A Review on Current Status of Facility Management Practices in Building Industry and Prospective BIM Intervention to Manage the Facilities Effectively during its Service Life

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Abstract

BMS are deployed to manage buildings such as Shopping malls, office, and residential complexes. However, the information needed for their efficient functioning are either incomplete, generated separately, or hard to determine. BIM generates and stores useful integrated information during design and construction phases of the building projects. These Information are well utilized during design and construction stages but their usage in FM stage is limited. The guidelines and standards to facilitate BIM model during design and construction stages, are not considered critically usable. Hence, this paper aims to identify the need for crucial asset information during FM practices while executing the BMS process, to develop a standard framework for information specifications during the early development of BIM model, and utilize the same as a source for BMS in FM processes. Nevertheless, this paper addresses the common FM practices and its building data requirements towards efficient BMS implementation pivotal to the mechanical and electrical systems for a conceptual framework of a BIM model. The research adopts deductive approach through semi-structured qualitative interviews with FM stakeholders of the malls in Saudi Arabia to obtain the standard FM data requirement from client perspective, while managing the FM process through a BMS system.

Keywords
Building information Model, BMS, Facility Management.

1. Introduction

A typical Facilities Management (FM) process requires multidisciplinary roles and activities which have to be carried out meticulously, the failures in which, will lead to poor facility management. Scholars (Tan et al.2018) have pointed out the causes of inadequacy in data interoperability. Adoption of an adapted BIM model promises many bonus rewards such as clash detection, better visualization, saving time and cost and better delivery of products to the building owner while leaving positive impact on building's Life Cycle Cost (LCC). Moreover, it is believed that BIM being a centralized platform allows integration of its own variations into a single model, thereby making the design coordination easier (Liu and Issa 2014). It integrates building objects and their related parameters into an intelligent collaborative platform (Wijekoon et al.2018). BIM adoption in early stages of construction facilities is more advantageous than in design and construction phases (Azhar, 2011). Research also indicates greater value of BIM in maintenance activities (Ilter and Ergen 2015).

Furthermore, significance of timings and the value of information in FM highlight the need for collaborative information exchange and user support to identify essential data to support the responsibilities of facility managers. The optimum flow of information through various phases of the project can ensure success of BIM in FM by providing opportunity to the facility managers to engage without delays. Besides that, one study confirms the significance of legal and contractual framework as one of the many critical challenges in BIM adoption and implementation (Kassem et al.2015), thereby, invoking the need for a process for researching key information requirements within the industry. Facility managers in most circumstances rely on their own set of data, which lack originality, reliability, or worthiness. Therefore, a set of problems can be evaded if facility managers would receive a well-organized and resourcefully constructed information regarding the building.

Facility managers must determine the nature of information they need to implement in BIM model, as designers and contractors depend on the guidelines circulated through organized data on the basis of which they should assign to the model (Eriksson 2014). It has been found that not all of the information collected are valuable, adding to the fact that the nature of FM information to be integrated with BIM model remains unclear within the existing building construction practices (Kassem et al.2015). Thereby, such problems lead to varying impact on cost, design and handover process and regenerating the information several times from design and construction phases make the project costly but also hints a clear gap in the existing knowledge of BIM-FM integration due to the lack of collaboration and information sharing among the stakeholders. In order to perform their tasks effectively, facility managers should identify the Level of Details (LoD) that needs to be attached to the as built BIM model. Besides that, to facilitate a continuous information flow up to facility management, it is essential to rationalize both facility management and asset information management in the early stages of the project life cycle.

As there are very few proposed models for facility management, the limitations owing to the difficulties in collecting data would be evident. This research identifies the standard facility management practices exists in BMS process, the common facility management practices, and its building data requirement towards efficient BMS implementation. The study focused on commercial buildings specially shopping mall complex. The data are collected through interviews with diversity of groups of stakeholders and facility managers and analysed with appropriate statistical methods.

2. Literature Review

2.1. BIM Model and Facility Management

The concept of Building Information Model or BIM dates back to 1970s and relates to various approaches to define the process of facilitating information exchange between project teams to integrate information of a project during the project lifespan. The existing studies suggest two perspectives of BIM: the process related and technical related (Wango et al.2018).

The National Building Information Model Standard Project Committee (NBIM-SPC) recognises BIM as a model that exhibits functional and physical attributes of a facility and plays a pivotal role in organized sharing of informational resources about the facility, making BIM an important guideline in decision making throughout the project lifecycle (Rokooei 2015).

BIM encompasses all the project information throughout the progression of a project. U.S. General Service Administration specifically defines BIM in these words: the purpose of BIM is to make the design information explicit, so that the design intent and program can be immediately understood and evaluated. A BIM-based approach supports 'on demand' generation of documents (e.g., drawings, lists, tables, and 3D renderings) from a consistent BIM. In a sense, these documents present views of the current BIM. A BIM model, therefore, can live longer, contribute more to process efficiency, and provide superior accuracy than traditional 2D CAD drawings." (GSA BIM Guideline, 2007)

BIM, unlike the traditional information exchange method, is an object-based modelling process of designing a facility which enables owners, contractors, and designers to share information among each other, considering various parameters of the project with a digital approach. Numerous studies of the past years have recorded the advantages of BIM showing the qualities within a given span of time, the value and cost for all stakeholders in a building construction project. Furthermore, it is widely agreed that BIM is a shared knowledge resource for the facility that depends on all project participants' action such as add, extract or update information in the model database which will be reflected immediately to all the project participants. Poor communication among different stakeholders in the project is the main reason for building defects (Eriksson, 2014).

