent research works showed significant gaps between the as-planned BIM implementation and the way it is really managed in projects (Eadie et al. 2013; Froese 2010). Moreover, many implementation attempts ended in failure (Oakley 2012); using appropriate protocols is not a guaranty of success. The main reason is that current project management practices seem obsolete to encompass the requirements for an efficient BIM implementation. It is indeed not sufficient to add a BIM execution plan as supplementary project management tools without rethinking the management practices in order to integrate at the same level the planning, the controlling and the execution aspects. If BIM protocols provide practitioners with interesting approach and tools to support the planning of BIM implementation, little attention has been paid on the way it is executed and controlled.

The Project Management Institute Body of Knowledge (PMBOK) Guide is considered as the reference for documenting Project Management recognized practices (Project Management Institute 2013). As asserted by Koskela and Howell (2002), the PMBOK framework is built on 3 core processes: planning, executing and controlling. There is little room for the execution dimension in the traditional planning and control scheme. Activities and tasks are the units of analysis in these core processes. Its underlying principles are the transformation of inputs to outputs and the decomposition of the total transformation hierarchically into smaller independent tasks. The linear and fragmented design and delivery process used in construction exemplifies this model. Koskela and Howell (2002) consider project management to be based on three theories of management: management–as planning, the dispatching model and the thermostat model. Indeed based on construction application domain, they demonstrated empirical evidence anomalies in the theory of project (lack of flow conceptualization, lack of value generation), the theory of management (impossibility of maintaining a complete up-to-date plan), the theory of execution (need of informal management to succeed) and the theory of control (lack of the learning function).

Winch (2010) reinforces this view stating that construction management is about the management of information processing. He identifies information gaps occurring at each phase of the transformation process which alter the client information regarding needs and expectations, impacting value generation. While Koskela and Howell (2002) concentrate on the flow of material, Winch (2012) brings the concept of management of the information flow.

Of course the PMBOK has lightly improved since Koskela and Howell (2002)'s discussion. The current version (fifth edition released in 2013) is proposing more processes while retaining the core processes. An extension to construction project has been proposed (PMI 2003). Nevertheless, the advent of BIM and new procurement methods in the construction industry seems to show more limitations to the application of project management principles to manage construction projects.

Approaches have been developed to manage the development, exchange and use of the building information between the members of the project network. The most recognized one is the BIM Execution Plan, a document that shares some similarities to the PMBOK's Project plan. However, little has been said about the contradictions emerging from the duplication of roles and plans to manage the project and the production of the information to deliver it outcomes. Based on a real BIM implementation case study, this paper explores the gap between as-planned BIM implementation and the actual implementation process, from a managerial point of view. It also discusses the lessons learned and proposes an update to Koskela and Howell (2002)'s theories prompt from the BIM practices and newer editions of the PMBOK.

The article is organized in three main sections. First, the background related to project management practices in the construction industry is explored, including the current project management body of knowledge, the management practices and the involved roles in construction projects, and the evolution of the managers' role. Based on a case study, the second section presents how BIM implementation can change the management practices and roles. It focuses on the BIM manager responsibilities in order to emphasis the overlaps with the project manager role. Finally, the lessons learned are presented and discussed.

2. Construction projects management: theories and practices

2.1. Current project management body of knowledge

The main aim of the PMBOK Guide is to define the fields of knowledge covering project management and to identify the recognized professional practices in project management (Project Management Institute 2013). Because PMI philosophy and its certification programs are very widely disseminated, the PMBOK Guide dominates the general perception of the discipline (Morris 2013). Since its first edition in 1983, the Project Management Body Of Knowledge (PMBOK) has evolved and "there have since been several more updates, most relatively minor" (Morris 2013). The current edition, released in 2013, proposes 47 processes and 10 knowledge areas. The processes include 2 initiating processes, 24 planning processes, 8 execution processes, 11 controlling and monitoring processes, and 2 closing processes.

