

# Integration of Facilities Management (FM) Practices with Building Information Modeling (BIM)

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**Abstract**— Facilities management (FM) is a multi-disciplinary services and activities that have integration between people, place, process and technology. From the aspect of a building or facility, a system of comprehensive and incorporated FM should be generated systematically so that the maintenance, asset and life span management are implemented properly. An integration of Building Information Modeling (BIM) with FM system offers a higher standard platform of system, which functionality of managing buildings, facilities and other fixed assets can be integrated as a digital repository for each building component. BIM can also enhance the cooperation between the various disciplines of work, the ability to manage change and capability to provide full information support and management throughout the life cycle of the building. Hence, the purpose of this paper is to discuss the concept and definition of FM with BIM and the integration between FM and BIM.

**Keywords**—Facilities Management (FM), Building Information Modeling (BIM), Integration between FM and BIM

## I. Introduction

Facilities Management (FM) is a diverse profession and was born in United States of America (USA) in the year 1970s in conjunction with business sector of outsourced services. Its main objectives are to provide quality environment and to answer to companies' demand in order to have a qualified and specialized single-handed point of reference, being able to optimize all the activities concerning the management of internal services which support the business organization [2].

In Malaysia, FM began and started its development in the second half of 1990s [30]. In 1996, the government has privatized the non-clinical support services in the government hospitals to three FM companies, which can be regarded as the biggest FM contract by the government during that time and thus, marked the starting of the new era of FM in Malaysia. It was during the opening of the Kuala Lumpur 21 Convention and Exposition in February 2001,

the Deputy Prime Minister of Malaysia emphasized the referenced of FM to the state [24]:

*“Unless Malaysians change their Mentality to become more aware of the need to provide good services and improve the upkeep of buildings, we will forever be a Third World country with First World Infrastructure.”*

Since then, Malaysia has put great determination, focus and emphasis on the development of FM, particularly in public sector. Holistic approach towards integrating effort and collective responsibility is now the main agenda for greater performance of FM in Malaysia [24]. Therefore, the adoption of BIM will support the FM system with more successful and excellent [17]. FM can be described in many aspects, from asset management and finance up to the operations, maintenance and also towards the fast track of management and planning measures [36]. With the use of BIM, FM methods can easily be generated in a centralized network database. In this network database, information that is not required can be removed and the data of 3D geometric buildings will be linked through the function and usefulness of FM in supporting the operation of a building and facility [36].

## II. Definition and Concept of FM

Facilities Management (FM) is an interdisciplinary field devoted to the coordination of space, infrastructure, people and organizations [27]. As of today, there is no specific definition used by professionals in Malaysia in the implementation of FM in their profession. Each individual or group of related professions attempted to translate the terms according to their understanding and professionalism about FM respectively.

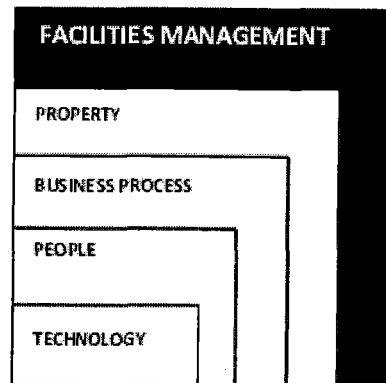
The table below is the definitions or interpretations of FM that has been discussed: -

