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BIM IMPLEMENTATION IN FACILITIES MANAGEMENT: AN ANALYSIS OF IMPLEMENTATION PROCESSES

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Abstract

The potential of Building Information Modeling (BIM) to add value to Facilities Management (FM) has long been recognized. The usefulness of BIM in asset management, including operations and maintenance has been described by numerous authors. Crucial to its implementation is the integration of information, which increases efficiency and productivity on the job and, in turn, positively impacts the primary organization's mission and goals. In view of the potential of BIM to add value to FM which in turn can boost the mission of organizations, there is a potential to study the experiences of early adopters, map out patterns and differences and to record lessons learned. This research aims to investigate how BIM is implemented in operations, how value can be derived and what the critical success factors are. What are the areas of process waste and consequent loss of value within the lifecycle phases of facilities? To this effect, the case study of a large tertiary educational institution is undertaken, mapping the processes of information flow between the BIM project team and the facilities management department during and after construction. Process mapping of organizational processes will identify areas of potential waste or non-value-adding activities, and also areas of potential value-adding opportunities. By studying BIM value through the lifecycle value chain, and identifying best practices and challenges in light of the more subjective nature of value delivery in FM, more impactful outcomes should be derived.

1. Introduction

The positive value that BIM can add to FM practice has been described in detail and long anticipated. Sabol (2008) listed one of the benefits of BIM in FM from her case study on the Sydney Opera House, as comprising increased speed and effectiveness in FM practice. The advantages of a consolidated digital repository present within an application or externally on a database system as achievable in cloud computing is evidenced in real-time access to data, essential for effective facility operation (Sabol, 2008, Wong & Yang, 2012). BIM in FM has the potential to add value to an organization, but the implementation of this has been an unclear journey for many. Studies show that there is a disconnect between project team members on both sides of the commissioning line. 51% of the 443 construction industry respondents to an IMAGINit (2015) survey posited that Owners' not knowing BIM was their greatest obstacle to providing BIM data to them. This is all in spite of the fact that the study found that 90.6% of the FM respondents had participated in the collaborative phases of design and/or construction. Williams et al. (2014) described the clear "language and knowledge gap" within collaborative interaction in the project stage. Added to this is the admittance by FM personnel of their inability to maintain the data received; in the same proportion as their lack of knowledge and training (IMAGINit, 2015). McGraw Hill (2014) also reported amongst the greatest needs of Facility Managers, the need for increased abilities in the utilization of BIM deliverables (88%) and more examples of demonstrated benefits of BIM in FM (78%). This inevitably leads to the question on the knowledgeability of FM personnel in regards to the BIM process, and the associated readiness of owner organizations to efficiently manage the digital data and deliverables handed over from project BIM. The interoperability waste uncovered by the Gallagher et al. (2004) study has been shown to significantly multiply and literally explode during the lifecycle phase. There is therefore a need to improve process efficiency within BIM processes during project execution in order to avoid the inevitable multiplicity of problems in latter phases. Related to this is the need to investigate the actual implementation of BIM in the lifecycle phase so as to uncover other avenues of process waste within FM activities. However, many FM owners don't have the procedural and technological structures; nor skill of management and personnel - to effectively maintain and actively use digital BIM deliverables (IMAGINit, 2015). There lies the opportunity for targeted interventions or structured approaches to implementation to fill the gap of documented experiences and demonstrated benefits of implementation.

The dearth of value-focused research into the implementation of BIM in Facilities Management has informed the need for this study. The need has been established for tracking the origins of process waste within the implementation of BIM in FM; and to explore front-end and lifecycle strategies in mitigating these. Since adoption and implementation of BIM in FM was shown to be slow and hesitant, the requirement for more examples of successful implementation was highlighted. This would serve to expand the current knowledge base; bringing to light the experiences of early adopters – and their successes and challenges. A study of the BIM implementation process, concomitant with the facilities management process would uncover areas of process waste and non-value adding activities.