It is also clear that all of the perspectives of the BIM model highlight its significance in using it for the entire lifecycle of building projects, though scholars defined BIM differently, but its advantages support its application in project facilities management. The use of BIM is being considerably identified across all phases of project life cycle, and it is worth mentioning that although the implementation of BIM in building industry is expanding to lifecycle, BIM implementation in operation is still in its primitive stage and construction industry has struggled to achieve lifecycle BIM uses (Shou et al.2015).

While advantages and the beneficial deliverables of BIM has become evident, it is worth mentioning that most scholars had oriented their research on the design-construction phases instead of the facility management in its entirety. Notably, there is growing trend that emphasis is being directed towards facility management to improve BIM tools and with the increasing trend, an in-depth understanding that will lead to better integration of BIM with FM. In one study, Pardis et al. (2018), examined the FM-enabled BIM implementation in a real-world pilot project describing the process of planning and developing BIM for its later use during the handover and operations phases and applied State-of-the-art BIM-enabled strategies and tools on the project to achieve the successful handover of FM-enabled BIM, stressing the need for a framework for future studies in BIM for FM.

Nevertheless, integrating BIM into FM is facing certain challenges which act as barriers to BIM adoption, particularly in building construction industry (Kassem et al.2015) points out the existence of two factors creating difficulties that prevent BIM adoption in FM applications. First, the various stakeholders of the project when do not intend to collaborate during modelling or in optimum utilization of the BIM model, and second, lack of awareness by clients which is aggravated by the shortage of BIM skills and absence of understanding by finance management professionals. So, this is a major challenge for the reason that for the building itself, as well as its owners, BIM processes and models in use, need sustained efforts by facility managers so that they remain effective – a perspective that would be extended in section 2.3 below.

Facility management is a method that traces back to the 1970´s and defined differently by different scholars; one commonly used definition comes from Atkin and Brooks (2005) which views FM as "an integrated approach to operating, maintaining, improving and adapting the buildings and infrastructure of an organization in order to create an environment that strongly supports the primary objectives of that organization" (Eriksson 2014). Further, if sustenance of the core business is the ultimate objective, FM has no option but to devise and adopt a strategy that complies with and helps realize the major goals of organizations. In this regard, Pavick (2010), cited a survey conducted by the International Facility Management Association (IFMA) in 2009, that identified eleven core competencies of FM: Operations and maintenance, Finance and business, Real estate and property management, Human related factors, Project management Leadership and strategy, Technology, Communication, Environmental stewardship and sustainability, Quality Control, readiness for emergency and manging business sustenance.

Facility Managers view BIM as an active tool that can be used during FM stages to collect documents that would support management of building information with required accuracy (Aziz et al.2016), and that throughout the operational life of the facility and mitigation of cost during the life cycle of the building BIM provides a source of

facility information, allowing the flow to support the facility managers (Olapade and Ekemode 2018). Access to information is pivotal to the performance of facility managers and an important element on which facility managers' decisions about facilities are based. Thus, facility managers have to understand the type of building they are managing, the nature of systems in place, the variety of components and their places or positions in the facility, manuals, warranties, drawings, contracts, documents, instructions, maintenance schedules etc. They should be able to read the building information and how it is performing over time and benchmark the performance with other buildings.

BIM through structured method of information sharing among the stakeholders, targets reduction in building lifecycle cost, to accomplish the basic requirement of FM. However, most studies have shown that the information required in facility management did not get the needed focus in the existing BIM model which stresses on controlling lifecycle costs through systematic communication of information among the stakeholders. Stressing on the desirable outcomes, in one study it is argued that apart from clearly identifying FM-enabled BIM information, ensuring successful execution of a construction project depends on certain discrete factors viz, a proven interoperability plan, implementation of FM-enabled BIM and the collection of BIM data that could support FM throughout the project. (Chapman 2005).

it is believed that adoption of BIM for FM will provide means and methods to manage building operations knowledge that can later on support the creation of further viable designs. (Kassem et al.2015). BIM-FM integration can reduce time, support in decision making, improve documentation, reduce operational cost, collaboration, clash detection and information updating (Aziz et al.2016).

A BIM project which includes the operational phase only for the design-build phases and leaves out operational phase is not a complete BIM project. Furthermore, FM should take full benefits from the BIM model particularly during the operation phase by careful information handover. Most of the construction project costs is generated in operation phase and can be minimized by improving the design-build phase which will remarkably enhance the operation and maintenance phase. Therefore, using BIM software in the pre-design phases of construction projects forms an effective tool to reshape the building construction process in a way that provides rich and reliable information to support better decision making. Appropriate documentation will thereby empower the facility managers and make them self-sufficient for operating the facilities

2.2. BIM and Facility Management Challenge

Scholars argue that BIM is either lacking an approach or to an extent, seems to be inadequate (Dixit et al.2019) and considering provisional appointment of FM contractors there develops a notion that BIM, being an incomplete model in its original form, cannot support any facility in general, which leads to obstacles for BIM to perform efficiently in FM applications. (Kassem et al.2015). Discrepancies take place due to traditionally manual transfer of data or information to FM phase leading to the main cause of incomplete and inaccurate information flow. The chances are there that information is either delayed, changed, manipulated, or destroyed before reaching to Facility managers. Since these are essentially required in FM, the facility manager and owner must contribute timely before it raises questions over the imperfections in BIM. In case the data is enormous in size, these are stored unused and the Facility managers then need to validate or recreate data by

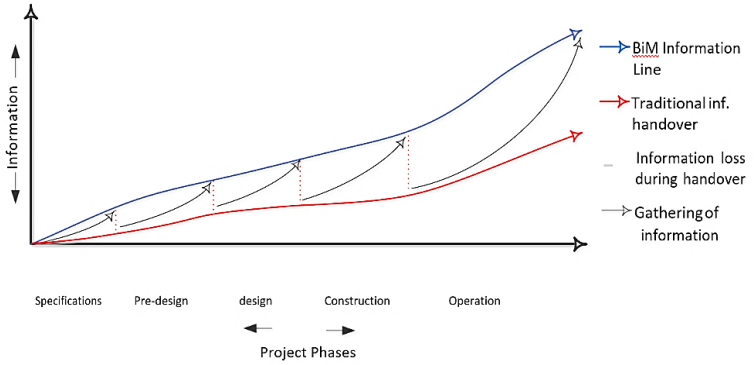

Figure 1. Information loss at different handover stages in projects (Based on the graph of Smith & Tardif 2009)

physically checking and documenting information that should already be available to him. Consequently, there exists the possibility of losing time as well as the critical data during traditional information transfers.