**Table 1: Summarized Definitions on FM [44]**

Becker (1990) [9]	FM is the discipline responsible for coordinating all efforts related to planning, designing and managing buildings and their systems, equipment and furniture to enhance the organization's ability to compete successfully in a rapidly changing world.
Cotts and Lee (1992)[16]	Practice of coordinating the physical work with individual and organizational work: in which it combines the principles of business administration, architecture and the behavioural and engineering sciences.
Then (1999) [40]	FM is a hybrid management discipline that combines people, property and process management expertise to provide vital services in support of the organization.
Tay & Ooi (2001) [39]	FM is the integrated management of the workplace to enhance the performance of the organization.
Barett & Baldry (2003) [7]	FM is an integrated approach to maintain, improve and adapt the buildings of an organization in order to create an environment that strongly supports the primary objectives of that organization. Barrett (1995) provides a more robust FM definition but restricts the FM paradigm to buildings, while neglecting the diverse nature of the FM nature.
BIFM (2003) [12]	An integration of processes within an organization to maintain and develop the agreed services which support and increase in effectiveness is the main thing. FM encompasses multi-disciplinary activities in developing and managing the environment that affect human and workplace.
Chotipanich (2004) [15]	The support function coordinating physical resources and workplace, and support services to user and process of works to support the core business of the organization.
US Legal Definitions (2005) [41]	FM is the integration of business administration, architecture, and the behavioural and engineering sciences. In the most basic terms, facility management encompasses all activities related to keeping a complex operating. Facilities include grocery stores, auto shops, sports complexes, jails, office buildings, hospitals, hotels, retail establishments, and all other revenue-generating or government institutions.
International Facility Management Association (2005) [22]	Profession that encompasses integration of multiple disciplines activities to ensure the functionality of the integrated environment management of human capital, work, process and technology.
Bernard Williams Associates (2006) [11]	FM covers not just land and buildings (which are considered as premises), but other support services established as well as infrastructures such as telecommunications, equipment, furniture, security, childcare, catering, stationery, transport and satellite work environments. Premise and support service that are available in an organization with the facilitating information and communication technology are claimed to be the two important elements of the definition.
Pitt & Tucker (2008) [32]	The integration and alignment of the non-core services, including those relating to premises, required to operate and maintain a business to fully support the core objectives of the organization.

Royal Institution of Chartered Surveyors (2009) [33]	A discipline that improves and supports the productivity of an organization by delivering all needed appropriate services, infrastructures, etc. that are needed to achieve business objectives.
Kamaruzzaman & Ahmad Zawawi (2010) [24]	FM is a balance between technical, managerial and business acumen that may be related to operational, tactical and strategic decision-making processes.
Global Facilities Management Association (2012) [20]	The basic concept of FM is to provide integrated management on a strategic and tactical level to coordinate the provision of the agreed support services (facility services).
Sulaiman (2013) [37]	FM is an integrated of a wide spectrum of organizational core business and support service devoted to the coordination of people, property, business process and technology in achieving sustainable facilities management best practice excellence.

If to be understood in depth, the definition of FM emphasises the same trend and repeated to form an identity and concept of FM. The first aspect is the work space, the second role of providing services to support and enable the organization to grow and achieve their core goals while the third is the coordination of human capital, premises, processes and technology in the workplace. See **Figure 1** below:



**Figure 1: Illustration of Facilities Management's Position in Organization by CEFM**

From **Figure 1**, it shows the concept of FM in organization. As stated by Tay & Ooi [39], FM can be summarised as an integrated management or integration of work to improve the performance of the organization and by taking all of the above definition, hence it can be concluded that FM involves multi-disciplinary activities that have integration between people, property, business process and technology as proposed by the Centre of Estates and Facilities Management (CEFM) [37].

### III. Issues Regarding FM

As for today, FM has been developed a modular suite web-based application that enables organizations to access and analyze information about the facility, property and maintenance in real life [25]. It has three main modules:

#### (1) Space Management

Enables detailed inventory of space, occupancy data and facilities benchmarks to improve occupancy rates and space utilisation;

#### (2) Strategic Planning

Allows real estate and facilities plan to be aligned with business operations by analysing the headcount requirements and forecasting future space needs.

#### (3) Asset Management

Enables detection of furniture, equipment, computers, life safety systems, artwork and any other physical assets.

