Optimizing Facility Management in Malaysia: A Mixed-Methods Approach to Early BIM Integration

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ABSTRACT

Building Information Modelling (BIM) can greatly improve the efficiency of building operations, the management of assets over their entire life cycle, and decision-making based on data. But in Malaysia, the use and implementation of BIM for FM is still limited, especially in the early stages of building projects. The goal of this study is to create a strategic framework that will help facility management organizations in Malaysia start using BIM-FM together. The study uses a mixed-methods research design that includes a systematic literature review, semi-structured interviews with FM professionals, and a quantitative survey to look at the current state of BIM adoption in the Malaysian FM sector, including current practices, problems, and readiness levels. Key findings show that even though more people are learning about BIM, it is still hard to use because of technological, organizational, and knowledge-based barriers. The study finds that early collaboration with stakeholders, building digital skills, and leadership commitment are all important for successful integration. The resulting conceptual framework gives Malaysian FM organizations a strategic way to start using BIM at the planning and design stages of projects management. This study adds to the growing conversation about how to combine BIM and FM by putting global knowledge into a local context and making practical suggestions for changes in policy, education, and business.

Keywords: Building Information Modelling (BIM), Facilities Management (FM), Early Integration, Project Management, BIM Adoption Strategy

INTRODUCTION

The application of Building Information Modelling (BIM) has "transformed the architecture, engineering, and construction (AEC) industry" through the use of digital models depicting the geometry and functions of a building over its intended lifespan (Azhar et al., 2012; Succar et al., 2012). Using information models for planning and coordinating construction activities propelled BIM technology to the operations and maintenance phase, enabling enhanced Facility Management (FM) practices (Volk et al., 2014; Becerik-Gerber et al., 2012). BIM integration with FM, or BIM-FM integration, is aimed at connecting the construction and occupation stages with a data-driven framework to enhance maintenance, asset management, and spatial optimization (Ghosh et al., 2015; Lu et al., 2020).

Although global breakthroughs have been achieved, BIM and FM integration remains underutilized in most developing nations, including Malaysia (CIDB Malaysia, 2020; Azmi et al., 2024). The Malaysian construction sector, with the thrust of programs like the Construction Industry Transformation Programme (CITP) and the Construction Industry Development Board, Malaysia (CIDB)'s BIM Roadmap 2021–2025, has achieved success in stimulating BIM adoption during the design and construction stages (CIDB Malaysia, 2020). Its adoption in the FM sector is still one step behind. A critical lack exists in early participation of FM stakeholders in BIM planning and model development, leading to operationally suboptimized models and inefficient data exchange upon project completion (Ghosh et al., 2015).

It is essential to integrate FM needs early in the BIM process so that the produced asset models will fulfil facility managers' long-term operational requirements (Eastman et al., 2011; Lu et al., 2020). Bringing in FM experts early on helps develop Asset Information Requirements (AIR), makes sure that data transfers smoothly between stages, and helps people make better decisions based on the lifecycle of an asset (Ashworth et al., 2019; BS ISO 19650-3, 2020). But early integration is often slowed down by organizational, technical, and human issues, such as not knowing enough about BIM, not being able to use computers well enough, not having clear rules for exchanging data, and poor communication between project delivery teams, project management and facilities management staff (Tsay et al., 2022; Ghosh et al., 2015).

Due to the rising demand for more intelligent and sustainable building operations, there should be an orderly approach to facilitate early BIM-FM integration within FM organizations (Lu et al., 2020). Recent studies show that combining BIM and FM can be helpful, but most of them only look at the post-construction phase. They do not talk about how important it is to involve FM stakeholders from the beginning of the project (Zhang et al., 2022; Motawa and Almarshad, 2013). The Malaysian FM business is also lacking in real-world data and strategy models, as digital maturity and FM practices are very different from those in developed countries (Ibrahim et al., 2019; CIDB Malaysia, 2020).

This research seeks to build a preliminary BIM-FM integration strategy specifically designed for facilities management organizations in Malaysia. This study employs a blend of research methodologies grounded in Rogers' Diffusion of Innovation (DoI) theory to examine the present level of awareness, identify facilitators and barriers to integration, investigate the influence factors and develop a strategy that promotes early engagement of FM stakeholders in BIM adoption. However, this study highlights the first three stages of Rogers' (2003) Diffusion of Innovation theory Knowledge, Persuasion, and Decision. These stages represent the early phases in which FM organizations become aware of, form attitudes toward, and decide whether to adopt BIM-FM integration. The analysis reveals critical gaps and influencing factors that shape innovation behavior in Malaysian FMOs, forming the foundation of the proposed conceptual framework for early BIM-FM integration.