One of the main criticisms about the PMBOK Guide is related to the fact that it rests on narrow theory (Kupec 2013). Indeed, considering empirical evidence from the construction industry, Koskela and Howell (2002) noted that “the theoretical base has been implicit”. According to Morris (2013), this ‘theory light’ aspect is not any more understandable nowadays even if it was so in the 1980s. Koskela and Howell (2002) formulated a second criticism related to the fact that the nature of projects is faultily understood and the planning, execution and control definitions are deficient.

Construction project managers face a major dilemma since the construction industry was quite unsuccessful applying project management best practices outlined by the PMBOK (Winch 2010). Because of a procurement process that favour a high fragmentation of work divided between the members of a temporary coalition of firms, most of the core tools (Critical Path Method (CPM), Work Breakdown Structure (WBS) and others) cannot be effectively used to plan and control construction projects. Tools proposed for developing the BIM execution plans are much more effective and collaboration between BIM managers of the different firms much greater than between project managers. With the increasing success of new information technologies including the BIM approach, the construction management practices are significantly changing. Consequently, project managers are facing new challenges related to both their role and how to achieve success in the projects.

2.2 The traditional role of project manager

The role of the project manager is crucial and his competence is seen as "clearly a vital factor in the success of project" (Crawford 2000). Moreover, the main factors of failure identified for project management include "wrong person as project manager" (Munns & Bjeirmi 1996). Kerzner (2013) stated that "the major factor for the successful implementation of project management is that the project manager and team become the focal point of integrative responsibility". According to Cooper (1991), the basic business of the project manager is to deliver an end product compliantly with performance requirements and within budget and time limitations specified by the customer. The generic responsibilities of the project manager include defining the work’s requirements establishing the work’s extent, allocating the required resources, planning the activities execution, monitoring the work progress and adjusting possible deviations (Munns & Bjeirmi 1996).

Since projects generally involve professional specialists from different disciplines, the role of the project manager is also seen as an integration role. Project managers are then considered as integrators whose aim is to achieve "the unity of effort among the major functional specialists" (Lawrence & Lorsch 1984). As integrator, the project manager has to accommodate personal goals with the global objectives and to ensure a good team integration as well as consistent and efficient information flow.

Therefore, according to the literature in Project Management, the Project Manager plays the roles of the planner, and is the one ensuring that the project is delivered according to his plan. However, researches show that the project usually does not happen according to the plan and there are major discrepancies between the work that is planned and the one executed, reducing productivity and generating rework (Ballard 2000). Moreover, CPM are ill-adapted to context in which construction projects are delivered nowadays (Yamin & Harmelink 2001).

2.3 The emerging roles of BIM managers, coordinators and champions

Assuming that changes induced by the implementation of the information and communication technology such as BIM are not purely technical, Froese (2010) stated that changes to management processes are necessary. Indeed BIM can be a "catalyst for Project Managers to reengineer their processes to better integrate the different stakeholders involved in modern construction projects" (Bryde et al. 2013). Froese (2010) identified 3 main types of impact on construction project management, including: 1) the need to explicitly manage project information and information systems and 2) the need to recognize, to represent, and to manage more explicitly the interdependencies due to the high degree of integration and collaboration across the tasks of the project.

According to Froese (2010), the fundamental changes are prompted by the fact that the project team members need to collaborate, using computer-based tools, to produce comprehensive "virtual prototypes of all aspects of the construction project as the central activity for the design and management of the project" (Froese 2010). The distance between technical competencies and management functions in the project has then to be considerably reduced; consequently managers need to be closer to the virtual prototypes. In its issue of February 2013, AEC Magazine stated that the changes made by the BIM are so important that it is utopian to think that only the CAD[1] manager can effectively be responsible for its implementation in a firm (Day 2013). It is necessary to have support from senior hierarchy and to establish a good method for change management. Managing BIM involves different levels of responsibility and technical expertise that requires the appeal of new roles in the use of technology and modeling standards, but also in the coordination necessary for the BIM implementation contexts (Barison & Santos 2010). Thus, new roles are appearing and one of the most often cited is the BIM manager who is far from a simple substitution of the usual CAD manager as showed the AEC Magazine (Day 2013).