Despite that, professional classes of FM are not able to manage a building sustainably, efficiently and effectively for long-term time frame [43]. In a report made by the Royal Institution of Chartered Surveyors (RICS), *'Raising the Bar: Enhancing the Role of Strategic Facilities Management'* which is a global survey involving 400 facilities management professionals from 40 countries highlighted that on average, Facility heads can only be committed and dedicated less than a day in a week for long-term planning and strategy [34]. Although more than three-fourths of facilities managers say that FM should be strategic, this is what actually happened these days. In a report published in November 2012, the RICS said the absence of strategic thinking has led to the management of buildings and facilities that are not sustainable, efficient and effective [34].

Deke Smith, chairman of the Facilities Information Council for the National Institute of Building Sciences (NIBS) stated that members of the staff at a FM firm may not have such a long tenure of service as facility executives have contracts that are for less than 12 months, compared to the life of a building that could be 25, 50 or 100 years. Thus, the staff members tend to have a significantly shorter horizon than the complete life cycle of a facility. This reduces their incentive to plan for the long term and put together a system that will have a long flow of information [43].

Besides that, FM also faces challenges such as lack of recognition, education, and training needs; professional status, information standards, career pathways, performance benchmarking, cost value versus value in service procurement and corporate and community contribution of FM [6]. In short, facility managers always faced with the challenge to improve and standardize the quality of information they have, where both are required to meet the daily operational needs and required to provide a strong and correct data to top management for organizational management and planning [36].

However, Building Information Modeling (BIM) approach and technology can serve and be gainfully used for FM, as it is able to provide and store so much information of a building with the right information and the right [42]. In addition, the storage of this information can be reused for the operation and maintenance of the building and not have to build it again. Integration of FM with BIM Integration Component enables the connection of BIM data from the design, construction and renovation of facilities and operations management [25].

### IV. Definitions and Concepts of BIM

Building Information Modeling (BIM) is a set of interactions between policies, processes and technology to produce a "method for managing importance of building design and project data in digital format or virtual environment through the building life cycle" [29]. Hardin [21] stipulates that BIM is not just a clever use of 3D models, but also making significant changes in work flow and project delivery process. On the other hand, NBIMS [28] states that BIM as a tool for digital representation comprising physical characteristics and function of a facility. BIM also is a source of knowledge about the shared facilities as further information in order to form a solid foundation in determining the outcome of the building during its life cycle; defined as existing from the initial concept to demolition.

In other words, BIM is a process of design drawings and construction of a building by using technology approach, and it involves a procedure in the Architecture, Engineering, Construction and Operations (AECO) and a basic premise of BIM is collaboration of many different stakeholders at different phases of the life cycle of a facility to insert, remove, update or modify information in the BIM to support and reflect the roles of the various stakeholders. BIM approach allows an object or model is defined in terms of elements and building systems such as space, beams, and columns. These models are equipped with all the data associated with a building, including physical characteristics, functions and information life-cycle project, which is called 'smart objects' [17].

According to Global Eastman *et al.* [19], these types of digital models are not categorized as BIM: -

- (1) The model contains 3D data only and not the properties of the object.
- (2) A model with no support of behaviour.
- (3) The model consists and composed of a variety of 2D CAD reference files that need to be combined to determine the building.
- (4) The model allows changes to the dimensions in one view only and cannot be seen automatically in the other views.

BIM involves a design or model are presented as objects - vague and unidentified, generic or specific product, solid or space oriented (like the shape of a room) consisting of geometric characteristic, and the nature of relationship building. The geometry is in 2D or 3D digital form [18]. Building objects are abstract with conceptual and detailed visual building where the entire design collection objects will determine the production model of a building. All objects are formed together to define a visual model building. If a 3D object is changed or removed, it can be done easily and can be implemented with a single computer instruction. BIM design tools in turn will allow the building model to be displayed from a variety of different visual view of production drawings and other uses. The different visual view of existence consistently and automatically - in the sense that building objects is consistent in all sizes, location, and specification - since each sample and the overall state of the object displayed, as in the real world [18].