Workflow and data handover has to be enhanced and throughout the lifecycle of the building this data has to be maintained; else, poor handover of the data during the change of contracts may lead to duplication of information that would incur additional costs to the project. (Kassem et al.2015). Therefore, BIM in FM relies critically on greater perfection in the handover process for which the need is highlighted in the findings of Lee et al. (2012) that reports industry's high volumes of avoidable expenses in recreating lost or faulty information in addition to the cost incurred in correcting inefficient workflows. However, the silver lining is that even though current interoperability challenges do exist during the building lifecycle, the resources in terms of time and funds needed to build FM systems can be minimized by proper BIM information collection (Gu and London 2010 and Lucas et al.2013).

Findings in 2005 estimated that annual loss in the USA due to lack of interoperability among computer aided design software used in the AEC industry was 15.8 billion dollars which is the sum of estimated financial burden for the four key stakeholders in the AECO industry. Figure 1 above, illustrates information loss at various handover stages in construction projects. By providing a neutral platform of interoperability between different software platforms, owners can find pathways to eliminate this data loss in the construction industry (Chapman 2005).

Additionally, Facility managers need details and priorities for their information requirements. The lack of contractual and legal framework for the implementation of BIM in general and for BIM for FM in particular is a significant area of challenges. Therefore, a process for researching key information requirements has to be explored and implemented within the FM and the industry (Teicholz 2013). a proposal for BIM implementation: In one study, (Carbonari et al.2018), investigated relatively inefficient tasks that during operation al phase of the construction project, and whether BIM information can affect the efficiency positively.

On one hand, FM deals with an enormous amount of asset information, including acquiring, updating and analysing of such information and to facilitate a continuous FM it is pivotal to realize the role of FM as well as asset information, especially in the design phase of the project lifecycle. On the other hand, scholars argue that there is no substantial evidence on the kind of FM information that should be integrated with the BIM model and the methods to be adopted to include such information and there are uncertainty on the value attached to such information (Wijekoon et al.2018). With the help of Australian FM experts, the research by Hosseini et.al.2018 points out the observed knowledge gap in BIM-FM literature. Therefore, while scholars identify a clear gap in the existing knowledge with regards to BIM-FM integration, most factors affecting the integration are unclear BIM workflow, Improper information capture, failure to update BIM information and lack of client demand (Dixit et al.2019).

3. Method

The data collection targeted a semi-structured interview, its selection is to meet the tendency of the interviewers to ask follow-up questions on answers considered important (Bryman and Bell 2011). The study adds to the growing body of literature based on a commercial project namely a popular Shopping Mall in Eastern region (the port city of Saudi Arabia and a business hub) The study focuses on a cross-sectional research extending the data collection to all the stakeholders of the shopping mall with respect to information management affecting operations, maintenance, and costing at the time of survey.

Based on previous knowledge of the Shopping Mall representatives of each of the core activities were selected as interviewees. The results of analysis after data collection intended to explore the significance developing BIM-based FM that would fit the requirements of the Mall as the sample of study. The suggested BIM-FM model should work as a prototype for similar projects in construction industry, but the survey showed that only a few employees used BIM in their daily work.

The main data of the study is comprised of interviews of personnel in each core activity within the Shopping Mall shown in Table 1. The interview proceedings were divided into five phases (Kvale 1996), namely a preparatory phase, the initial contact phase, the orientation phase, the substantive phase, and the final phase. The number of

respondents in these semi-structured interviews were limited to 13 participants comprising mall manager, owner representative, facility managers, operation and maintenance manager, project manager and engineers. The sample represents the main technical activities within the Shopping Mall. The most important factor in the selection process was interviewee's extent of participation in the building information handling which remained pivotal during data collection process. To understand the activity of the main groups of the practitioners, we made a distinction between six activities based on their object of work.

Table 1: The activities of the Shopping Mall and the number of interviewees representing these activities

Positions Interviewed	**Activity within the Shopping Mall**	**Object and main content of the work**	**Number of interviewees**
Mall Manager	Internal and external activity	Supervising all services and activity on the mall and managing contract with related parties	2
Owner's Representative	construction supervision	Coordinating and quality controlling of the detail design, tender and construction stages of the new build and refurbishment projects	1
Facility Manager	System development	Developing the FM and maintenance systems and their integration	3
Operation and Maintenance Manager	Maintenance	Taking care of minor repairs and maintenance, supervising technical systems	3
Project Manager	Archives	Organizing the preservation and availability of all project documents	2
Engineers	Project planning and preparation	Preparing the project plans and budgets for new build and refurbishment projects for the decision making of the city council	2
Total			**13**

The following text analyses the capabilities of the four main FM systems of the Shopping Mall. While focus was on the tools and techniques of these employees and stakeholders; importance was given to external information systems and sources they used or have developed themselves.

1) Engineers by profession, was a senior, highly experienced person having worked on numerous projects and could understand the various perspectives of BIM-FM integration. He was able to comment based on the present scenarios.

2) The Owner representative being stakeholders have a unique significance in a project. The owner representative was interviewed, who shared about the investment plans in the project, the risks associated and the interest towards BIM implementation. He was into coordination and quality control of the detail design, tender and construction stages of the new build and refurbishment projects.