LITERATURE REVIEW

Overview of BIM-FM Integration

Building Information Modeling (BIM) has significantly transformed the architecture, engineering, and construction (AEC) industries, and it is now also valuable in Facility Management (FM). The integration of BIM and FM involves utilizing BIM data throughout the building's lifecycle to support maintenance and operational activities. By incorporating FM requirements into the BIM process during the early design phases, operations can run more smoothly, decision-making can be enhanced, and asset performance can be improved (Jang & Collinge, 2020). Early integration of BIM and FM ensures that crucial data is preserved, organized, and easily accessible for FM teams, given that facility lifecycles can extend for decades (Patacas et al., 2020).

Benefits of Early BIM-FM Integration

BIM technology offers numerous advantages across different domains for facilities management. The involvement of facilities management in building information modeling at an earlier stage will influence project outcomes, especially regarding building performance. The integration of BIM with FM provides several advantages, including automation, as it facilitates data transfer and updates via the 6D BIM model. The integration process will facilitate swift and effective access to information regarding all facility components, thereby delivering accurate data and enhancing maintenance practices (Erni Yusnida et al., 2024).

BIM-FM facilitates the integration of extensive graphical and non-graphical data within data management and libraries. The data must be conveyed and analyzed through a robust application for information exchange. During the operation and maintenance phase, non-graphical data should take precedence over graphical data to facilitate the integration of information into the FM system project management. Integrating data from both systems will subsequently improve data management capabilities. The BIM model facilitates the visualization of equipment locations and provides pertinent data, thereby reducing the time required to access information (Erni Yusnida et al., 2024).

The BIM model offers facility managers an efficient approach for space monitoring and analysis. Computer-aided design (CAD) files are used in the most common method of space management, which is complemented by computer-aided facility management (CAFM) and computerized maintenance management systems (CMMS). Utilizing BIM technology enables visualization of the area, understanding of underutilized spaces and necessary space requirements, and tracking of assets across multiple relocations. BIM technology is utilized to automate a preventive maintenance program by integrating with existing software and providing essential data in project management phase. BIM-FM integration enables building analysis, especially in sustainability initiatives designed to reduce environmental impacts and operating costs significantly. Bolshakov et al. (2022) show that Building Information Modeling (BIM) has great potential for implementation during the operations and maintenance (O&M) phase, as its application can lead to reduced operating expenses and better collaboration and communication among stakeholders. Marmo et al. (2019), emphasize that the integration of BIM and FM can improve the quality of the indoor environment and manage operational activities more efficiently.

Obstacles of BIM-FM Integration

There are many benefits to using BIM technology, but the literature also talks about things that make it hard to use in FM. In addition, FM has different values for the built environment. To make FM a necessary part of the process these days, the construction industry needs to change its culture. So, the biggest thing keeping BIM from being used more is that there aren't enough facility managers in the early stages of a building's life. As a result, facility managers can't say what data they need for long-term maintenance and operation when they are making decisions (M. Al-Kasabeh et. al, 2021). Even though they were involved in the project's early stages, research shows that they are not seen as valuable contributors. Facility managers' lack of BIM knowledge makes it even harder to use BIM.

Planning and conception, design, construction, commissioning and handover, operation, and maintenance are all parts of the facility life cycle. In the same way, different operation and maintenance workers who work on different types of facilities may need different types of BIM data. Because of this, information moves in a straight line and across these levels. It is very important to keep an eye on the quality, usefulness, and accuracy of this data, especially when making smart choices during the Operation & Maintenance stage. So, one of the hardest things for owners to do when a project is turned over is to check the BIM model's information quality (IQ) for facility management. Sadly, most BIM data is made during the design and construction phases, which leads to a number of quality problems, such as data that is wrong, missing, or not needed.

Patacas et al. (2021) found several problems with the BIM for FM practice, such as the lack of a framework that explains the whole BIM for FM workflow, the limited use of regularities to check the compliance of BIM for FM areas, the limited use of open standards for the data sources needed for the operational phase, and the lack of a CDE that can reaffirm and construct the designated structured (i.e. graphical and non-graphical) and unstructured (i.e. documents) data.

Numerous studies have addressed the poor compatibility of BIM and FM technologies, which leads to issues with data interchange and interoperability (Parn, 2017 and Yalcinkaya, 2014). The main things impeding the broad adoption of BIM for FM, according to Jang & Collinge (2020), are interoperability issues and vague requirements specifications. Aside from that, the mismatch between the present capture lifecycle of BIM and

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FM technologies makes it difficult to share data between developing BIM systems and existing building systems.

CAFM and other asset management systems are crucial for a common data library due to differences in BIM and FM technologies' capture lifecycles. For the data exchange, the Construction Operation Building Information Exchange (COBie) is the primary form but is rarely used due to its significant data management effort. COBie exports 3D BIM data to a spreadsheet format, however it must be manually entered into FM systems. Thus, additional details about information provision, timing, and by whom are required (Sandra et al., 2022).