Barison and Santos (2010) have tried to inventory the new roles and responsibilities which are coming with BIM. An interesting outcome from their work lies in the fact that these roles are not simply related to technical competencies. It is also about integration and leadership-related aspects. For example, “the main function of a BIM Manager is to manage people in the implementation and/or maintenance of the BIM process” and a BIM Facilitator has the responsibility of assisting other professionals and usually improving the communication between the engineer and the foremen or contractors (Barison & Santos 2010). Through these examples, there seems to be some overlaps between the traditional project management roles and the new BIM-related roles.

3. Managing construction projects in the age of BIM: a case study

3.1 Research approach

According to Gerring (2004), case study is “an intensive study of a single unit for the purpose of understanding a larger class of (similar) units”. Case studies are more generally defined as empirical and rich description of a phenomenon particular instances, typically based on a variety of data sources (Yin 1994). Theoretical propositions and constructs can be created by using case-based evidence (Eisenhardt 1989). The case study method can use both quantitative and qualitative evidences (Yin 1981). These evidences can come from observations, verbal records, and fieldwork, with many data collection methods including ethnographies, participant-observation, etc. (Yin 1981). Then, case study represent a research strategy (Yin 1981) and the case study method is then defined as a “way of defining cases, not a way of analysing cases or a way of modelling causal relations” (Gerring 2004). It is distinguished from other methods by the reliance it has “on covariation demonstrated by a single unit and its attempt, at the same time, to illuminate features of a broader set of units” (Gerring 2004). A good usefulness of case studies is to form descriptive inferences (Gerring 2004).

[1] Computer-Aided Design

The case study presented in this section is related to the expansion of the Québec airport and the main aim was to study how BIM has been implemented in the project. It has been conducted during the first half of 2015 while the project was still in the design stage. The research approach, inspired by the ethnographic approach, is based on three major data collection tools: a survey, semi-structured interviews and observations. An online survey was first conducted. Based on the responses, semi-directive interviews were then carried out to deepen various aspects of the implementation of BIM in the project. Finally, the researchers observe the practices for a period of two weeks on side in order to consolidate the results of the interviews.

3.2 A study of the Québec airport extension project

The business managing firm of the Québec City airport has the will to stimulate its growth through the expansion of its property portfolio. After conducting a market study in 2013 to forecast the attendance at the airport during the next thirty years, the firm estimated that the construction of a new terminal would meet his needs and those of airlines and future passengers. The long term goal is to offer long-haul flights to destinations outside Canada. To maximize the growth of the airport, its new infrastructure must meet high requirements in terms of quality and operation. The business managing firm has then decided to implement BIM for this airport expansion project. This is due to a need for improved coordination during the design and construction phases as well as the desire for optimized equipment management through the integration between BIM technology and its current facility management system.

Based on both the experience of the owner and the recommendations of a consultant firm, a BIM Execution Plan has been defined, based on the BIM Project Execution guide proposed by Pennsylvania State University (Computer Integrated Construction Research Program 2012). The document identifies the project objectives, the priorities and the related BIM uses. It also describes the responsibilities and the generic processes to be applied. It finally identifies the technological and software environment and the needs of exchange and coordination between the various trades.

Among other goals, the owner main aim is to successfully implement BIM during the design and the construction phases, but also to be able to integrate BIM information within its existing Facility Management system for future purposes. To ensure a good understanding of the challenges, an iterative process was set up to study in detail the needs. This process was very important but induced a significant delay. For this reason and other ones, a fast track approach was adopted for the project delivery. In fast tracking, the normal duration of the project could be considerably reduced. A fast track project is a project which is "completed in less than 70% of the time it takes to do traditional projects" (Williams 1995).