From the point of processing, BIM can be defined and viewed as a virtual process that encompasses all aspects, areas and systems of a facility in a virtual model that allows all parties involved as owners, architects, contractors, engineers, sub-contractors and suppliers to collaborate in a more systematic and efficient when compared to traditional systems [4]. Carmona & Irwin [14] stated that in line with the production of a model, all parties will continue to improve, coordinate and adjust their roles according to project specifications and design changes to ensure that the model is complete, correct and accurate as possible before the construction started. Thus, the basis of the application and success of BIM is situated on two things, the 'communication' and relations 'cooperation' which requires the involvement of all parties from the beginning of the process of a project implemented [5].

BIM has 5 stages of development, which are the LOD (Level of Development) 100, 200,300, 400 and 500. This development levels help determine the consistency of expectations through the building's lifecycle from planning through design and construction, and in particular the building's lifecycle. LOD 100-300 has a background of traditional project delivery methods 2D and LOD 400 and 500 are specific to the BIM process [10]:

- (1) **LOD 100** includes the concept of a building, which usually involves the overall design of the building to carry out the entire analysis of various buildings, including building orientation and space, square foot cost of construction and so on.
- (2) **LOD 200** describes the building design model, where the model will have a centralised system, including estimated quantity, size, shape, location and orientation. LOD 200 is typically used for system analysis purposes and objectives set.

(3) **LOD 300** is about building models. In this LOD, the elements of the model are equivalent to traditional construction documents and shop drawings. LOD 300 models are well suited for estimating construction as well as coordination for clash detection, scheduling, and visualization. Should LOD models include the attributes and parameters defined by the owner in the BIM deliverable standards.

(4) **LOD 400** is also about the production or fabrication of model building. LOD is normally used by special trade contractors to build and create the components of the project include the MEP system.

(5) **LOD 500** is the latest development in BIM and it is about building models that are ready and equipped with facilities management system. Model building will be configured to be a data storage centre to integrate into the operation and maintenance of building systems.

LOD specification allows for both an interim/middle and end model can be seen clearly and completely, in which case it is an effort that has so far been successful [10]. For BIM efforts, this allows the existence of a generation of higher value delivery, avoidance of excessive cultivation model, planning and tracking is far better, the scope and price of the exact model of enterprise and fair, more reliable models, and the ability and capacity to utilization more models for many purposes. This is all leading to increased efficiency and significant cost savings [10].

In contrast, it can be concluded that BIM is not just a technology, but it also encompasses the process by using product of the right kind of software [3]. BIM application connects all parties to be involved, such as architects, contractors, surveyors, designers and owners to work together on a common information system [18]. This allows all parties involved to share information with each other and increase the confidence and consistency of all parties. A BIM model contains a representation of the actual parts used in the construction process to build a building, in which case it contains the geometry, spatial relationships, geographical information, the number and nature of the building components, cost estimating, project schedule and material inventory [8]. The life cycle of a building can also be simulated by using BIM from the beginning of construction of the system up to operating facilities [36].

## v. FM+BIM: The Integration

In an era of increasingly sophisticated and modern technology, BIM is set to offer a new level of functionality for FM of a building as well as physical assets in it. However, in adopting the use of BIM technology implementation, there are several things that need to be seriously considered by the facility manager prior to the implementation of integrated BIM in FM [1]. Among them are:

### **(1) Personnel Management**

The facility manager needs to ensure that only the most suitable people are involved in the BIM transition process. A suitable gap analysis needs to be conducted to establish existing capabilities, and requirements for additional personnel for hiring. The development of a comprehensive and robust training plan for staff at each level is crucial as well.

### **(2) Communication Protocols**

Efficient and result-oriented communication needs to take place between all involved parties, for BIM to be an FM success. A clear communication plan, both internally for the staff, and externally for the supply chain, needs to be put in place.

### **(3) Procurement**

A clear schedule of deliverables needs to be established with the supply chain. Engage it to determine the readiness of these deliverables with contractors, and yours to accept them. Processes must be defined to handle any changes or deviations from existing workflow processes, or new forms of procurement.