3) the Mall Manager were taking care of the internal and external activities, preparing rental contracts, and defining the level of the rent under changing circumstances. Besides that, the Mall Manager is the sole employee to report overall business to the higher management, so access of information from various departments played a key role in his responsibilities.

4) The Project Managers were adept in information gathering from all the project entities and based on the existing information they designed documents for a project. He assigned to save project information for completed new building and refurbishment projects. He gathered updates from designers and contractor who should have entered the information directly into the system

5) The Operations and Maintenance Manager, in coordination with the project manager, were engaged in follow-up of services, communication with maintenance men and the reception of service requests from the users of premises. They were responsible for managing orders, rental agreements, and maintenance responsibility tables, and monitoring the proceedings of a design process whenever needed.

6) Facilities Manager worked in coordination to develop the FM and maintenance systems and their integration. As part of his role, he was supposed to supply the Employer's Information Requirement (EIR) to the designer, use a BMS system in managing the FM and be a decision maker in BIM-FM implementation.

Conclusively, these working professionals of the shopping Mall were assigned different activities and used a range of functions of the information systems of the Shopping Mall in a variety of modes and for different purposes. This signified that they all had different information needs. Such a wider range of functional roles needed specific use of external information tools.

4. Data analysis

The practitioners at the Shopping Mall identified above, had different experiences and familiarity on BIM. None of them groups had a strong familiarity with the BIM application in their scope of work. Apart from recording their application of BIM, they were asked to comment on their perception of BIM challenges and potentialities. Then, we analysed their views concerning their uses of BIM, kind of barriers, challenges or worries they mentioned concerning BIM, and kind of future visions they had about it.

A close analysis of interviewees' responses gives some tangible information regarding BIM-FM implementation and its future prospects it can be classified under:

1) early introduction of FM to the BIM Process:

Leaving aside only few exceptions, majority of the respondents agreed that stakeholders can see facility managers engaged early in design and construction phases. They recognized the significance of early development of facility management in projects. Although they confirmed the beneficial use of BMS system in facility management of their organizations, they were seen contending equally in their choice of supplying Employer's Information Requirement (EIR) to the designers. Almost all the respondents agreed that EIR does and EIR will help in setting up the BMS-FM system. However, mostly they declared that their as-built information can be used in the BMS. Regarding the possibility of embracing BIM in their companies, while some of the interviewees had already been using it, almost half of them were sceptical about its implementation in the near future.

2) background, adoption, and engagement with BIM for FM:

There were only few respondents who expressed clearly on background, adoption, and engagement with BIM for FM. Among those who commented, expressed the importance of BIM for FM and its use for facilities management with some reservations. Some of them were of the view that such an integration is of moderate value and depends on how important the facility and its systems are to maintain and operate. According to them. Others accepted its early implementation, right from the planning stages of the project as it would give viable results due to easy and systematic access to information, which otherwise, remains a hefty task for the facility managers. They also highlighted that BIM for FM promotes cost savings for the organization at both delivery and operational levels of the building unit, besides, its positive impact on project execution leading to improved client satisfaction. However, those who realized its role hinted towards the demerits of using old version of BMS that needed continuous upgrading.

On the matter of their own capabilities for leveraging BIM for FM, about a quarter of the respondents were confident on their human capabilities to act professionally in data collection, in use of advanced technologies, and in using their technical expertise or experience to support the implementation team. The other quarter stressed on enhanced capabilities through proactivity and efficiency assisted by technologically advanced systems in the near future. Those who commented on organizational limitation in leveraging BIM for FM complained of outdated technologies in use which cannot be even upgraded to fulfil the FM needs. while a few of them pointed out on the need of maintaining a professional workforce who can utilize the tools and resources for FM to make data-driven decisions easier, others thought they were capable on technical know-how and could support the BIM-FM integration.

Whether facility managers are currently utilising BIM for FM in daily routine at workplace, remained a matter of concern for most of the respondents. More than two-thirds agreed that BIM for FM not utilized for their project facilities. In some organisations it is, however, it is being used in routine work activities but on a rudimentary scale.

3) Challenges for Facility Managers in FM

The responses on the type of challenges faced by the Facility Managers varied immensely among the interviewees from one department to another. For better picture, these are categorized as follows:

a) Cost-related challenges
Interviewees agreed almost unanimously, that during the start of the FM phase the main challenges for facility managers were controlling the initial cost, which was the outcome of several other factors, most of these outlined below, were within the domain of FM.

b) Employee-related challenges
Some of them identified that human resource management and creating conducive organizational culture were more critical issues. This required employee training as well as error-free recruitment procedures. Allied to it, remained the major challenge of mobilization which depended on a realistic mobilization plan. Shortage of skilled personnel was another concern faced by facility managers, especially in technology-based projects.

c) Information-related challenges
There were many challenges felt in the beginning of FM phase, due to the lack of required information which might be due to the underutilization of BMS system and its workflow at the facility. Hence, facility managers face a critical issue of troubleshooting the BMS system to restore the missing data; for instance, if they have no as-built data, or the operation manuals is missing.

d) Project Plan-related challenges
Proper action plan or implementation plan shows the readiness of operation and maintenance team. Lack of a mature plan for operation and maintenance leads to many errors in the initial phase. Since level of operation remains high at the starting of operation and maintenance phase, facility managers are coping poor coordination in the absence of a practically feasible plan. Such challenges could be minimized by maintaining engineers who are not only aware of their technicalities but are capable in coordinating with PMO as well as operation and maintenance.

e) Equipment and Technology-dependent challenges
In the early phase of a facility development, there are hardly any challenges, provided all equipment and system are new but as these equipment start to wear out with the progression of project, the need for maintenance and replacements arise, causing disruption at the project. This becomes a matter of concern for the facility managers. Moreover, the choice of right technology to coordinate between the numerous project players, requires tremendous data which if not provided on time would impact the cost, the deliveries, and the operations.

