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BIM Data Handover from Construction to Operations

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Facility owners and managers rely on trusted asset data developed during projects in BIM for reducing risk in operations, strategic planning, design, construction, sustainability, and environmental responsiveness. The prime contractor is the party responsible for construction handover and for fulfilling the project owner's requirements to deliver the building information model (BIM) and the asset data as set forth in the BIM Project Execution Plan (BEP). This research was approached with a broad perspective of the state-of-practice of BIM data use for Facilities Management (FM). Using a questionnaire sent to facility owners, managers and those in similar positions this study sought to identify why the project data handover from construction is vital to facilities management for operations and maintenance, and how the project data is collected and used for facilities management purposes. The results discussed here were limited to Construction Deliverables and Facilities Management. The research found that following a prescribed process for understanding O&M needs, as defined in the UK for some years, could help. Understanding the issues identified in this paper is a great starting point for construction handover. Reflections from this study should be applicable for O&M stages in both the USA and UK respectively.

Key Words: BIM, Construction Handover, Operations & Maintenance, Facilities Management

Introduction

The handover stage of a project from construction to operations is crucial for facility owners as it is the stage where they are provided the relevant building data needed to operate the facility (Cavka, Staub-French, and Poirier, 2017). Information provided at this point will be used for the operations and maintenance stage (O&M) over the remaining lifecycle of the building. The prime contractor is the party responsible for construction handover and for fulfilling the project owner's requirements to deliver the building information model (BIM) and the asset data as set forth in the BIM Project Execution Plan (BEP). The level of information required at construction handover varies by project owner. For example, the Massachusetts Port Authority (MPA) BIM Guidelines requires handover of data at the end of construction that includes the as-built model and construction to operations building information exchange (COBie) worksheets with special emphasis on spaces, MEP, and equipment for

facilities handover. Additionally, the as-built model is required to provide an archival record of what was constructed at a higher level of development (LOD) than the record model. The guidelines allow for the as-built model to also contain additional file formats from shop models and fabrication detailing with information coordinated in the project, where exactly the new or renovated work is located (Massport, 2015). In the United Kingdom, Gatwick Airport's BIM processes and principles were created in 2012 to support handover from construction to O&M (Bechtel, 2014; Hulse, Cod, and Neath, 2014). At Gatwick Airport the owner's information requirements (OIR) are developed by the airport and used to create the asset information requirements (AIR). In the AIR, all the asset types corresponding to what information should be recorded are identified and listed by the function the asset would perform. For each asset, multiple property sets are defined in the AIR, included in the model during design and construction phase and handed off to asset management at the end of the project (Mallela, Blackburn, Grant, Kennerly, Petros, and Yew, 2020). Like Massport, the Gatwick BIM requirements ensure that the required asset data is included in the model for seamless handover of project data models to asset managers for their development and maintenance of the asset information model. These are just two examples of project owners and their information requirements for BIM models they have established from the construction to the operations stage of a facility. This study focused on BIM use and handover requirements for operations and maintenance of facilities on university and college campuses in the mid-Atlantic region of the United States. Reflections from this study should be applicable for both O&M stages in the USA and UK respectively.

Background

Building Information Model (BIM), as defined in the National BIM Standard – United States® Version 3 is the digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility, forming a reliable basis for decisions during its life cycle from inception onwards (National BIM Standard, 2015). Facility owners and managers rely on trusted asset data developed during projects in BIM for reducing risk in operations, strategic planning, design, construction, sustainability, and environmental responsiveness (Massport, 2015). In general, owners should review their current information needs for operations and maintenance and establish data requirements that support those needs. At a minimum, major equipment should be described by facility attributes such as make, model, manufacturer, and serial number. Additional attributes include warranty information, parts lists, maintenance schedules, and manufacturer contact information would further contribute to asset management if included with the handover (NIBS, 2017). International Standard Organization (ISO) 55000 defines asset management as the coordinated activity of an organization to realize value from assets. Furthermore, asset management achieves business objectives through asset-related decisions, plans, and actions within a strategic framework of processes, techniques, and tools. It seeks to optimize the cost, risk and performance of assets over their lifecycle at an individual asset, asset system, and asset portfolio level (International Standards Organization, 2014). BIM based asset management is a process in which project data is linked to a Record Model, delivered at project handover, to aid in the maintenance and operation of a facility and its assets. These assets, consisting of the physical building, systems, surrounding environment, and equipment (NIBS, 2017).