One interesting particularity of the project lies in the fact that all the project team members have to share a common physical space provided by the business managing firm near the construction site. The idea here is similar to the “Big Room” concept and aims at developing collaboration synergies among disciplines. The “Big Room” concept comes from lean construction theories and consists in bringing “together cross-functional teams under one roof to explore problems” (Forbes & Ahmed 2010). The project is managed by a project manager designated by the owner, who is assisted by external consultants. Five main trades are involved: architecture, structural engineering, civil engineering, MEP (mechanical, electrical and plumbing) engineering and contractor. The firms involved in the project composed a team dedicated to the project including a project manager and a BIM manager per trade (See Figure 1).

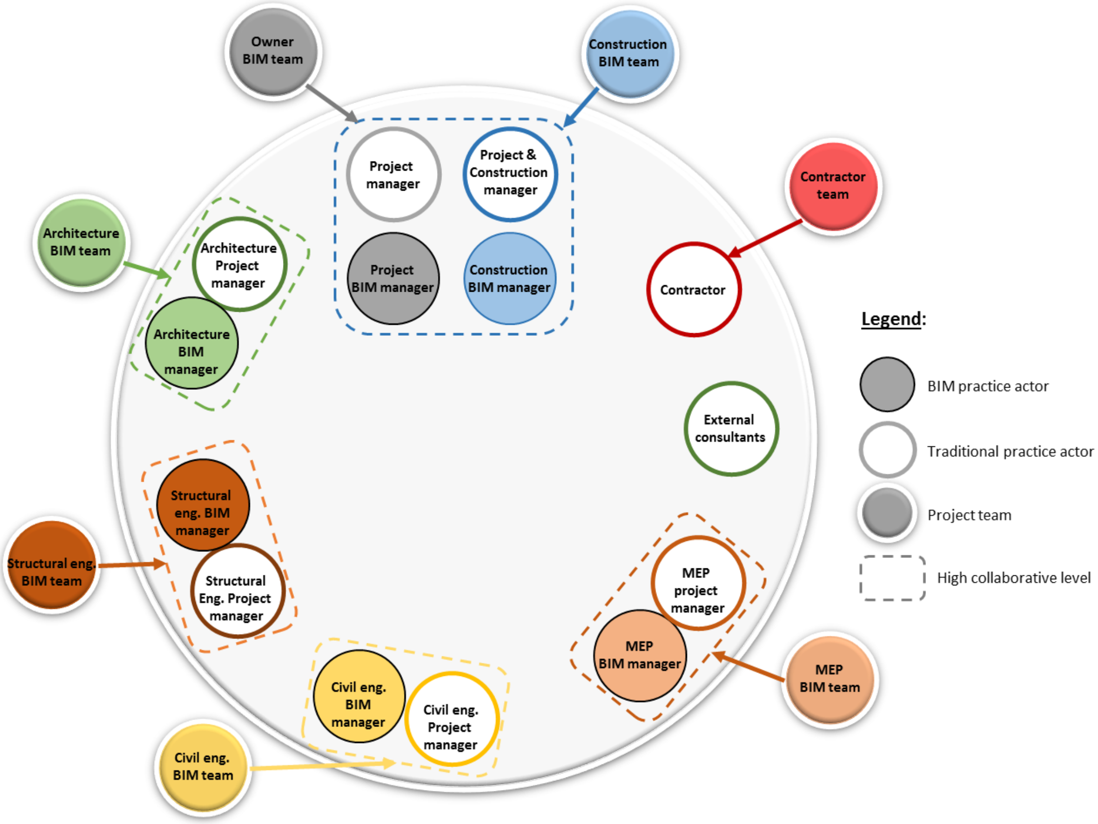

Figure 1: Managerial roles in the project (source: Project documentation)

3.2.3 The implementation of BIM in practice

Some differences have been found between the as-planned processes and those actually implemented. Indeed, all participants interviewed believed that the process recommended by the execution plan is too theoretical, too general and not adapted to the project. In general, the proposed processes are seen as difficult to apply and not close enough to the project reality. It should be mentioned that even if it was claimed that the execution plan was inspired by the Pennsylvania State BIM Project Execution guide, the proposed processes are not described using the Pennsylvania State formalism. The formalism used was also not the BPMN advocated by the Building Smart alliance.