f) Time-related concerns
Most Projects require involvement of experienced planners or project managers who can schedule and execute project milestones perfectly. Focusing on the advantages and disadvantages of various phases of the FM, proper scheduling would impact the designing of the process flow and ultimately the decision-making and customer satisfaction. The whole project is at stake if facility managers are not updated with the right information at the right time.

g) Operation and maintenance- related challenges
A professionally coordinated equipment control assisted by qualified technicians can help facility managers to alleviate such concerns. Equipment tagging that reflects database accuracy which would assist in identifying the sources and locating them. To maintain the assets in use, Facility Managers are depended on real-time updated data, which is a matter of concern for them, in addition to other related issues such as the which equipment to use, when to phase out, and what to purchase for the project.

4) Main challenges for facility managers at the end of commissioning

Respondents expressed varying views on the challenges faced by facility managers at the end of commissioning. One view was that it is challenging to familiarize people to start using a new system with absolute performance, or to hire those who are properly experienced with its operation or use. Preparedness requires that both the equipment as well as the operator should be technically ready. This is a cumbersome task and needs a lot of collaboration. Others commented on the significance of healthy contracting wherein all the liabilities of contracted equipment as well as the skilled labour goes to the contractor, thereby, making it a responsibility of consulting office to take over contractor rather than the facility manager, which means:

" The FM has no great challenge on this phase because, he is not dealing with contractor directly. FM receives the project from the consulting office."

Likewise, most respondents highlighted the critical dependency of Facility Manager on contractor in the progression of project milestones after commissioning which may be due to untimely mobilization or demobilisation of workers or some technical problem in equipment functioning during testing, installation, or operational stages.

To avoid problems with the clients during project handover, Facility Managers have to review at every stage after commissioning, the quality, and specifications of the built asset for conformity. Testing and commissioning record for all equipment, verify that all these are tested and passed. So, access to accurate information is the major concern for Facility Managers which requires that facility managers should be involved during testing and commissioning and smooth communication should be ensured between Facility Managers and the contractor as Facility Managers can get the things done from contractor to resolve a range of issues after commissioning.

4.1. Technology and process-related challenges

The technology challenges were assessed while maintaining 65 as the peak value of challenges for all the challenge types as shown in Figure.2. The comparison was made between each of the actual challenge type and the maximum attainable challenges. The study considered a range of technology and process types that forms the basis of BIM-FM implementation in most of the similar projects: Keeping the maximum rate constant, the four identified parameters varied marginally. The results are explained as follows:

(1) A significant number of respondents (77%) reported unclear roles and responsibilities referring to data feeding into the BIM model and its maintenance as one of the critical challenges.

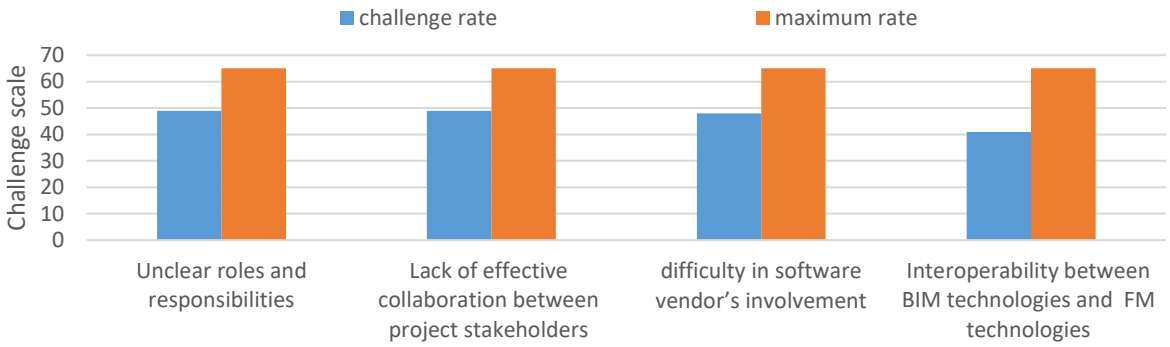

Figure 2. Technology and Process Challenge

(2) Nearly two-thirds of the interviewees agreed that due to possible information loss during handover of documents in operation stage between BIM technologies and FM technologies such as CAFM, accuracy and reliability in data interoperability was challenging.

(3) Majority of the responses expressed the criticality of stakeholders to collaborate effectively to design, implement and utilize the model.

(4) Procurement issues, supplier involvement and competition with diversified interests were identified as the most common challenge being faced on the projects.

4.2. Organizational challenges

The Organizational Challenges were also recorded on the same scale as for technology and process challenges while maintaining 65 as the peak value for all these challenges as shown in Figure.3. Keeping the maximum rate constant, the three identified parameters varied marginally with each other in terms of their extent of being clear challenges. . The results are explained as follows:

(1) Approximately 66% of the respondents viewed that the interference of cultural barriers in adopting new technologies is distinct challenge in the implementation of BIM.

(2) About two-third of those interviewed highlighted the resistance posed within the organization towards adopting new technologies. Such resistance could be from one or multiple directions, including resistance to investment in infrastructure, training, and new software technology.

(3) Majority of the interviewees believed that building design and construction phases needed integrating owner's view through optimum legal framework, which was considered a major challenge being faced towards BIM-FM integration.