### **(4) Cost Control**

Delivery costs must be identified right at the outset. Internal costs may include expenses on training, communications, ICT, process & protocols, legal issues, etc. BIM model setups and supply chain development may constitute the major external costs for the facility manager. An effective monitoring system for expenses incurred, must also be accounted for.

### **(5) Risk Management**

Identifying and curtailing risks must be an important consideration for BIM adoption among FM decision makers. Risks could arise from the lack of standardization, in procurement and workflow handling, and in the legal or contractual aspects of the transition process. Other functional risks could involve concerns like ICT interoperability, the lack of empirical data, and incompetence of the supply chain.

### **(6) An Over-arching BIM Strategy**

The most important part of devising a BIM adoption roadmap is to have a firm commitment from the management to develop a steady BIM strategy. This can be achieved by defining overall business objectives and desired outcomes. BIM implementation must be treated as a "change" program that initiates at the corporate level, and is deliverable at the project level.

The use of BIM started at the beginning of construction of a facility [36]. It was then used in all stages of design and construction smoothly. This makes the task of making strategic decisions smoother and more scientific, which is used in both the concept and the implementation [23]. In addition, the BIM has the real potential to take the next step and continue to play an important role in the final stage which involves the maintenance and upkeep of a facility through the life cycle, until finally it destroyed or demolished. The expansion of FM engagement involves significant implications for the industry FM [13].

BIM software includes more than 3D building models available on a computer [26]. Other than information of architecture, the complete BIM contains all the information of the building, from wall systems, structural systems, HVAC equipment, plumbing fixtures, doors and windows scheduling, and finishes, up until to the manufacturers, suppliers, and the square footage of each material specified in project [35].

Approach to the adoption of BIM in Facilities Management industry involves the use of several tools and process technology. Unlike painting and labeling software before, which is basically a computer system to help design, BIM allows the creation of a 3D representation in the form of facilities, and provide a mechanism for the database storage properties and parameters of all elements present in the facility. This allows facility managers have an advantage in implementing the use of BIM on new buildings, not the least in the old building [42]: -

### **(1) Pre-BIM Facilities**

BIM is able to prove it is an effective and affordable need of the group or facility staff to manage the old building that did not have any record of a digital model, as it is for the people who make modern construction using BIM technology and software from the designs. For such facilities and buildings, BIM models can be built using a construction record of the existing building. In fact, when the record 'built' or 'as-built' does not exist, one can easily get the information dimension using 3D laser scanning device, which can then be used to sculpt the building models. Facility managers, especially those who operate and manage the premises, have a different location for safekeeping, or more usually changing place and design premises regularly, often find it easier to get and obtain information 'as-built' and develop BIM where and when it is needed. For those who do not have a 3D scan or ability to develop BIM, they can always maintain specialised services in the design and review of the firm for this purpose.

### **(2) New Construction**

FM group for new buildings can look and find the owner of the building to get BIM models, which are usually handed over to them at the end of the construction phase. Should not the owner, one can always check the checkers checking the design firms or construction to see if they keep their models have been used to stage their work. In some other cases, designers and contractors can build and use the model separately according to the utility and convenience of their own performance. An important decision for management, as part of the deployment and use of BIM, it is possible to select the best model in terms of facility management efficiency. Group 'In-house' FM is encouraged to take professional help to determine the most appropriate model from point and facility management standpoint. Furthermore, for the facilities of extensive experience moving or remodeling, management should consider developing BIM uses painting 'as-built' 2D conjunction with 3D laser scanning.

## VI. FM and BIM: The Benefit

Benefits and the interests of using BIM for FM generally include [1] [31]:

### (1) Faster, Effectively and Efficiently of FM

This is done by providing information that can be shared easily and efficiently by the contractors working in the AECO.

### (2) The Performance of A Simpler Simulation

For projects to upgrade and refurbish, BIM helps to analyse carefully design and as a result, implement simulation more easily and orderly.