1.1. Process Mapping in Various Sectors

Singh et al. (2011) noted that *"whenever there is a product for a customer, there is a value stream. The challenge lies in seeing and working on it."* The versatility in application of process mapping can extend to any business activity, and Singh et al. (2011) noted its importance for the identification of mismatches in transactions and communication, in addition to showing inefficiencies of process. The term process denotes action; and comprises activities, which transform an input to an output or goal. The mapping of a process involves the documentation of how the process is done; whilst the modeling of the same illustrates how it should be done. Process modeling thus goes a step further by analyzing processes, identifying bottlenecks and inefficiencies and ameliorating these in a prescriptive manner. Process mapping has its roots in the interconnections between people, information, activities and objects within a process (Biazzo, 2002). The main goal of process mapping is for a deeper understanding of one's business, and the subsequent performance improvement of the process. Process thinking has been applied in other economic sectors such as manufacturing, with a prominent example being the Japanese uptake of process thinking on a national scale (Ohno, 1988). Their success has been widely acknowledged, with many other countries and industries adapting their approaches to suit the basic structure of lean thinking. Though process thinking has been applied widely in the construction industry, the value proposition, which is a salient part of it, need not be left behind. The core of the kaizen approach is the value-added concept and the elimination of waste within the process (Ohno, 1988). Value Analysis and Value Engineering have taken this approach, aiming to eliminate waste from the design and construction processes. However, there is need to apply this waste-eliminating, process-focused mindset to the implementation of BIM within the lifecycle of a facility.

Process modeling has been widely adopted in the AEC/FM industry, with established frameworks such as the Royal Institute of British Architects (RIBA) Plan of Work in existence since the 1960s. Isiadinso (2007) lists the aims of construction industry process models to include a focus on collaboration and decision-making as a distinguishing feature in addition to other common aims such as efficiency and performance. Many BIM implementation guides are in existence, developed by different organizations within the public and private sectors in the USA; such as the US Army Corps of Engineers (USACE), Veterans Administration (VA), GSA, Association of General Contractors (AGC) and the Pennsylvania State University, to mention a few (Table 1). The existence of a wide variety serves to show the magnitude of efforts aimed at structuring the BIM implementation process. The levels of detail and scope of coverage of the process guides vary as expected, however most of them focus on the implementation within the early lifecycle stages of design and construction. A few, such as the Penn State BIM Execution Plan for Facility Owners (CIC, 2012), delve into the lifecycle stage; guiding on considerations and planning for lifetime implementation. However, guidance on planning and monitoring the value proposition of the process, as well as the elimination of waste is not explicitly tackled.

Table 1: A sampling of BIM Guidelines in the US

Federal	**State**	**Ministry**	**Local/University**	**Organizational**
GSA Guidelines 2006	State of Texas	Veterans Administration	LACCD Indiana University	AGC Contractor's Guide 2006
NIST NBIMS Guidelines 2007	State of Wisconsin	USACE BIM Roadmap	Penn State University Guidelines	AIA IPD Guide 2007
NIBS Data Exchange Format	State of Ohio	USCG BIM Roadmap	Penn State University Guide for Facility Owners	

2. Case Study

2.1. Background & Demographics

A case study of the Pennsylvania State University's Office of Physical Plant (OPP) was carried out, with a focus on the main campus. The study is aimed at mapping out the BIM processes within facilities management and operations following the handoff of BIM data from the construction phase. The institution was founded in 1955, and employs over 1,338 full-time OPP staff to maintain the 7,927 acres of its main campus. The institution has an asset base of 956 buildings that cater to over 47,000 students and 18,000 employees. Penn State is an owner-operator institution, which has been considered a pacesetter in the planning and execution of BIM in design and construction. The institution has applied the use of BIM deliverables in facilities management for space and asset management, the two BIM uses whose processes are explored below. The methodology of the research utilized interviews and document reviews in the collection of data. The process steps were investigated by interviewing the key personnel involved with the BIM data during the construction process and following the closeout of the project. 7 personnel were interviewed (Table 2) from the different departments in order to establish how information flowed between processes.

Table 2: Interview participant details

Department	**Job Role**
Space Management	Facilities Analyst
Real Estate	Real Estate Specialist
Project Management	Project Manager
Data Management	Facilities Specialist
BIM Planning	Virtual Facilities Engineer
Work Planning & Scheduling	Maintenance Engineer
GIS	GIS Programmer/Analyst

The process of location naming for space management is mapped out (Fig. 1); followed by data transfer and entry to the Computerized Maintenance Management System (CMMS), Maximo (Fig. 2). The sources of submittal information that is linked to the CMMS are also explored. A Process Profile Worksheet was developed, which recorded the process name, description, trigger, and steps; including the responsible party and all data inputs and outputs. The processes were mapped in the Business Process Modeling Notation (BPMN) format (Figure 1), which was selected because it is useful for mapping detailed processes, displaying time sequences of tasks and including conditional branch blocks.