Handover

According to Joroff and Project (2000), there are four roles associated with four phases of operations and maintenance (O&M) during a facility's lifecycle: 1) strategy making (policy maker), 2) controlling (controller), 3) deal making (user), and 4) task managing (technical manager), with data

flowing continuously between all four. This information flow is often the difficulty that exists in a large FM organization. Most of the data needed for the O&M stage is created during the design and construction stages (Smith and Tardiff, 2012). Before this data can be used in the O&M stage it often has to be modified, mainly due to user interventions. Typical activities completed during O&M include portfolio management, asset management, property management, and service management (Schraven, Hartmann, and Dewulf, 2011). Asset management focuses on the implementation of a building plan for the owner to realize the lifecycle value from the building assets (The Asset Management Institute, n.d.).

The information provided will be used for the O&M stage and the lifecycle of the building. Prior research reported industry professionals deal with two types of data, structured and unstructured (Mayo and Issa, 2015). Typically, unstructured data can be in paper or digital format, which owners and their FM teams often receive in an unorganized and incomplete manner. Warranty information, equipment manuals, and manufacturer information, are a few examples of unstructured data currently provided from construction to FM teams. Structured data examples include construction drawings, project manual, and various spreadsheets containing project information. Therefore, structured data is any type of organized data from the project. However, all this data must typically be "unpacked" by the facility owner to make it accessible to be used for the O&M phase. There are instances where early planning for handover data is done to provide the owner with a means for quicker upload of data to the owner's Integrated Workplace Management System (IWMS) or Computerized Maintenance Management Software (CMMS). In the past, the facility handover procedures from construction did not provide owners with the confidence and assurance that they were receiving the data needed to operate and maintain the facility at optimum performance. To resolve this issue the industry has slowly implemented strategies and tools for handover data to ensure owners receive the data they need. These strategies and tools include utilizing open standards (i.e., IFC and Information Delivery Model (IDM), AIMs (Asset Information Models), Owners Project Requirements (OPR), and Building Information Modeling to name a few. The literature review revealed that the BIM model is currently being used by the FM team primarily for space management, asset management and reporting on volumetric needs such as HVAC/room volumes.

Methodology

This research was approached with a broad perspective to identify the state-of-practice of BIM data use for Facilities Management (FM) and to review the importance of specific data. The aim of this study was to answer the following two research questions.

- Why is project data handover vital to facilities management for operations and maintenance?
- How is project data collected and used for facilities management purposes?

An electronic survey link with an overview of the purpose of this study was sent to 284 individuals in the role of facility owners, facility managers, or similar positions at university campuses in the mid-Atlantic region of the United States. The level of BIM use and competencies of individuals was unknown when the recruitment email was distributed. The survey contained 23 questions, which were divided into six sections designed to review the overall state-of-practice for O&M by facilities managers.

- Section 1: BIM Personnel – asked about dedicated BIM roles and BIM related leadership roles in the organization
- Section 2: BIM Requirements – included questions about the percentage of projects where BIM is used, BIM adoption, and BIM requirements created by the organization.

- Section 3: Construction Deliverables – were questions related to the timing of asset data collection, validation of the data collected, formats of requested handover deliverables, and types of BIM deliverables mandated by the organization.
- Section 4: Facility Management – asked questions about the timing of BIM model reviews, QA/QC procedures for model-based deliverables, the format most frequently used by FM teams for referencing data needs, floor plan use, time spent on final BIM deliverable to make it useable, most common reasons why building documentation is not collected, and the importance of BIM for the O&M stage.
- Section 5: Visualization & Asset Management – asked about visual formats useful for O&M tasks, protocols, role responsible for providing the data. to the facility owner.
- Section 6: Demographics – questions related to the participants' role and organization

The response rate was 21%, with 59 participants in total recorded. However, some early feedback provided an indication that the survey may not have reached many facility owners experienced with BIM use, and therefore, some participants may not have been able to fully understand or answer some of the questions. Due to the page limitations for this paper, the results discussed are limited to Section 3: Construction Deliverables and Section 4: Facilities Management.