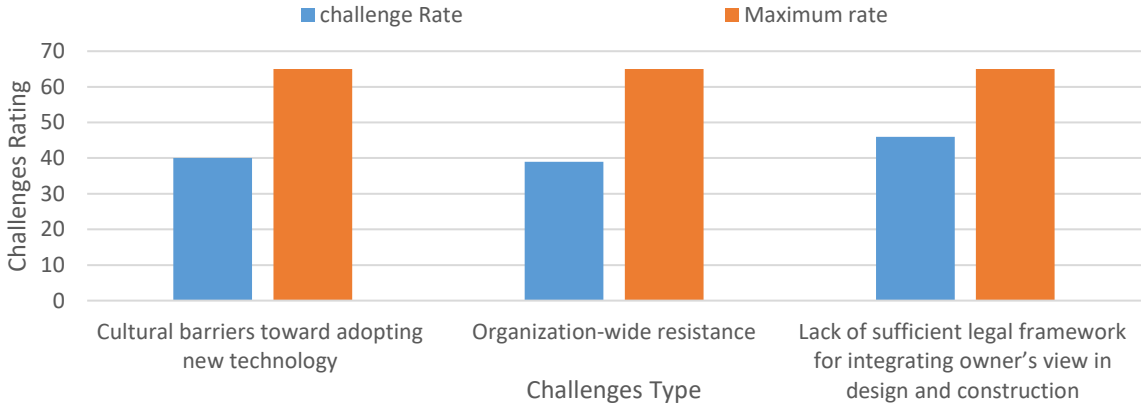

Figure 3. Organizational Challenges

5. Facility Management Data Required

From interviewer's experience on operation and maintenance at the property, data required in BIM utilizing BMS system from each mechanical and electrical system are identified. These are the standard data required from client on managing FM process through BMS system. The two main categories under study were the Electrical and the Mechanical Systems. The sub-categories for each of these are tabulated in the Table.2 below:

Table 2. The two main categories and the sub-categories under review

Electrical System		**Mechanical System**	
Subcategory	***Details***	***Subcategory***	***Details***
Power Distribution Network	DP Locations	**HVAC System**	CHW Piping Network Diagram
	DP Diagrams		Air Duct Network Diagram
	Cables Routings		Units/Equipment Locations
	Cables Sizes		Units/Equipment Models
Earthing Network	Resistance Reading		Units/Equipment Readings
Lighting System	LP Locations		Units/Equipment Status
	LP Diagrams	**Water Supply Network**	Network Diagrams
	LF Locations		Mains routing
	LF Models Number		Mains Sizes
Lightning Protection Network	Air Terminal Locations		Pumps/Equipment Locations
	Network Diagrams		Pumps/Equipment Models
	Ground pit resistance		Pumps/Equipment Readings
Low Current Systems	Fire/Smoke Alarm		Pumps/Equipment Status
	System Diagram	**Water Drainage Network**	Network Diagrams
	FAP Location		Mains routing
	FAP Status		Mains Sizes
	Detectors Locations		Pumps/Equipment Locations
	Detectors Models		Pumps/Equipment Models
CCTV Network	System Diagram		Pumps/Equipment Readings
	Cam Locations		Pumps/Equipment Status
	DVR/NVR Location	**Fire Fighting System**	Network Diagrams
	DVR/NVR Model		Mains routing
	DVR/NVR Status		Mains Sizes
Public address Network	System Diagram		Pumps/Equipment Locations
	BS Location		Pumps/Equipment Models
	BS Model		Pumps/Equipment Readings
	Telephone Network		Pumps/Equipment Status

Electrical System		**Mechanical System**	
Subcategory	***Details***	***Subcategory***	***Details***
	LAN/Data Network	**Smoke Management System**	Network Diagrams
			Air Duct routing
			Air Duct Sizes
			Fans/Equipment Locations
			Fans/Equipment Models
			Fans/Equipment Readings
			Fans/Equipment Status
		Elevators/Escalators	Equipment Locations
			Equipment Models
			Equipment Readings
			Equipment Status
		Automatic Doors	Doors Locations
			Doors/Equipment Models
			Doors Readings
			Doors Status

5.1 Electrical Systems

The main categories selected for the importance ratings (as illustrated in Figure.4) were power distribution network, earthing network, lighting system, lightning protection network, low current systems, CCTV network, and public address network. On an average, the survey responses show that 70% of the employees and stakeholders considered these categories important in the BIM-FM process. Even though some variations could be seen in importance of power distribution network (88%) and the public address network (70%), the rest of the categories occupied their significance in between these two. Such a minor differences in their importance level indicate that each of these categories are critical in the BIM-FM process.

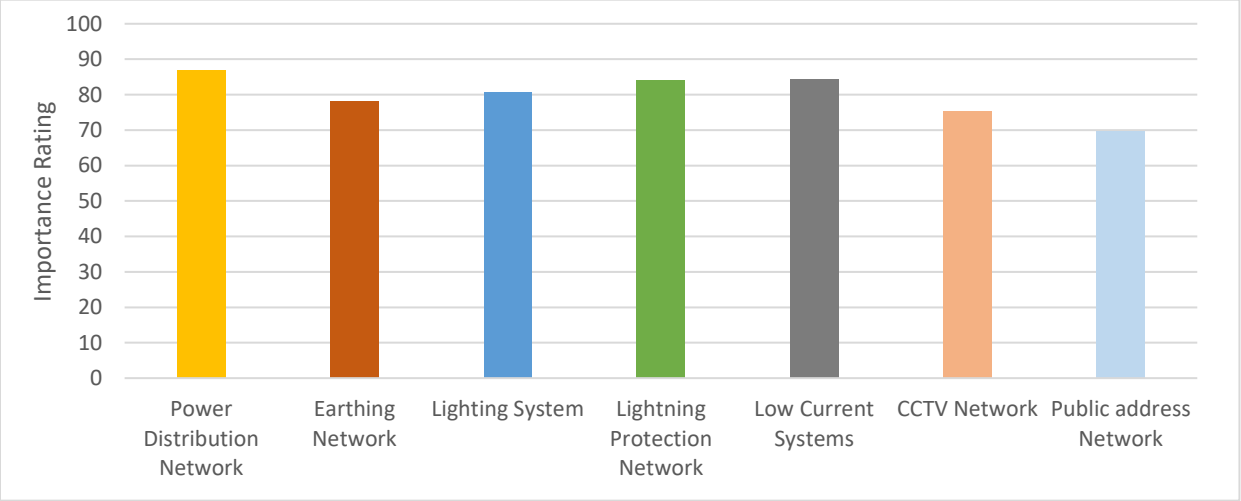

Figure 5. Electrical System

As illustrated in the Figure.5, leaving aside some differences among the sub-categories of the electrical systems, almost all of these ranged between 70 to 90 on a scale of 1 to 100, which means that respondents highlighted the significance of these subcategories in the overall electrical systems of the project.