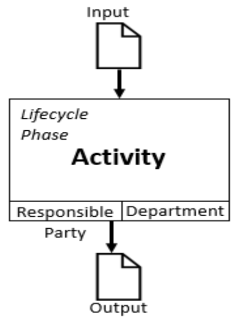

Figure 1: Process Notation for BPMN mapping

1.1. Findings

The interviews focused on determining how data flows within the departments in support of the external BIM planning and execution processes conducted by the project team. Two main interactions between the facilities management department and the project team were noted. Firstly, during the planning and design stage, location information is required by the project team to properly name the spaces within the BIM model, as well as appropriately name and place the assets within those spaces. Secondly, the data flow into the CMMS (Maximo) is detailed to illustrate the process steps taken to upload the project data into the facilities system. Thus interaction between the project team and the space and asset management units is necessary.

1.1.1.Location Information Process

The project team has to transfer project information from the design software (Revit) into AutoCAD and then combine this with information from the project database to send to the Facilities Analyst, who spends days analyzing the data and extracting the information he needs into a working format. This is then sent back to the team in a spreadsheet format. The location information received is entered into the Revit model, and then this is combined with asset information and exported into a CSV (Comma Separated Values) file that stores data in a tabular format; which is sent to the asset management unit. The information again goes through a loop of importing a standard asset list based on the Maximo format and naming conventions, duplicating these, and then linking them with the appropriate location data within the spreadsheets. Placeholders are created within Maximo for the eventual asset population. This list is sent back to the project team, who then appropriately names the assets, and populates them back into the Revit model.

1.1.1.Asset Information Process:

The second batch of interactions comprises the process of data population into the CMMS, Maximo, following project handoff and commissioning. The steps were found to be far from automated, as had been generally assumed for the BIM handoff of information to facilities management. Because the projects were designed in Revit, which is incompatible with the CMMS (Maximo), a manual process of import and export, data verification and editing is required. The steps noted are as follows:

- Data verification: Identify assets and parameters
- Maximo Export (standard Maximo data samples):
  - Identify matching assets and parameters
  - Highlight and export assets to spreadsheet
  - Copy and paste assets to meet required number
- Data analysis & processing: Formatting Data to match asset inventory
- Validation: Double-checking asset inventory
- Data transfer: Importing asset inventory into Maximo