### (3) Streamlined maintenance

The key challenge in developing a maintenance program is entering the product and asset information required for preventive maintenance. The Information about building equipment stored in BIM models can eliminate months of effort to accurately populate maintenance systems.

### (4) Efficient Use of Energy

Facility managers can analyze and compare the various alternative energy using BIM technology, to reduce environmental impact and operating costs.

### (5) More economical and Easier Modifications

BIM models presents one way or the easy steps to represent the three-dimensional characteristics of a building. Information about existing conditions to reduce the cost and complexity of building renovation.

### (6) Building Equipment Management

Maintain an appropriate inventory of building equipment with reference to building equipment information from BIM models, in order to avoid a time-consuming task and expensive in developing a coordinated program of maintenance.

### (7) Better space management

Facility managers can build inventory space and use existing building property in an efficient manner with reference to BIM models. This will reduce unnecessary costs.

### (8) Building Lifecycle Management

For a model created by the designer and updated over time by the construction phase, it will have the capacity to be a model 'Built' or 'As Built', which can also be delivered to the owner. The model will be able to contain all the specifications, operating manuals and maintenance (O & M) and information assurance, which is useful for future maintenance. This enables the elimination of problems that can be experienced now if the O & M manual has been mislaid or stored in a remote location.

## VII. FM and BIM: Mind the Gap

Although BIM system can be integrated with FM, there are still impediments that need to be highlighted, especially by the facilities managers. The barriers include [38]:

### (1) Awareness

FM profession has so far had very little input into the evolution of BIM. FM has been slow to engage with BIM.

### (2) Silo Thinking + Practice

Majority of construction teams still operate in SILO among the collaborators. This SILO attitude would damage the communication flow. Usually, this communication does not reach out to FM managers.

### (3) Ignorance

BIM must not be ignored by the FM industry and its players/stakeholders. BIM must be added to the skill set of FM professions.

### (4) Inconsistency of Data

Interoperability is important for BIM stability. No single computer application can support all of the tasks associated with building design + production. BIM requires standardised data-library of knowledge for data exchanged processes.

### (5) Aging Infrastructure

Worldwide organizations are facing their largest collection of aging buildings. It is very costly for the building owner to create a substantial amount of BIM information for instance by doing laser surveys.

### (6) Disconnection with Project Teams

FM managers should not be disconnected from the rest of the Facility Lifecycle particularly at the early stages within integrated project teams.

### (7) Model Bloat

Depending on how well this data is managed, there is the risk of something commonly referred to as "model bloat". This is where the model contains so much data it becomes large and unwieldy.

However, these barriers or impediments can be taken away if these actions taken into considerations [38]:

### (1) Raise up FM Profile

Continue to raise the profile of FM across the construction industry.

### (2) Lifetime Value of Buildings

Clarify and emphasis what is meant by the 'Lifetime Value' of buildings.

### (3) Involvement at Specification Stage

FM professionals should be involved at specification stage, where they would be in position to work together with other collaborators.

#### (4) Updated of Projects

Throughout the construction period, the project team must continuously update the FM Teams.

#### (5) Involvement of Standards

Involve FM Teams in the development of standards or system classification + datasets.

#### (6) Usefulness of BIM Technology

Ensuring that BIM technology is developed in a way that is useful for FMs.

#### (7) Government Support

Government support for having a complete LOD100-LOD500 in the national built environment sector is necessary.

### VIII. Conclusion

In conclusion, the adoption of BIM in a building will support the FM with more successful and outstanding [17]. FM can be classified in many things, from financial and asset management through to operations and maintenance facilities, and even to the measures of 'fast track' management and planning [36]. By using BIM software, the FM methods can easily be generated in a centralized network database. In network databases, the data or information that is not needed will be removed and the 3D geometric data building will be connected via FM function and usefulness in supporting the operations of a building [36]. Integration of FM with BIM enables the data connections from the design, construction and renovation for the use of operation and lifetime management of buildings, assets and facilities.

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