A CHANGE MANAGEMENT PERSPECTIVE ON THE IMPLEMENTATION OF BIM FOR FM

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ABSTRACT

Change plays a significant role in the implementation of any building information modelling (BIM) initiative. For owners transitioning from a traditional facilities management (FM) approach to one supported by BIM, change management is required due to the technological and organisational transformation involved. Yet little is known about the characteristics of how that change is managed. Based on a case study, this paper provides an example of a change strategy employed by a university client/owner during the implementation of BIM-FM integration on a new building project. It describes a 'niche project' change management strategy and its key attributes during the early stages of an owner transitioning to BIM-FM integration.

Keywords: Building Information Modelling, Facilities Management, Change Management.

INTRODUCTION

Almost a decade ago, Eastman et al. (2008), defined as: "…a new approach to design, construction, and facilities management, in which a digital representation of the building process is used to facilitate the exchange and interoperability of information in digital format" (Eastman et al. 2008). Whilst BIM has long been framed as a new approach to FM, comparatively low levels industry maturity have limited BIM's application to the project stages. However, an increasing number of research studies reflect the benefits, challenges and new technologies to facilitate the application of BIM to building operations. The aim of BIM-FM *integration* is to support operations by preventing the loss of building information, improving data access, and automating data entry. As a result, BIM-enabled FM can increase operational efficiency, reduce costs, increase the building lifecycle, and support collaboration and communication across business units. BIM-FM integration thus represents a major socio-technical challenge for the architectural, engineering, construction and operations (AECO) industry.

A growing number of case studies have also been documented, describing the implementation and benefits of BIM-FM integration (Arayici et al. 2012, Kelly et al. 2013, Jupp 2013, Codinhoto & Kiviniemi 2014, Kassem et al 2015). Researchers have also begun to identify BIM-FM information requirements (Becerik-Gerber et al. 2012, Pinheiro et al. 2015, Ibrahim et al. 2016, Ashworth et al. 2016) and how they can be managed across the interfaces of the building lifecycle (Jupp & Awad 2017). What these studies highlight is the cross functional nature of BIM-FM integration and its impact on the way an owner/operator runs their business, addresses their market, leverages core competences, and manages data.

This paper explores the key characteristics of change management that result from the implementation of a BIM-FM initiative. It focuses on change relative to the business context, technological and organisational issues of a university owner/operator organisation. The paper presents the findings of a case study based on qualitative interviews with key personnel on a major university building project, and a review of project documents. The paper concludes with a discussion on alternative approaches to change management as owners transition from traditional approaches to FM.

TRADITIONAL BUSINESS MODEL

The aim of any public and private owner/operator with multiple capital investments is 'value creation', obtained by maximising revenues while minimising costs and inefficiencies in building operations and maintenance. Over recent years, value creation for owner/operators has transitioned from simple cost reduction to improving occupant experience and building performance (Jensen 2010). As a consequence, a range of building services and maintenance activities have been outsourced and operations have been fragmented across specialist business units. Whilst outsourcing and specialisation in building operations has increased the level of outward-facing 'openness', such business models can decrease internal collaboration and communication. An owner's development activities relating to project and programme management are often therefore entirely separate from building services and maintenance activities, resulting in the dispersion of knowledge and informationamong different business units. As a result, owners have had to deal with the resulting siloes of knowledge and information.

With the adoption of BIM during design and construction stages, digital transformations have enabled actors within the owner's business units that support building development and project management to engage with BIM technologies, processes and protocols; the increasingly levels of maturity across project stakeholders are assisting these business units in developing BIM competencies, where BIM maturity can be characterised by the use of 'best of breed' technologies, processes and protocols to deliver accurate, coordinated geometric and non-geometric data. The dispersed and siloed design, construction and project management activities are thus slowly being transformed by digital project delivery methods (Boton et al. 2017).