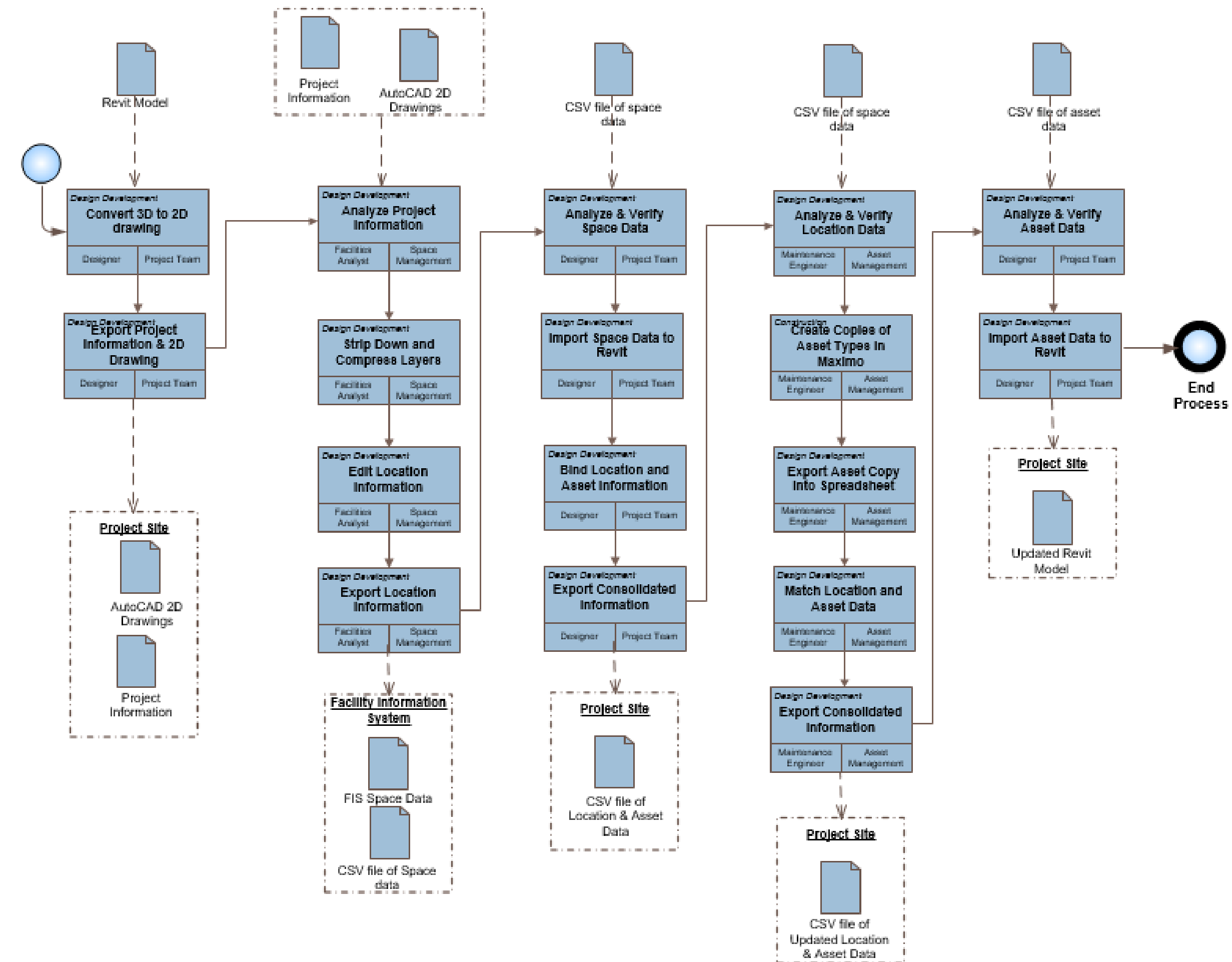

Figure 2: BIM data transfer process map for space management

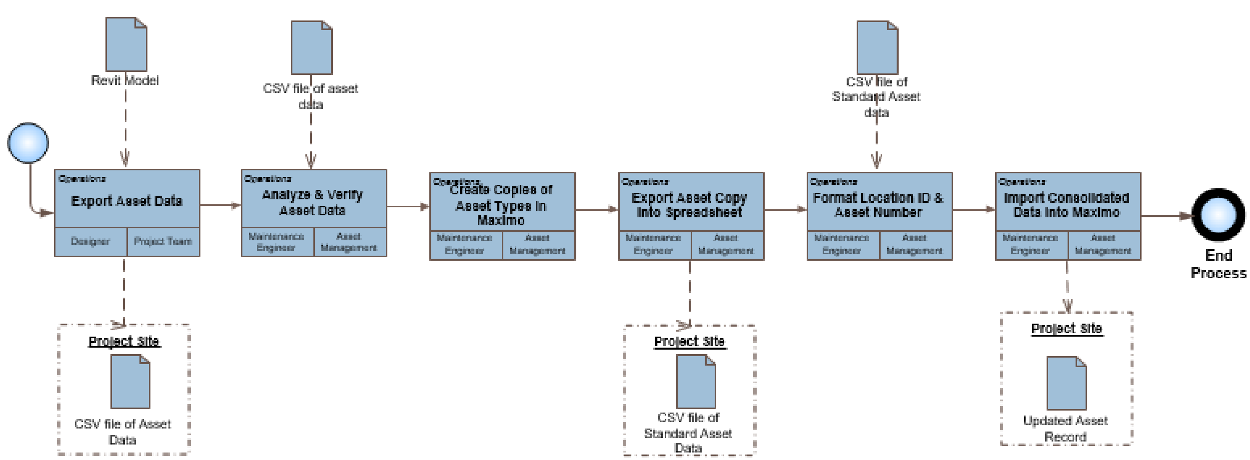

Figure 3: BIM data transfer process map for asset management

2.2.3. Submittal Information Sources:

The sources of the required information for maintenance planning and scheduling comprises submittal information; as identified in Figure 4. It was found that the Maintenance Engineer responsible for uploading the asset information has to do so from at least 4 sources.