Beyond the formalization issues, one of the main criticisms made about the execution plan by the practitioners is that it does not take into account the great need required for a fast track project for different disciplines to coordinate with respect to each other. This is particularly the case for the structural engineering firm that in reality had to issue its first outcomes very quickly before the other firms while taking into account the evolution of the architectural and MEP models. In collaboration with the other stakeholders, it was finally decided that deadlines would be applied to MEP engineers and architects only on the parts of the model required to produce the structural models.

Moreover, issues related to the quality control processes have been widely mentioned. For the structural engineering firm, there are too many quality control processes described in the execution plan that were not adapted to their situation. They believe that an effective quality control as described would take three full weeks, which is totally unthinkable which such a fast track project where the models continually evolved. The participants adopted the collective idea of advancing the models and performing interference detection at planned moments when the appropriate elements have been modelled properly. Another aspect of quality control is related to the contractor who, according to the execution plan process, had the responsibility to audit the models and its compliance to Uniformat standard. This process, planned to be managed by the contractor, raised some contractual liability questions. Although it was not possible to validate these assertions during the observation period, some stakeholders believed that the responsibility for interdisciplinary quality control should be under the responsibility of the BIM managers. That raises the question of the BIM-related roles and responsibilities on the project.

3.2.2 The BIM managers' roles and responsibilities

Each firm uses its own hierarchy and organization, but the BIM execution plan has placed a particular emphasis on the responsibilities of the BIM managers. From a theoretical point of view, these responsibilities are mainly related to the management of the models content, quality control and 3D coordination. In practice, the architecture firm and the MEP firm have designated dedicated actors (different from the project manager) to hold this role in their organization. The BIM manager designated by the structural engineering firm seems to have a more general role that can be likened to a project manager. He is assisted by a BIM coordinator who is responsible for internal BIM models management.

In practice, the BIM managers' roles are not really similar from a discipline to another one. The BIM manager designated by the architecture firm has both technical and managerial roles. He is responsible for the weekly upload of the architectural models and the integration with the other models. He defines in advance the elements to be checked for intra- and interdisciplinary clash detection. He also ensures that each of the designers conducts the internal quality control on the architectural model after working on it during the week.

The MEP firm has a different hierarchy due to the compounded nature of its business. The designated BIM manager is coupled with a BIM administrator dedicated to each branch (ventilation, electricity, plumbing, etc.) with whom he organizes the work for the whole team. He performs visual inspections of the MEP models. In addition to ensuring that MEP technicians check the quality of their model, he performs an important job of managing and correcting warnings in Revit. The aim is to produce models with the fewest errors.

The BIM manager designated by the structural engineering firm plays a more general role than in the other two disciplines. He has to work with the project manager in order to plan and to organize the work to be performed by the structural engineers. He also ensures the quality of 2D conceptual rendering provided by his designers without having any real responsibility for the content of the 3D models. This role belongs to the BIM coordinator who has to carry out quality checks on the models. The BIM coordinator role here is quite similar to the BIM manager role in the other firms.

The contractor also designated two BIM managers on the project to lead the 4D and the 5D aspects. During our study, they were still in an appropriation stage.

4. Lessons learned and discussions

Traditionally, the project manager plays the roles of the planner, and is responsible to ensure that the project is delivered according to his plan. One important lesson learned from the case study is that a significant part of this planning and control role has shifted to the BIM managers who are responsible for the production of the BIM model. That seems to be the source of important overlaps between these two functions which are likely to co-exist henceforth in construction projects. This creates two contradictions in the management of the project:

1. As opposed to project management practices, the preparation of the BIM Execution Plan is collaborative. BIM managers act as facilitators and coaches to help the team develop a shared plan and to elaborate the strategy for the production of the models in the course of the project.