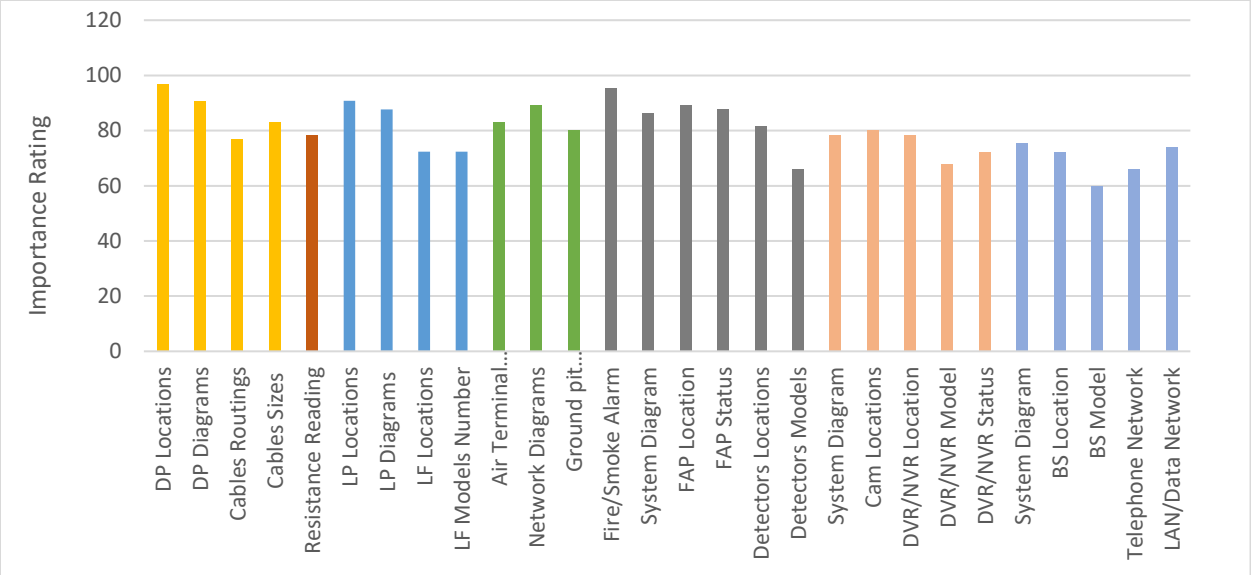

Figure 5. Electrical System - Subcategories

However, DP locations and Fire-Smoke alarm received the highest priorities while Detectors Model and BS Model were given relatively less (60%) weightage. Those categories which comparatively occupied average place (80%) in the importance ratings were Cables sizes and routings, Resistance reading, Air Terminal, Ground Pit, Detectors locations, System Diagram, Cam Locations and DVR-NVR Locations. Sub-categories that were close to the lower importance levels were LF Locations, LF Model numbers, DVR/NVR Status, System Diagram, BS Locations and LAN-Data Network.

5.2 Mechanical Systems

With reference to Table 2 above, the responses exhibit contrasting distinctions in importance ratings of the main categories in the Mechanical System which can be illustrated in the Figure.6

The remarkable contrast is between the lower important Water Drainage Network and the Automatic Doors on one hand, and the highest important Fire Fighting System on the other. However, it is clear that even the lowest importance rating does highlight its own significance in the Mechanical System by scoring 78 out of 100, which shows that these variations are comparative while the importance ratings for all of these suggest their key role in the Mechanical System. HVAC Systems, Elevators/Escalators and Smoke Management Systems occupied next place in this hierarchy of importance, whereas Water Supply Network received mediocre weightage among all.

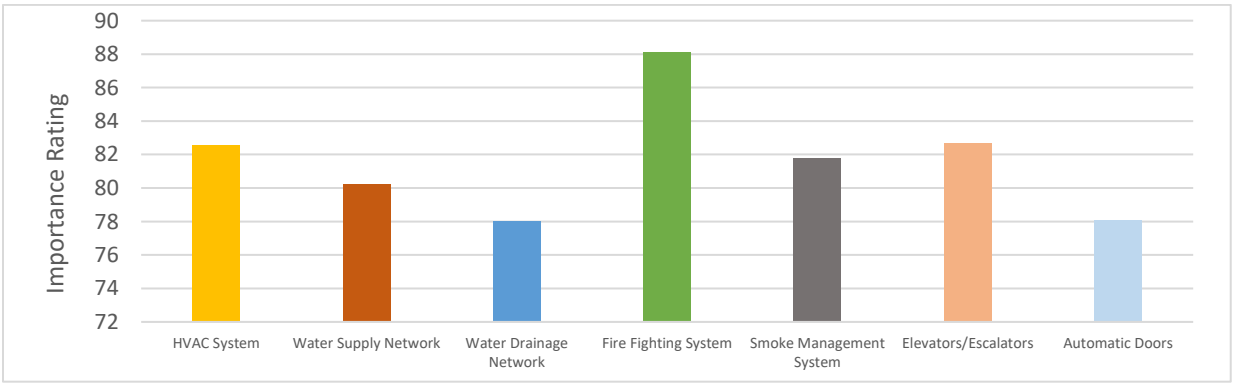

Figure 6. Mechanical System

As evident from the table, the responses illustrated in the figure.7 show varying importance levels among the sub-categories in the Mechanical System. Beginning with the anomalies, most of the higher importance ratings were received in Firefighting Systems with four of the six subcategories scoring above 90% importance among all the subcategories of mechanical system in the project.