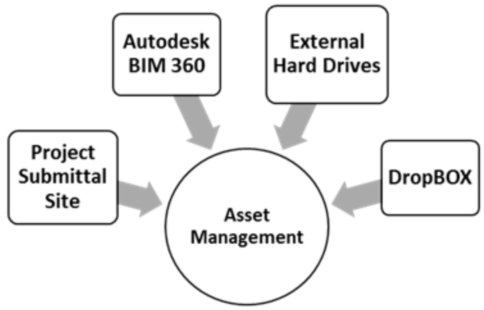

Figure 4: Sources of submittal information for maintenance planning and scheduling

The information handoff does not follow a standard process or predetermined order, leading to delays in finding the information. Each project team uses a selection or combination of project submittal sites, the BIM 360 Field, DropBOX and submittals also made to the Print Room of the asset management unit. Submittals to the print room are stored on hard drives. Another huge challenge lies in the area of labelling the files and folders. Every project team groups and labels their submittals differently, leading to delays in looking for the information from any of the four sources. Project submittal sites face the problem of differing access requirements and passwords, varying formats, grouping and labeling of documents. There is also the prospect of information loss following the closeout of the project and website. Though the organization's DropBOX is a more permanent archive, the unstandardized naming conventions and file grouping presents a huge problem; and information may be incomplete within it. The Maintenance Engineer noted that DropBOX is only useful as an archive if it can be uniformly organized. The same problem exists with the submittals formally handed over to the print room – recently on hard drives, and in the past on CD ROMs. BIM360 was deemed by the Maintenance Engineer to be the most feasible option of the four, as it is a live document and progresses with the project – thus ensuring currency of information and historical data. The information can be more easily queried and extracted as a spreadsheet, though the main issue was that sometimes the site closes with the project.

3. Discussion

3.1. Processes

There are a total of 34 projects over $5m with a BIM requirement, which cost a total of $1.15bn. There are currently up to 29 types of assets tracked per project, each with a maximum of 235 asset attribute parameters within the database. With an average number of assets placed at 311 per project, and a maximum of about 2,000, it stands to reason that anything between 33,135 and 440,860 asset attribute parameters will require population into the CMMS for any project at a time. BIM projects are usually large projects over $5m, or technically complex – such as laboratories. The average amount of Gross Square Footage (GSF) per building is 35,000 GSF – thus the number of spaces to be named and assets to be tracked within them covers a wide range. There were a total of 17 steps taken in order to obtain the appropriate location information and asset names for the 3D model during design. This would have taken a considerable amount of time to extract and format the data for export, process it and exchange between parties. There were several loops in the process evident from the departmental streams flowing from the project team to the space management unit and back; then to the asset management unit and back again, in order to obtain the required data. There were 5 data exchanges between 6 data formats from Revit, AutoCAD, the project management database, space management database, Microsoft Excel and Maximo. Although there were only 6 steps that take place during the process for uploading asset information into the CMMS, the sheer volume of information to be processed manually usually has a multiplicity effect of thousands. This is owed to the huge number of asset attribute parameters that are matched to every asset, which has to be sorted and double-checked.