However to maximize the use and maintenance of buildings and minimize risk and operational costs, the occupancy phase must be considered from project inception. The information requirements that this depends on must therefore be specified and continually managed throughout project phases (BSRIA 2009, Ibrahim et al. 2016, Jupp & Awad 2017). Due to a lack of BIM compentencies across most owner's FM teams, the specification of information requirements and management of control systems to ensure data quality limits the owner's ability to participate and ensure successful BIM-FM outcomes. FM teams remain largely separate from project activities and BIM learner experiences. Compounding this problem, FM units must first undergo digital transformation and integration of their existing tools and processes. Thus support for a BIM-FM initiative requires two key tasks to be undertaken by owner/ operators, including:

1. Transformation of information and communication technology (ICT) and underlying ICT infrastructure, allowing integration of all building related data via appropriate software.
2. Transformation of an interventional organisational view of the extended enterprise, enabling integration of AECO processes and activities across the entire building life cycle.

TECHNOLOGICAL TRANSFORMATION

BIM-FM software can be defined as the 'connective tissue' that enables links between design, construction and FM processes throughout the enterprise. Business operations can be divided into four streams:design management, supply management, construction management, and operations and service management. Each stream forms its own unique 'chain' of software, with interdependent information and data management requirements.

From a software perspective, the chain of design and design management processes is enabled via software such as 3D CAD (Computer Aided Design), CAWP (Computer Aided Workflow Planning) and CAPE (Computer Aided Manufacture). The chain of construction management processes is supported by tools such as: QT (quantity take-off), 4D modelling (4D Planning and Scheduling), and 5D modelling (5D costing and resource management). Running across the design and construction management processes are a number of collaboration tools including EDM (Electronic Document Management) and CPM (Construction Project Management) systems).

The integration pathways of design and construction software are steadily maturing, with levels of interoperability supported by increasingly robust mappings between proprietary software and open standards such as the Industry Foundation Class (IFC) open standard (Liebich 2013). The IFC schema used together with buildingSMART's Information Delivery Manual (IDM) and Data Dictionary (ISO 2007, buildingSMART 2012), also known as the International Framework for Dictionaries (IFD), is capable of describing what kind of information is exchanged by providing a mechanism that creates unique IFD IDs, thereby enabling a connection between information from existing and disparate databases to IFC data models (Laakso and Kiviniemi 2012). A number of advanced digital facilities management systems are currently available. However the variety of systems employed by building owners often consists of ad-hoc combinations of 'off-the-shelf' FM systems and BMS (Gökçe & Gökçe 2013). In Australia, many of the larger university building portfolios are managed via a range of disparate software and are equipped with a variety of disparate building automation systems. Thus, their ability to manage maintenance and operations data whilst monitoring performance or predicting maintenance is at best sporadic and at worst inconsistent due to variations in their application across the portfolio. This ad-hoc combination presents difficulties for building owners in relation to the management and upgrade of these systems, and the transformational change that BIM-FM integration represents, as the BMS can consist of a number of components utilizing various information exchange protocols that have to be integrated. Often, these existing tools neither support the exchange of information between different application stages, nor do they consider the extension of an existing wired or wireless monitoring and control system during operation (Gökçe & Gökçe 2013).

Against this backdrop, the linking of BIM and FM software represents a recent development in industry. A variety of facilities and asset management functions are currently supported by various BIM-FM software ranging from basic asset registry functions, managing defects, commissioning data, energy monitoring, emergency response, disaster planning, to maintenance scheduling (Becerik-Gerber et al. 2012). However, geometric and non-geometric data produced by design and construction teams is only useful if it is accurate, appropriately structured and formatted, and capable of being linked to FM and/or the BMS. Common BIM-FM tool functionalities include: (i) the capture of room data associated with the model (e.g., dRofus), (ii) interface support between BIM models and FM/asset management (e.g., Ecodomus), (iii) interface support between data sources *and* associated workflows (e.g., Zutec), (iv) support for building life cycle activities, from feasibility studies to design, construction and operation as well as FM/asset management via interoperable and transparent linkages between data (e.g., VEO M-six and VEO Archive), and (v) audit processes for FM-ready models including maintenance and space data checking and data quality analysis (e.g., Invicara). Further, software to support lifecycle management such as Autodesk's Vault™ together with ERP (Enterprise Resource Planning) solutions are being linked to form data and information integration platforms. This enables project management and business analysis software to be linked with 3D authoring and reviewing tools, as well as from 4D (time) and 5D (cost) software. The linking of information to the 3D BIM provides the backdrop for data integration in product data management softwares such as Vault (Holzer 2014). BIM-enabled FM software is therefore moving towards more tightly coupled integration. However, there is currently no 'out of the box' product to provide a one-stop solution to integrate BIM with FM data and current approaches to achieving streamlined data transfer between software vary greatly.