2. Traditional tools used by project progress do not work well with BIM. Client project managers require the production of 2D drawings to assess the evolution of the construction documents. This proved to be quite ineffective, slowing drastically the production process (generating 2D drawings from a 3D model is time consuming). It also does not measure the real state of development of the BIM models.

Therefore, BIM managers have a much better control of the design process and seem to be in a better position to have a significant impact on the project delivery.

Table 1: Comparison of the PMBOK's project plan and BIM Execution Plan contents

	PMBoK's Project plan	**PSU – BIM Project Execution**
Project information	Project management approach	Project information
	Procurement management	Delivery strategy / Contract
	Project scope	Project goals / BIM uses
	Milestones	Project Deliverables
Resources and planning	Schedule Baseline and WBS	Model structure
	Resources	Technological infrastructure needs
	Quality management	Quality control
	Staffing management	Organizational roles / Staffing
	Schedule management	Schedule for delivery
	Cost management	
	Risk management	Risk management[2]
Collaboration and exchanges	Change management	Collaboration procedures
	Communication management - contacts	Key contacts

[2] The PSU BIM Project Execution Plan guide refers to the BIM ConsensusDOCS 301 BIM Addendum

	Communication management - exchanges	BIM information exchanges
	Procurement management	BIM process design

The overlaps could be explained by the fact that the existing BIM execution planning guides and protocols are structured similarly to the PMBOK's project plan. Indeed, many protocols and guidelines exist to support the industry in BIM execution planning (U.S. Army Corps of Engineers 2013; Computer Integrated Construction 2011; Autodesk 2010; Building and Construction Authority 2012) and most of them are based on the guide proposed by the Pennsylvania State University. As shown in Table 1, the structure of their BIM execution Plan is quite similar to the content of the PMBOK's project plan.

The similarity between both structure/content can also explain the difficulties of the current execution plans to be efficiently applicable by practitioners. Indeed, as stated by Koskela and Howell (2002), the project management theories seem obsolete for construction projects management: aligning the BIM execution plan on the PMBOK project plan cannot lead to success.

The core principle of BIM is the management of the information processing through a shared and unique platform. BIM related technologies have been considered disruptive, since they may require reconfiguration of work within and between specialized practices involved in the design and construction process to move from the management of activities and tasks to the management of workflow and dataflow. It also challenges the way the relationships between the members of the project network are set through design-bid-build (DBB) contracts. An effective management of workflow and dataflow obviously involves significant changes in the project planning and control methods, as well as the project delivery method. The Lean Construction principles appear attractive for this purpose. The Last Planner and Value Stream Mapping for example seem very interesting tools to optimize processes and information flows. However, their use in BIM projects has not yet received the attention they deserve. It also seems obvious that the project delivery methods must evolve to allow an effective implementation of such new approaches. The survey conducted by Becerik-Gerber and Rice (2010) with construction professionals has also shown that new project delivery methods including Integrated Project Delivery (IPD) seem to be more appropriate to carry out BIM projects than the traditional DBB.

5. Conclusion

Based on a case study, this paper explored the impact of BIM implementation on application of traditional project management approaches. It raised two main challenges. The first challenge is related to the new roles necessary in BIM project, including the BIM manager. The project manager seems no longer to be the central actor of the project and the BIM manager appears as a new major player, with important managerial responsibilities. The involvement of these two main roles in construction projects could be source of critical overlaps and conflicts. The second challenge is related to the ability of the current project management theories to support effective planning and control in BIM projects. BIM implementation requires to move from the management of activities and tasks to the management of workflow and dataflow. BIM execution plans should not rely on the current project management body of knowledge but on new approaches and Lean principles could be a good starting point. The project delivery methods should also evolve to enable the required transformations.

Bibliography

Autodesk, 2010. Autodesk BIM Deployment Plan : A Practical Framework for Implementing BIM.

Ballard, H.G., 2000. *The Last Planner System of Production Control*. University of Birmingham.

Barison, M.B. & Santos, E.T., 2010. An overview of BIM specialists Roles and responsibilities of BIM Specialists. In W. Tizani, ed. *Proceedings of the International Conference on Computing in Civil Engineering*.

