Automation in Construction 83 (2017) 169–183

Contents lists available at ScienceDirect

Automation in Construction

journal homepage: www.elsevier.com/locate/autcon

Developing owner information requirements for BIM-enabled project delivery and asset management

Hasan Burak Cavka*, Sheryl Staub-French, Erik A. Poirier

Department of Civil Engineering, The University of British Columbia, Vancouver, BC V6T 1Z4, Canada

ARTICLE INFO

Keywords:
Building information modeling (BIM)
Project delivery
Facilities management (FM)
Operations and maintenance
Information requirements
Facility handover

ABSTRACT

Building information modeling (BIM) is emerging as a potential solution for facility owners to address the challenges of poor information fidelity, interoperability, and usability in project delivery to support the lifecycle of their assets' information. Despite the many benefits offered by BIM, its use for facility operations remains significantly limited. The reality is that implementing BIM in large owner organisations is a complex challenge. In particular, a significant barrier to BIM adoption for owners is the challenge of identifying and formalizing the information requirements needed to support model-based project delivery and asset management. This paper presents the results of a longitudinal research project that investigated two large owner organisations in Canada to better understand the process of developing and formulating BIM requirements to support the lifecycle of their assets. Specifically, the objectives were to formalize an iterative approach to the identification and characterization of owner requirements and to develop a conceptual framework that would relate digital and physical products to owner requirements and organisational constructs, to underpin the formalization process. As part of this research an array of requirements documentation were analysed, interviews were performed with numerous facility management personnel, and BIMs from four projects were analysed. A methodology is introduced to support a rigorous and detailed analysis of BIM requirements. The investigation of the owner requirements helped to develop an understanding of the required information content, and its alignment with BIM. Finally the relationships between organisational constructs, owner requirements, and BIM were mapped. As the construction industry shifts towards model-based project delivery, this research will inform owners about how to think about handover of digital facility models, and what to require in models based on their specific needs.

1. Introduction

In the mid-1980's, the National Academy of Science's National Research Council's Building Research Board suggested that integrated databases were potentially among the most cost-effective way of managing facilities [1]. Three decades later, building information modeling (BIM) has emerged as a solution, offering great potential to generate, consolidate and maintain these integrated databases, which contain a facility's (or a portfolio of facilities') relevant information to support operations and maintenance. Yet, despite increased research efforts aimed at developing tools and technical capabilities to support BIM uses for Owners, of which BIM for facilities management (FM) is perhaps the most discussed, widespread adoption is still relatively low around the globe [2] [3]. Indeed, it has been reported that the utilization of BIM for FM, among other uses of BIM for owners, is falling behind design and construction applications of BIM [4].

The issues underlying the slow rate of BIM adoption on the part of Owners is multipronged. Becerik-Gerber et al. [2] identified *technology and process related,* and *organisational* challenges in implementing BIM in the operation and maintenance processes. Kiviniemi and Codinhoto [5] indicate that the difference in project based business and lifecycle management is one of the main challenges in implementing BIM in the FM processes. The literature on barriers in implementing BIM for FM ([6]; [2]; [4]; [7]; [8]) indicate the complexity of the implementation process. In our own studies of facility owners, we observed the complexity of the implementation process as one of the most important barriers [9]. The prevalent discourse around identifying requirements for owners' handover models focuses on the required attributes primarily related with the components of the design. From this point of view, digital spreadsheets of component attributes are often seen as the critical representation of an owner's modeling needs. However, the complexity of implementation is in part due to the overall shift in practice which is required throughout a facility's lifecycle and across the different departments that are involved in the delivery and management of that facility. The shift in practice is mainly related to how individuals generate, consume, manage and exchange facility

* Corresponding author.
E-mail addresses: hbcavka@civil.ubc.ca (H.B. Cavka), ssf@civil.ubc.ca (S. Staub-French), erik.a.poirier@gmail.com (E.A. Poirier).

http://dx.doi.org/10.1016/j.autcon.2017.08.006
Received 5 September 2016; Received in revised form 26 June 2017; Accepted 8 August 2017

information across its lifecycle [10]. For owners, who are consumers of facility information during the design and construction phases and then shift into an information generation and management role (while retaining their consumption role) during the operations and maintenance phase, the role they play is crucial in initiating and carrying facility information throughout its lifecycle. Indeed, owners establish the facility's requirements upfront (i.e. what are the needs, design criteria and the performance to be met), ensure compliance to the requirements during design and construction, and require deliverables that accompany the facility to assist with operations and facility management.