AECO stakeholders are therefore beginning the process of migrating their data storage and management from spreadsheet based approaches to a centralised and integrated web-based platform, increasing the information content and data management capabilities (Holzer 2016). However the establishment and assignment of authoritative 'master' data in the chain of supporting workflows and modelling software, involves upfront planning and documentation. Model authoring tools, together with Product Data Management (PDM) and product lifecycle management (PLM) functionalities are beginning to form the backbone of recent attempts to connect information through-life (Reefman & Nederveen 2011).

From this software point-of-view, BIM-FM integration can be considered as the coordination and synthesis of three levels of ICT: (i) greater consolidation of separate information systems across the owner's entire business into a centralised system for data storage and management, as well as software integration, (ii) greater awareness and planning of the tool ecologies used across AECO activities with detailed specification of data transfer and management, potentially requiring greater use of PDM and PLM functions, and (iii) greater emphasis on local and remote collaboration tools using cloud-based software and web technologies to support remote communication.

ORGANISATIONAL TRANSFORMATION

The availability of new BIM technologies allows for a substantial reshaping of an owner's business processes. This has a dramatic impact on an owner's internal organisation. BIM-FM integration requires a close analysis of the way a building owner is engaging in design, construction and operations processes. That is how they specify and manage requirements, engage in design reviews, collaborate with project stakeholders, integrate processes and information, and collect, use and reuse data.

Business process analysis techniques (Becker et al. 2013) should play a central role in any BIM-FM initiative. In fact, such an initiative requires careful understanding of business processes and the required process reengineering activities. More substantially than in project level deployments of BIM, implementing BIM for FM is a more technology intensive initiative, with even higher levels of organisational change required. Organisational change encompasses both processes and supporting protocols and therefore also includes changes in skills and competencies across the FM team.

Business process reengineering is therefore an essential process in the implementation of BIM-FM initiatives. Such an undertaking requires the analysis of existing procedures and work environments through "as-is" process analysis and the definition of 'to-be' processes. However, existing task analysis methodologies, such as unified modelling language, are arguably not well suited to this analysis as they are unable to address required characteristics of BIM-FM integration. This is due to the main purpose of the methodologies being unable to adequately include in their analysis and modelling BIM-FM attributes such as workflow and information. In addition, a careful equilibrium in the level of detail defined in the process analysis and documentation phase is required if it is to be useful.

Whilst an owner executes processes at a single point in time, solutions must be adopted that are as flexible and adaptable as possible. The reengineering phase has to be carried out in collaboration with relevant managers according to the objectives, and may require senior management involvement. For example, if a future 'to be' process includes the use of a model-based function that is expected to be disseminate across departments, it is necessary to establish agreement so as to support organisational change and related technical competency requirements. Communication and documentation of proposed changes to business processes are therefore key.

To assist in the analysis of the required organisational changes, collaborative workshops are being introduced. Techniques that reflect experiential learning approaches (Kolb 1975) are also being used to allow employees, from different FM departments to identify shared knowledge and requirements. In this way experiential learning techniques can help owner organisations (and supporting AECO firms) to redefine the business processes that individuals are involved in through workshop sessions about new ways of working. Workshop enablers can include the use of information requirements templates such as COBie (Construction Operations Building Information Exchange), providing a tool for participants to identify common ground. Virtual simulation of new operational activities can also be undertaken by teams so as to explore 'to be' scenarios; allowing learning of new organisational needs. In this way, drawbacks are identified, allowing refinement of the 'to be' model.

After business and operational process analyses are concluded – with the definition of related information requirements and exchanges – the next aspect of organisational change is to establish the sequence and protocols for software use across project phases and FM departments. With the rapid evolution of BIM-FM software tools, it is necessary to select those that better match both present and future needs. Therefore, particular attention should be paid not only to the internal road map established for the necessary digital transformations to FM strategy but also according to future development.