Results

Construction Deliverables

The survey included three questions specific to construction deliverables and associated requirements. First, participants were asked how they collect and/or check asset data during construction. It is assumed that the 19 that did not answer are unsure if and how asset data is collected or checked during construction. The answer choice with the highest frequency was "Excel Spreadsheet." The next highest frequency was "BIM360 spreadsheet (native inside BIM360)," with a frequency of 10 whereas "Excel Spreadsheet" had just over double that amount at a 25 frequency of use that was reported by the 59 participants. Prior research established the current practice of using spreadsheets as the common format in either a .csv of .xml file type for construction to handover for transference of data into FM systems (Lucas and Addagalla, 2017). After integration with the current CMMS, it was revealed that the result exceeded the expectations of FM technicians, with a 20% reduction in the time needed for corrective action by providing quick access to floor plans and data. It also reduced risk associated with emergency events by developing "what if" scenarios. These are examples of the benefits realized with the handover of structured data. Figure 1 displays the total of participants responses to the question.

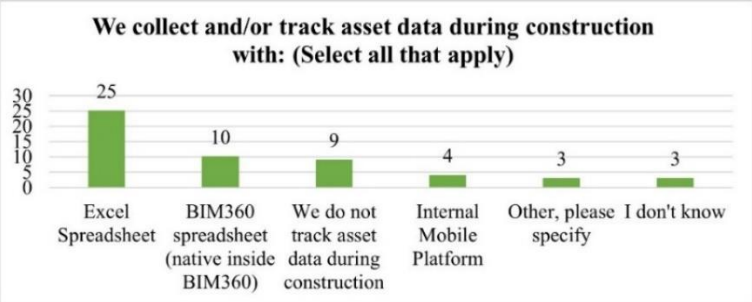

Figure 1 Asset data collection tools

In figure 2 both the "BIM model" and "Electronic" was indicated as the deliverable required for handover. Electronic could mean different things, such as paper formatted documents and information handed over on a jump drive, or a model, therefore it is unclear if there is overlap in responses. In hindsight, for this answer choice, a better option may have been to allow the participant to have an "input text option" as having "Electronic" is too broad of a choice. Comparing the frequency for "Spreadsheets" of 19 for this question to the question about tracking asset data during construction which had "Excel Spreadsheet" receiving 25 counts could be interpreted multiple ways and once again could result in duplicate of the responses for both questions.

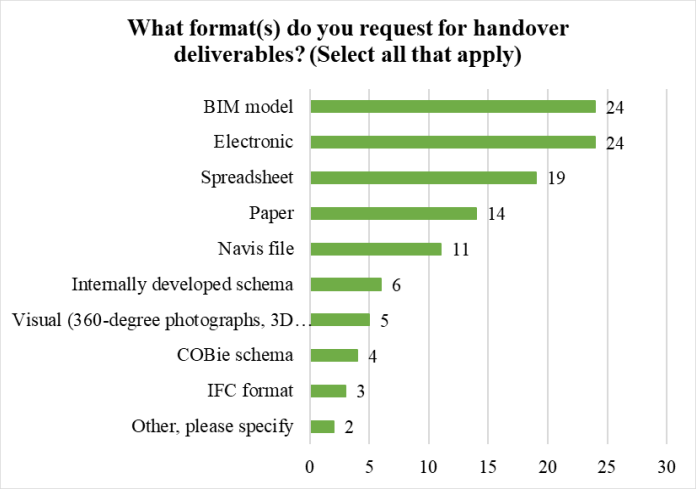

Figure 2 Format for handover deliverables

The final question pertaining to construction deliverables asked about what deliverables are mandated. To be clear, this does not imply that the organization is "using BIM" for O&M as some owners may get the models but not actually use them. However, this is a good indication of the percentages of those who have started mandating a model. One participant added, "Record documents are required, the Project Management leadership fails at not placing responsibility into the contract, as to who is responsible for update and turnover." This statement also validates the literature findings and is a recurring theme - which ties to the support of the leadership, and to the difficulty of implementation due to so many siloed roles in FM.