The advent of BIM, i.e. the transition from 2D graphical representation to digital representation of a facility which contains geometric and non-geometric project information in a structured format, is seen to offer many benefits to owners over an asset's lifecycle (e.g. [11].). However, reaping these purported benefits requires owners to be very specific in asking project stakeholders to deliver both a physical and digital product. Indeed, the development of project requirements with the appropriate amount of detail is an important step since owner's project requirements are considered to be the benchmark for all project related performance assessment. According to a survey of owners, more clearly defined BIM deliverables between project partners is the most important factor contributing to increased benefits of BIM [12]. Over the past decade, there has been increasing reports of large owners, such as universities, that provide their building project teams with detailed guidelines and deliverable requirements [13]. However, establishing these requirements so that they inform not only the physical product being delivered, but also its digital representation containing related project information is a significant challenge. Indeed, owner requirements, in the form of design guidelines, codes and regulations, technical manuals, etc. are not expressed in computable formats that lend themselves to BIM-enabled project delivery [14]. Furthermore, efforts to generalize owner requirements fall short, given the highly contextual nature of the construction and asset management industries. There is therefore a need to provide robust processes through which owners can develop requirements that facilitate and take advantage of BIM-enabled project delivery and asset management, while also allowing them to check for compliance to these requirements through quality assurance and quality control methods. BIM-enabled project delivery in this context relate to leveraging BIM for exchanging project information to support handover and FM functions.

The aim of this paper is to present the findings from a longitudinal research project that investigated the development of owner requirements to support BIM-enabled project delivery and asset management using two case studies from Canada. Through this paper BIM is used to refer to both a data model (building information model), and a process (building information modeling). The interrelationship between the process and the model is further explained throughout the following sections. The main objective of the research project was to better understand the process of developing and formulating BIM requirements to support the lifecycle of owner's assets. The research team set out to formalize an iterative approach to the identification and characterization of owner requirements as well as to develop a conceptual framework that would relate digital and physical products to an owner requirements and organisational constructs, which serves to underpin the formalization process. Throughout this paper, facilities management (FM) as an integrated process, and asset management as an FM function are often used. According to CEN, the European Committee for Standardization, and ratified by BSI British Standards "facilities management is the integration of processes within an organisation to maintain and develop the agreed services which support and improve the effectiveness of its primary activities" (EN15221-1:2006). International Facility Management Association (IFMA) defines FM as a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology. FM is divided into the core competencies and the FM functions of these core competencies. While core competencies have a higher level of focus such as operations and management, technology, and project management, the FM functions focus on tasks related to the core competencies such as asset management and maintenance management.

An overall methodology to guide owners in the development of their requirements for BIM-enabled project delivery and asset management is first proposed. As part of the methodology, a classification of owner requirements is developed based on data collected and analysed from ethnographic studies of two large owner organisations. Identification of required model information is exemplified through analysis of identified computable requirements from the owner requirements. Computable requirements in this research refer to the owner requirements that can be represented in and queried from a BIM. Model information requirements are then exemplified through the identification of computable requirements. Finally, a framework is developed through which, the relationship between digital (model) and physical (design solution) products with the types of owner requirements and organisational constructs are described.

The findings from this investigation suggest that current owner requirements are represented implicitly and explicitly in a large number of diverse documents as well as in the minds of facility management professionals, typically with little formalized structure. In this sense, requirements are often not formalized in a way that matches the content and structure necessary for BIM-enabled project delivery. Existing requirements available from national and international guidelines often fall short in offering a complete set of BIM requirements. This research describes how current owner requirements relate to BIM in light of a potential model-based project delivery process. The findings presented in this paper: (a) further our understanding of the challenges associated to developing BIM requirements from the owners' perspective and offer a solution to overcome them, (b) highlight the complexity of identifying and formalizing information requirements from a long and diverse set of existing formal and informal requirements and then realigning these existing requirements to suit BIM-enabled project delivery and asset management, and (c) highlight a lack of understanding by owners as to how to go about actually developing BIM requirements. In this regard, the owner organisations that were studied lacked the understanding of what information to require and how to require it from the project teams. Indeed, during the investigation, three core challenges were identified that related to establishing clear and detailed BIM requirements: (1) owners are not aware of the complete set of information they require to support asset lifecycle information, (2) they do not have enough experience in BIM to determine how much of this information can be exchanged and managed through BIM, (3) they are often unsure about how to require information in a BIM. The lack of means or expertise to evaluate the BIMs for quality and design compliance, and the lack the understanding of how these models can be leveraged for FM during operations phase even if these owners require BIMs as part of the handover set after the completion of construction was also identified as a core challenge. The methodology and subsequent classifications and frameworks developed from this methodology presented in this paper aim to overcome these challenges and help owners transition towards BIM-enabled project delivery and asset management through the development of clear and detailed requirements.

2. Background on BIM for owners

Despite increasing momentum in BIM adoption by building owner organisations, “the utilization of models during O & M is falling behind design and construction applications” (p. 350) [15]. Challenges, such as lack of BIM expertise and knowledge [16], diverse formats of data during handover and operations, and understanding what data is included in BIM and its effective use for daily work processes [17] still need to be addressed. This section includes background on owner requirements for project lifecycle phases, and the existing BIM requirements for facility owners.