CHANGE MANAGEMENT STRATEGIES

Change management plays an essential and core part of any BIM-FM integration initiative. To support such transformations two strategies can be employed: the deployment of a 'niche project with follow up', or an 'overall step-by-step' approach. The first supports the definition of a niche application area inside the organisation to introduce and verify the results and benefits of a proposed change. This approach looks at the transition-transformation process as if it were an experiment to be undertaken in a comparatively short timeframe. Motivated personnel are typically identified to support the niche project, and implementation timeframes are compressed. The goal is for tangible results to be identified from the project's execution and for lessons learned to be documented and used to secure further expansion of the initiative across the entire company.

The second approach devotes much more time to the careful planning and process reengineering of the organisation to include the full company. In this case, the definition of the 'as is' and 'to be' engineering process models play a fundamental role, as do workshops and carefully managed experiential learning sessions. Training is also carefully linked to process reengineering techniques under this change management strategy as they have to drive and control the overall step-by-step implementation. The latter strategy is less common as it is difficult to implement due to the upfront planning and resolution of numerous unknowns in workflow and information requirements.

In the remainder of this paper we explore the first of these strategies, the 'niche project with feedback' change management strategy.

UNIVERSITY BIM FOR FM CASE STUDY

A case-study, with a focus on the extraction of qualitative descriptions was used in this research, establishing the nature of the 'niche project' change management strategy during the deployment of a BIM-FM integration initiative. The project was provided by an Australian University's project management office (PMO) and facilities management unit (FMU), in conjunction with the main contractor.

The case studied describes a large university's initial BIM for FM project, which was based on a 'management contracting' procurement method. The building project comprised of a relatively small, four storey clinical education facility. All design processes and some construction activities were supported by BIM and were collaborative from conception through to handover, involving both the PMO and FMU staff working with the entire project team. Four of the PMO and FMU participants, and two from the main contractor, were selected for interviews based on their level of participation in the project. Two sets of interviews were conducted with these participants. A number of project documents, including the BIM Execution Plan (BEP), BIM-FM Implementation Exchanges, BIM Contract Addendum and internal technical reports) were also reviewed. The purpose of the interviews was to extract qualitative descriptions of change management techniques utilised during the niche project approach to BIM-FM integration. In terms of BIM or digital FM knowledge at the start of the project, the University was in a similar situation to many other organisations, in which there was a general internal consensus that the use of BIM should be adopted in both project procurement and FM, even if the details of what that actually meant were not yet fully understood. The University engaged a BIM consultancy firm to research and report to them how the organisation could adopt a BIM based approach to FM. At the conclusion of the white paper it was decided that the new building project was to act as a pilot project trialling some of the papers recommendations.

Thus, together with other members of the AECO project team delivering the building and the BIM consultant, some of the report's recommendations were put into action. As this was a niche project and the project team wanted to create something that was simple, easy to use, accessible, the agreed deliverable was a simple 3D as-built model accessed via a free model compilation viewer with embedded FM data attached to only specific maintainable building elements. The key processes that were undertaken to manage and deliver the FM ready BIM model and the BIM-FM integration system architecture were staged across the project timeline.

FINDINGS

The main features of taking a niche project are presented relative to three areas of BIM-enabled FM, namely: (i) how technical and organisational requirements were identified, (ii) how socio-technical changes were managed, and (iii) how communication on progress was conveyed.

(i) Requirements Identification: A BIM-FM working group was established and consisted of representatives from the university's project management office, the facilities management office, a bespoke data management team, a BIM consultancy and members from the main contractor. Meetings included interviews and presentations from the various stakeholders and interest groups. After several months the working party identified, and had to overcome challenges in the requirements identification process including: (i) How to define a vision for using a BIM based FM solution, (ii) To what extent integration with existing FM software should occur, (iii) What FM information should be captured and in what format, and (iv) Where this information should be stored and accessed. The search for an industry standard or software package to address these needs proved to be a challenge and was seen as a decision "too great for the assembled working group" on this standalone project. Therefore the decision was made to keep the project's data in an open source format for partial integration with the University's existing FM software and employ an approach that allowed for integration into a BIM based FM software at a later stage. To create a link between an element and the rest of its FM data, the main contractor used a set of asset names and IDs in conjunction with the Omniclass classification system to support search functions in the university's existing FM database where the bulk of the FM information for the project was to be stored. Throughout the working group process, the main contractor had a live draft of the BEP which would be continually updated as a result of experiential learning. The BEP was refined as the working group settled on data deliverables, workflows, data formats etc. The final BEP was agreed to by the owner, contractor and subcontractors.