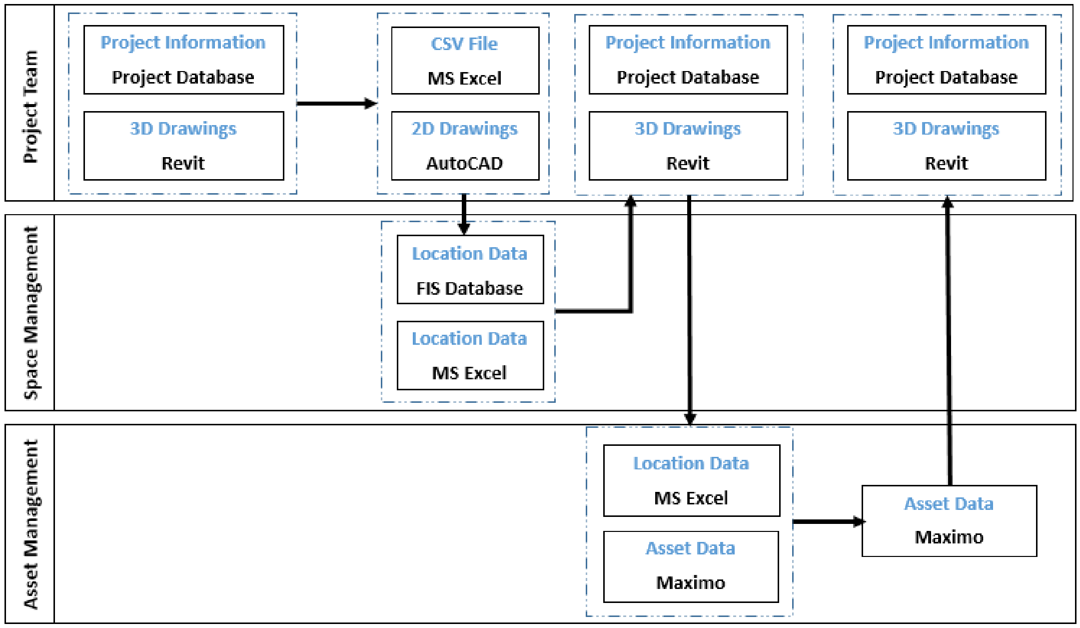

Figure 5: Data flow diagram for the location information process

The process could be improved by automatic uploading to reduce the man-hours required. Although Maximo has this feature – especially for high volume assets, in practice, the interoperability challenges faced in transferring Revit data through Maximo's Application Program Interface (API) does not exist. The core concept of lean processes is the reduction of unnecessary process steps and maximization of the necessary value added steps in a process for increased efficiency.

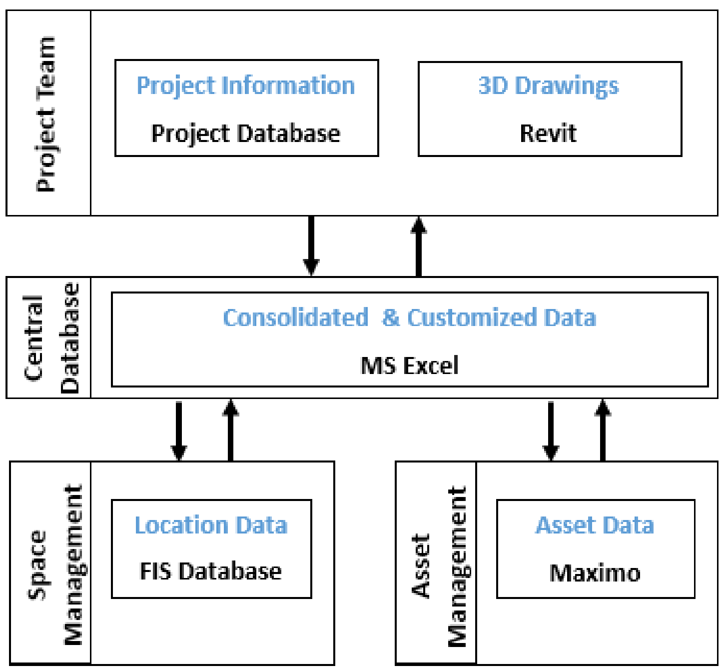

Figure 6: Alternative data flow diagram for location information process

A critical success factor for all processes is time, which is essential for a positive return on investment. Since it was observed that the CSV spreadsheet data format is the most commonly used and adaptable for both asset and space management processes, a way to get around the loops and labor intensity of the processes is to prepare the spreadsheets in a way that a faster data exchange can be engineered. Figure 5 details an alternative process where the CSV file becomes a central information source and destination. Each tab of the spreadsheet can cater for one of the information tables. The required spatial information can be organized into a standard spreadsheet for direct export of information from Revit in the specified format; thus avoiding the loop of conversion to 2D drawings and time spent by the Facilities Engineer stripping and extracting the required information. The CSV file, if put on a live interactive database, can thus be simultaneously populated with asset data, which can link the location information within its own tab. Having a centralized source edited in real-time can cut down the time that the project team has to spend in retrieving the information, as well as most of the data exchanges between the applications (Figure 6).