Table 1

Question	Answer choices available to select from		
Q12 – What types of BIM deliverables are mandated by your organization at construction handover? (select all that apply)	No specific model deliverable has been mandated	15.66%	13
	As built models provided by design team	21.69%	18
	As-built models provided by construction team	22.89%	19
	A populated COBie spreadsheet	1.20%	1
	A populated spreadsheet from contractor	13.25%	11
	Other, please specify	6.02%	5
	Record Model from design team	19.28%	16

Facilities Management

To review the current state-of-practice with regards to O&M staff and document use, the next question inquired about the different formats used. Literature has continually surmised that Revit is not a platform that can be used widely by field personnel due to a lack of BIM skills, but there were 13 responses that revealed something different. The most widely used format is still CAD, indicating that many are still hanging on to the traditional methods of space management and building documentation. Since this question also included the option to select all that apply, most of the responses include three or more format types, most likely due to the overlap in questions regarding IWMS, CMMS and CAFM systems and additionally, the need that many organizations must maintain hard copies of as-builts. However, one participant indicated that they utilize scanned (pdf) plans. Frequency of responses by question are shown in Figure 3.

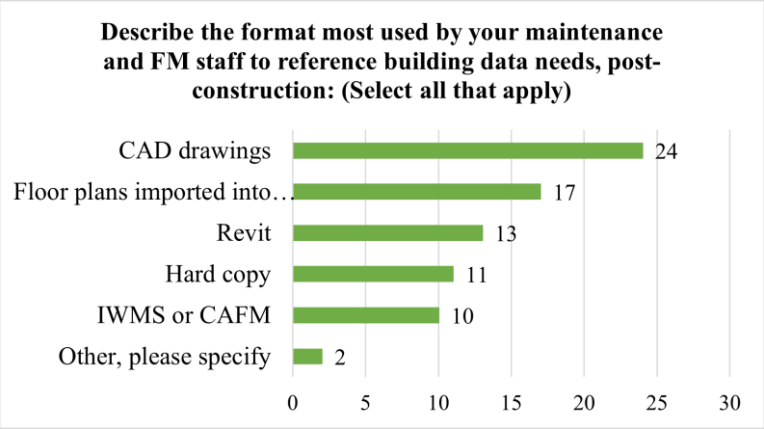

Figure 3 Post-construction data format for O&M

When asked how they will utilize the final deliverable(s) post construction, the answer choice with the highest frequency, at 25%, was "We do not currently use the model or its attribute data post construction," which means the model is not being used for O&M. The reason it is not used for O&M could be one of the many BIM implementation issues identified in the literature review, such as, lack of trained in-house personnel, lack of standards, interoperability issues, or other. Previous research has shown that BIM can be used as an information container, assist in decision making, be integrated with CMMS, CAFM and/or IWMS. Some facility owners have successfully implemented BIM for O&M. The second highest frequency answer choice was, "We utilize the model(s) attribute data to track space management" with "We utilize the model and/or its attribute data to track asset management" being a close second. The literature review discovered that space management and asset management are two ways to utilize BIM. As previously stated, owners can utilize an owner's project requirement (OPR) to ensure they are provided with the needed data for optimum O&M of the facility. One participant commented that "We have linked 3D geometric aspects of the model with hyper-linked close-out documentation." Two participants selected "I am not sure" and two participants selected "Other, please specify." The participants selecting the latter input the following:

- "Future existing conditions"
- "Models currently not in use, but plan to integrate GIS, CAFM, and maintain for distribution of existing condition records"

Most of the feedback illustrates that firms know BIM for O&M is the future but may not or have not reached that point yet. One participant stated that when it comes to O&M and BIM, they receive

models at handover but have no way to update them or distribute them as they have no dedicated staff or proficiency for this task. Furthermore, it was stated that the design and construction teams extract the construction documents and conduct analysis throughout the project and the organization archives the "derivative materials."' This question should have contained a "none of the above" answer choice, which may have resulted in a higher frequency for this question.