Becerik-Gerber, B. & Rice, S., 2010. The Perceived Value of Building Information Modeling in the U.S. Building Industry. *Journal of Information Technology in Construction*, 15(February), pp.185–201.

Bryde, D., Broquetas, M. & Volm, J.M., 2013. The project benefits of building information modelling (BIM). *International Journal of Project Management*, 31(7), pp.971–980.

Building and Construction Authority, 2012. *Singapore BIM guide*,

Computer Integrated Construction, 2011. *BIM Project Execution Planning Guide – Version 2.1*, The Pennsylvania State University, University Park, PA, USA.

Computer Integrated Construction Research Program, 2012. *BIM Planning Guide for Facility Owners*, The Pennsylvania State University, University Park, PA, USA.

Crawford, L., 2000. Profiling the Competent Project Manager. *Management*, pp.3–15.

Day, M., 2013. BIM is not CAD. *AEC Magazine*. Available at: http://aecmag.com/technology-mainmenu-35/531-bim-is-not-cad [Accessed July 1, 2015].

Eadie, R. et al., 2013. BIM implementation throughout the UK construction project lifecycle: An analysis. *Automation in Construction*, 36, pp.145–151.

Eastman, C.M. et al., 2010. Exchange Model and Exchange Object Concepts for Implementation of National BIM Standards. *Journal of Computing in Civil Engineering*, 24(1), pp.25–34.

Eisenhardt, K.M., 1989. Building Theories from Case Study Research. *Academy of Management Review*, 14(4), pp.532–550.

Forbes, L.H. & Ahmed, S.M., 2010. *Modern construction: lean project delivery and integrated practices*, CRC Press.

Froese, T.M., 2010. The impact of emerging information technology on project management for construction. *Automation in Construction*, 19(5), pp.531–538.

Gerring, J., 2004. What Is a Case Study and What Is It Good for? *The American Political Science Review*, 98(2), pp.341–354.

Kassem, M. et al., 2014. Building Information Modelling: Collaborative Design Processes Protocols. *Journal of Information Technology in Construction*, 19(July), pp.126–149.

Kerzner, H.R., 2013. *Project management: a systems approach to planning, scheduling, and controlling*, John Wiley & Sons.

Koskela, L. & Howell, G., 2002. The underlying theory of project management is obsolete. In *Proceedings of the PMI Research Conference*.

Kupec, C.J., 2013. Training Needs for Project Management Professionals in the Defense Industry. *Journal of Defense Studies & Resource Management*, 2(2), pp.1–10.

Lawrence, P.R. & Lorsch, J.W., 1984. New Management Job: The Integrator. *Army Organizational Effectiveness Journal*, 4(3), pp.27–34.

Morris, P., 2013. Reconstructing Project Management Reprised: A Knowledge Perspective. *Project Management Journal*, (October).

Munns, A. & Bjeirmi, B., 1996. The role of project management in achieving project success. *International Journal of Project Management*, 14(2), pp.81–87.

Oakley, J., 2012. Getting a BIM Rap: Why Implementations Fail, and What You Can Do About It. *AEC Bytes*, 65.

PMI, 2003. *Construction Extension to a Guide to the Project Management Body of Knowledge*, Philadelphia, PA: Project Management Institute.

Project Management Institute., 2013. *A Guide to the Project Management Body of Knowledge (PMBOK Guide) - Fifth Edition*.

U.S. Army Corps of Engineers, 2013. *USACE BIM Project Execution Plan Template -Version 2.0*,

Yamin, R. & Harmelink, D., 2001. Comparison of linear scheduling model (LSM) and critical path method (CPM). *Journal of Construction Engineering And Management*, pp.374–381.

Yin, R.K., 1994. *Case study research: Design and methods* 2nd editio., Newbury Park: Sage publications.

Yin, R.K., 1981. The Case Study Crisis : Some Answers. *Administrative Science Quarterly*, 26(March), pp.58–65.