(ii) Management of Socio-Technical Transformation: During this stage, the technical requirements of subcontractors were deployed and found to evolve or increase, meaning that the procurement process for them needed careful management. It was necessary to ensure that the main contractor was able to employ subcontractors who could understand and deliver according to the BEP and "buy into" why the accuracy of the data and as built information was especially important on this job. Although the technical aspects of the model were not onerous, there were small technical-related issues that some subcontractors had to overcome, such as ensuring good communication of workflows relating to model use, model coordination, and model management, enforcement of the BEP, and stakeholder management.

(iii) Progress Reporting: The quality and accuracy of as-built models will directly determine the usability and value of BIM data inputs relative to FM data outputs. Progress reporting during these data verification and harmonisation processes were therefore critical. The outcomes of model audit and coordination activities were conveyed regularly to senior management. Documentation and management of model coordination workflows across all disciplines (and datasets) was therefore key to the initiative's success. Verification and validation of building service models against actual installation was undertaken; however the use of laser scanning was seen to be cost prohibitive on this scale of the project. It was therefore proposed that approximately 30 locations per floor, involving building services, be inspected or photographed and visually compared to the federated model. As an audit method, it was perceived to be effective as the photo only needed to indicate that there was a variance between the design and the installation at which point the subcontractor was instructed to coordinate and update the model. The following progress reporting requirements were identifed as key: (i) Ease of access to all geometric and non-geometric data contained in discipline models, where software interfaces had to be simple and free; (ii) Regular communication surrounding the specified tolerance and LOD of the as-built representation of physical assets; and (iii) Use of saved viewpoints for ease and speed of communication. At building hand-over, the main contractor also established a feedback system so as to continue progress reporting and gather information on how the model was or was not being used by the FM team and how the data provide was being integrated.

DISCUSSION

An appropriate coordination effort is required to focus and direct all technical and organisational development activities surrounding BIM-FM integration in the short to mid-term. After senior management commits to the project, a change management strategy has to pursue the following path: (i) ensure regular information to top management on project implementation steps, (ii) ensure regular communication on project progress to all involved, and (iii) apply experiential learning approaches in change management activities so as to secure understanding, buy-in and feedback. With regard to these requirements, the advantages and disadvantages of a niche project approach are shown in Table 1.

Table 1 Disadvantages and advantages in 'niche project approach'

Advantages	Disadvantages
Motivated and involved personnel are made available	Difficulty in feeding forward into the subsequent, full scale, implementation
Quick implementation of the technical solution	Difficulty in evaluating the extent of project achievements and scale them
Focused resource allocation	Project is known only to a few persons
Objective outcomes achieved in short term horizon	Fewer variables to be controlled, which presents additional risks in subsequent full scale implementation

BIM-FM integration relies on a owner organisation's communication and coordination network to support the delivery of accurate as-built models and achieve the benefits of their use in operations. The more buildings in an owner's portfolio, the more a BIM-FM initiative will be complicated and require a clear strategy for change management. A global outlook on the BIM-FM systems architecture and its data processing system is therefore necessary. It is the goal of the information requirements which enable BIM-FM integration to support the network of specialised software tools. Thus information exchange protocols and information requirements management frameworks must be defined by the owner, rather than be left to the project implementation team.

The organisational change management path may be carried out progressively, project-by-project, or via a full-scale step-by-step pathway, according to senior management. The ability to support the correct use of BIM and FM tools will be an important criteria for making this decision. In order to benefit from the advantages of both solutions, mixed change management strategies involving both niche and overall step-by-step approaches could provide a solution. This would enable 'as is' and 'to be' situations to be analysed in full, in order to have a 'global project' that can be presented to senior management for approval. The combination of two different approaches may be most effective to support experiential learning in the first instance and push users to modify their working attitudes towards new reengineered processes, before enabling the required software training and practical use afterwards.

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