3.2. Waste

Multiple sources of waste were observed in the process, and are detailed in Table 3. The list of information waste found within BIM/FM processes were extracted from a literary analysis of the seven sources of waste (Ohno, 1988, Dubler et al.,2010; McManus & Millard, 2002), resulting in a consolidated list of the possible wastes related to the implementation of BIM in FM. An average of 15 wastes can be observed for any one identified problem, with the issue of non-standardized naming conventions registering the maximum of 19 possible wastes. All these result in delays, in addition to the problems of collaboration and the morale of personnel, who have to manually handle large volumes of data and pass it back and forth in a bid to retrieve and supply required information. The labor cost of the hours involved impacts the case for the business value of BIM in FM, as many of the processes have not yet been refined and maximized to the point of waste minimization/removal and the true addition of value to the process.

Table 3: process waste from the flow of information in BIM/FM implementation

Sources of waste		**Excessive Process Steps**	**Labor-Intensive Processes**	**Non-Standardized data naming**
Inventory	Poor configuration management			✓
	Incomplete information			✓
	Complicated retrieval	✓	✓	✓
Extra Processing	Unnecessary serial effort	✓	✓	✓
	Unnecessary data conversions	✓	✓	
	Excessive iterations or verification	✓	✓	✓
	Unnecessary process steps	✓	✓	✓
Transportation	Multiple sources			✓
	Security issues	✓		✓
	Information incompatibility	✓	✓	✓
Motion	Reformatting	✓	✓	
	Excessive file transfers	✓	✓	✓
	Non-centralization of information	✓		✓
	Required manual intervention	✓	✓	✓
	Distractions arising from movement		✓	✓
	Information searches			✓
Waiting	Late delivery	✓	✓	✓
	Development delays	✓	✓	✓
	Unavailable information			✓
Defects	Suspect quality		✓	✓
	Conversion errors		✓	
	Incomplete, ambiguous or inaccurate information			✓

3. Summary

The processes of BIM in facilities management for an early adopter were mapped out in the study. There is a need to investigate how organizations implement BIM in FM, and to study the value chain for areas of waste and opportunities for improvement. The flow of information between the BIM project team and the facilities operators was examined; including how the BIM handoff data is transferred into the facilities information systems in the operations phase. It was found that there are procedural loops and labor intensive activities within the system, contrary to the notion that all BIM interactions are automated. Three main problems were uncovered from the study of information flow, namely:

1. Excessive process steps in the process of information retrieval
2. Labor-intensive processes in uploading the BIM data to the CMMS
3. Non-standardized data labeling and storage following project handoff.

These three problems give rise to the problem of delay, illustrating the importance of time saving as a critical factor for business savings of the cost of labor hours. An average of 15 types of process waste was observed as arising from each of the three named problems, thereby negating the business case for BIM implementation in FM, and necessitating a more structured, value adding process. An alternative was suggested for the process of obtaining location and asset data during design. This involves utilizing the most common file convention (CSV) and placing it centrally within the project database, with prepared tabs already customized for data entry by the various entities. This would serve as a practical way to maximize the available software and tools, and cut down on the amount of time and effort spent exchanging and reformatting information multiple times.

4.1 Lessons Learned

Firstly, one important observation is that the processes of exchanging data between the project BIM process and facilities management are still not automated. Manual processes still exist, which have yet to be analyzed and improved for waste-minimization and value-adding potential. Another lesson gleaned is that the minimization of process waste can be achieved simply by utilizing available software and tools, and rethinking and reorganizing process steps. There also exists a need to formally organize and standardize submittal data naming conventions and storage locations in order to minimize the disorganization arising from retrieval of required information. As to the lack of interoperability of information systems which delays the quick transfer of information following handoff, there is a need to study opportunities for minimization of steps and finding ways to overcome the software incompatibility issues.

3.2. Future Work

Future work will focus on a more detailed study of the processes of BIM implementation in FM. The time factor involved will be studied and detailed in a value stream mapping process, which will calculate the time and cost implications of delay. Strategies to improve the processes will also be explored, and solutions developed to minimize/eliminate waste; and maximize value.

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