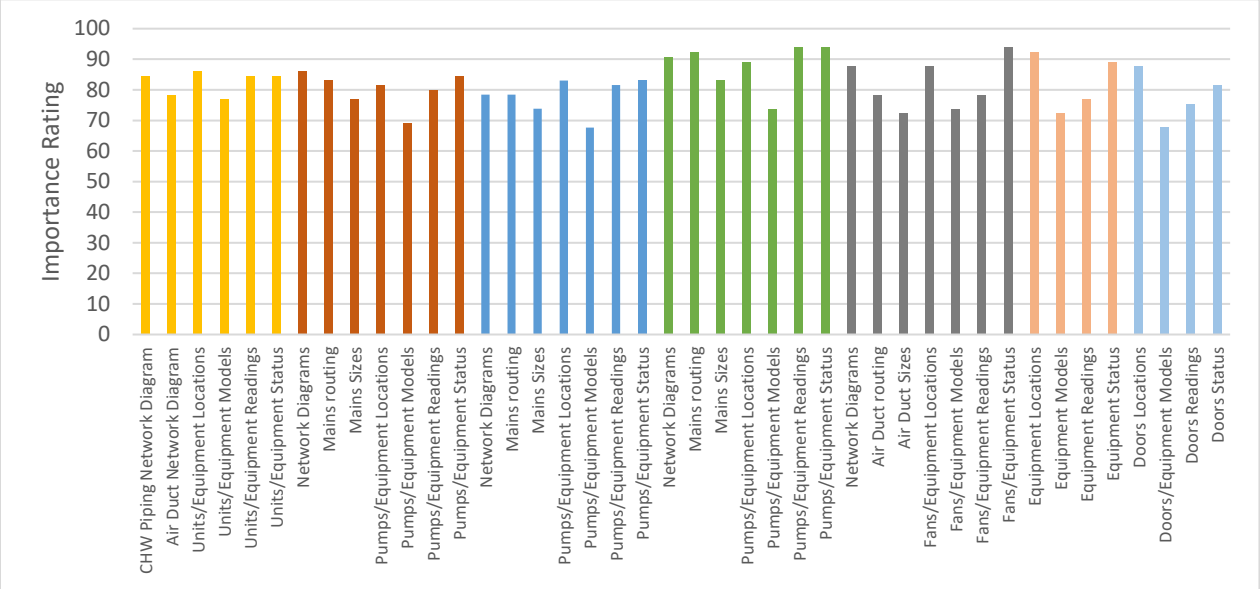

Figure 7. Mechanical System – Subcategories

The other two in the same weightage were Fans/Equipment readings from the Smoke Management system and the Elevators/Escalators. The lowest emphasis was on Doors/Equipment Models and Pump/Equipment Models from the categories Automatic Doors and Water Supply and Drainage Networks, respectively. Overall, none of the items were rated below 50%, indicating that all of the subcategories were assigned essentially important elements in the project and their critical role in BIM-MS system cannot be ruled out.

6. Discussion

Managing facility during a project a requires timely, secure, and precise information flow which is the core requirement in a Building Management Systems (BMS). The survey conducted in this case comprised of interviewing employees, stakeholders including facility managers who were supposed to utilize BIM models during design and construction phases of the projects. The research tried to identify the limiting factors or the reasons as to why BIM is not fully utilized by facility managers, as it was found that BIM is being underutilized in many cases and in some instances, stakeholders are even unaware of BIM models in operation and maintenance phases. Thus, through a deductive approach comprising semi-structured qualitative interviews, this survey gathered the perceptions of the role players regarding common FM practices employed including the BIM model and tools to identify the extent of BIM implementation so that a conceptual framework could be assumed for BIM models. Simultaneously, it was one of the objectives to identify the nature of data required, their handling and significance in BIM-FM process.

Multidisciplinary nature of the facility manager's role requires adequate data interoperability, multi-departmental reach, and use of intelligent collaborative platform in early stages of construction projects, not to mention, the design and construction phases of the project which can be acquired by the use of BIM in FM. Facility Mangers' dependency on scheduling, contractual assignments, documentation, data flow and retrieval confirms the need for an effective BIM-FM model adapted to suite the project milestones. However, the interview responses hint a clear gap in the

existing knowledge of BIM-FM integration due to the lack of collaboration and information sharing among the stakeholders.

7. Conclusion

The interview required respondents to answer on a variety of perspectives that fall within the range of BIM-FM implementation and the scope of facility management. Of the 13 interviewees comprising mall manager, owner representative, facility managers, operation and maintenance manager, project manager and engineers representing the technical capabilities, most of them recognized the significance of the BIM tools in their projects, unexpectedly, even those who were not implementing BIM at their capacities. Many respondents reflected discretely on information management affecting operations, maintenance, and costing at the time of survey, nevertheless, their knowledge of the scope of BIM-FM integration was limited. It was found that confusion or lack of information caused due to lack of collaboration exists on the nature of FM information to be integrated with the BIM model which is affecting project cost, handover, and client satisfaction. While this cross-sectional research focussed on commercial buildings and collected data to reach to a conclusion regarding the extent of implementation of BIM in FM, the responses gave a clear picture of the challenges posed to BIM-FM integration in construction projects as only a few employees used BIM at work.

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