Previous research stated that BIM output is typically limited to 2D data as users cannot see, handle or deal with any other data format due to a lack of knowledge of the various data formats (Bosch, Volker, and Koutamanis, 2015). Figure 4 shows the amount of time dedicated to organizing the BIM data after handover to make it usable for their organization. The time spent on making data useable could possibly be decreased to less than 3 weeks if the organization required an Information Delivery Model (IDM), an Owner Project Requirement (OPR), and/or open standards. An IDM is a model detailing lifecycle processes of assets, including data requirements for all processes to be completed (NIBS, 2017). An OPR guides the Owner on project execution as well as forming a basis for measuring all activities and products during decision making throughout the facility's lifecycle addressing form, time, budget, and function (NIBS, 2017). Open standards are data standards that are compatible and useable across a wide range of hardware and software platforms.

Figure 4 Time to organize data after handover

Discussion and Conclusion

Evident from the literature and study results, the state-of-practice for BIM data handover from construction to operations for asset management varies by owner and facility type. This study focused on university/college campuses in the mid-Atlantic region of the United States. While it revealed widespread differences in the participants requirements for handover data, approximately half of all participants require or receive the data in a BIM format. It also indicated that the majority of FMs spend a month or more organizing the BIM data to make it usable after handover. In figure 6 the ISO 19650 information management process is shown. The process includes the preparation of information requirements, review of prospective parties in relation to information management, initial and detailed planning for how and when information will be delivered, and review of information deliverables against the information requirements before they are integrated with operational systems.

The process is detailed in its requirements but should be applied in a way that is appropriate based on the scale and complexity of the project or asset management activities.

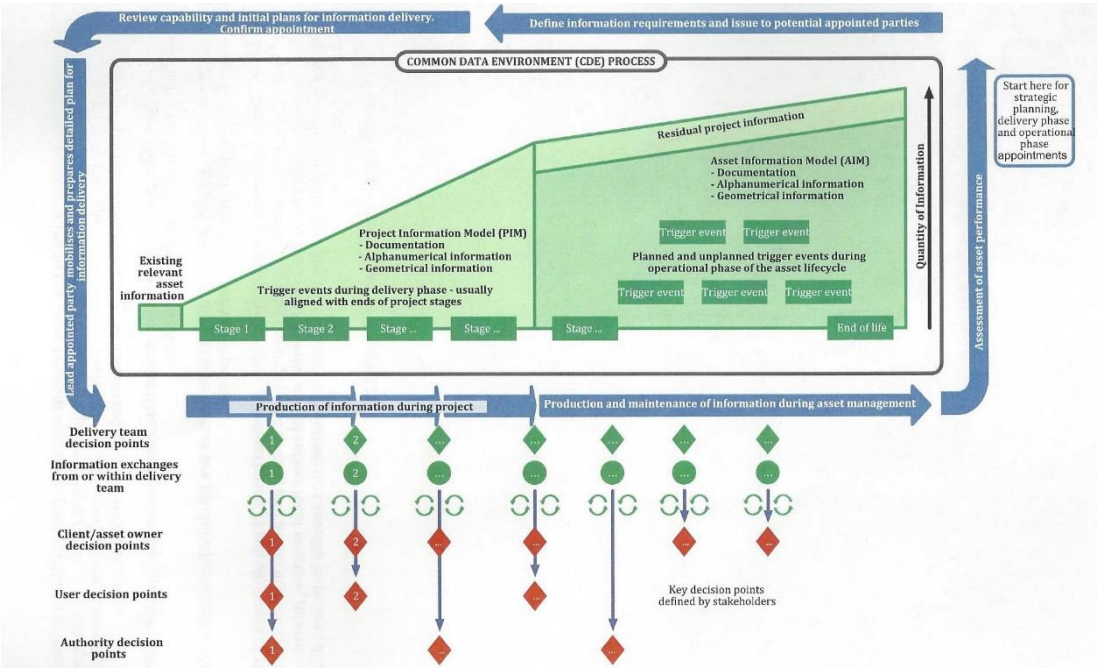

Figure 6 ISO 19650 information management process (ISO 19650, Part 1, 2018, p.28)

Figure 6 shows a potential solution to some of the issues identified in this paper. Following a prescribed process for understanding O&M needs has been defined in the UK for some years. Whatever process is followed it is imperative that the owner fully understands their information needs to effectively run their facilities. Understanding the issues identified in this paper is a great starting point. Using BIM to monitor the development of the information needed to run a facility is clearly a key enabler. BIM and a recognized information flow are both needed for an owner to fully use new technologies to better manage their facilities.

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