Despite international recognition of BIM technology, challenges persist in implementing BIM-FM due to various aspects that still pose challenges. According to Jang & Collinge (2020), these include problems with software interoperability, supply chain BIM awareness, contractual hurdles, and organizational communication. In the early stages of a project, they find it difficult to meet the need for more cooperation and improved communication among important players. Key stakeholders must work together more and communicate more throughout the early phases of a project in order for facility management to guarantee that the building's functionality is maintained throughout its entire cycle.

Adoption Factors For BIM-FM Integration

To successfully implement Building Information Modelling (BIM) early in Facility Management (FM), organizations need to rethink and redesign their operations. In Malaysia, whether FM firms implement BIM early in their operations depends on their willingness and preparedness to embrace the change. Nevertheless, in most scenarios, FM companies in Malaysia are introduced into the process after the construction is ongoing, thus failing to participate in the most important planning and design phases.

Beyond just being ready as an organization, decisions to adopt BIM are also influenced by a mix of internal and external factors, including the company's internal dynamics, the surrounding business environment, and the nature of BIM technology itself. These elements can either support or create barriers to BIM adoption across the Architecture, Engineering, Construction, Project Manager and Facility Management (AEC/FM) sectors. While many global studies have used surveys to identify what influences BIM uptake, Kim et al. (2016) highlight that these factors often differ depending on the country.

Ma et al. (2019) discovered through interviews with Chinese BIM professionals that robust project management and advanced software capabilities were primary factors for adoption. In the United Kingdom, Gledson and Greenwood (2017) identified that the primary attraction of 4D BIM was the distinct benefits users perceived it provided. According to Ahuja et al. (2016), in India, it was very important to have experienced staff, leadership backing, and the ability to test the technology. In Australia, on the other hand, Hong et al. (2016) found that the top factors influencing the deployment of BIM in small and medium-sized construction companies were awareness and a company's willingness to innovate.

Researchers have classified adoptive factors into institutional and technological categories, people, processes, technology, and external environment (Ma et al. (2019), Liao and Teo (2019). Meanwhile, Hong et al. (2016) focused on three main areas: motivation to adapt, organizational capability, and ease of implementing technology.

Diffusion of Innovation (DOI)

The innovation diffusion process covers decisions, activities, and impacts from needs or problems (Rogers, 1983). In this process, the decision-making units strive to learn about innovation and form an attitude towards it. Observing the initial conditions that affect the innovation-decision process, Rogers (1983) gives four kinds of needs to the understanding of prior conditions, which includes the set of existing practices, the perceived needs and problems, the innovativeness, that is the degree to which an individual unit or another adoption unit is relatively incipient in adopting new ideas from other members of a system, and the social system's standards. According to Rogers (1983), the felt needs and problems are parts of the characterization of the prior conditions that may lead to the adoption of an innovation.

In the meantime, innovativeness refers to inter-individual or organization differences reacting to these new things and accounts for much of their success or failure (Goldsmith and Foxall, 2003). Innovators may welcome them; the majority may gradually adopt them; laggards either slowly or never adopt them. Organizational innovativeness is considered "an organization's overall innovative capability to introduce new products to the market, or open up new markets, by combining strategic orientation with innovative behaviour and process" (Goldsmith and Foxall, 2003).

The process goes through five stages (Rogers, 1983). The stage of knowledge happens when the decision-making unit is exposed to an existing innovation and understands how it works. It includes the characteristics of the decision-making units about the socio-economic aspects, personality variables and communication behaviour (Achaporn Kwangsawad & Aungkana Jattamart, 2022).

Knowledge here means the members' exposure to the innovation's existence through knowledge awareness. Knowledge is established when "a person becomes aware of an innovation and has some idea of how it functions" (Rogers, 1983). According to this, the adopter's character is the main indicator to measure the level of knowledge of innovation. Persuasion happens when the decision-making unit forms a favourable or unfavourable attitude towards innovation (Roger, 1983). Perceived characteristics have a great influence at this stage.

The decision happens when the decision-making unit creates efforts in activities that lead to the choice between adopting and accepting innovation. The third stage is attained when members decide whether "[to] engage in activities that lead to a choice to adopt or reject the innovation" (Rogers, 1983). Concerning attitudes and the influence that knowledge and degree of persuasion have, this research paper considers contextual knowledge and attitudes that respondents hold. Attitudes in terms of willingness to be involved in BIM and expertise and degree of persuasion specific to innovation are assessed, in this case, integrating into the BIM process at the early phase (Alireza et al., 2018).

Diffusion of BIM-FM Integration

Diffusion of Innovations Theory (DOI) by Everett M. Rogers is possibly the most frequently referred to theory in innovation scholarship. The theory presents a clear and systematic conceptualization that describes and elaborates on the innovation diffusion process as well as its crucial components. As described in Rogers' book titled Diffusion of Innovations (initially published in 1962), an innovation can be understood as an object, practice, or idea perceived as novel by an individual or an adoption unit. As indicated by Rogers (Roger,1983), among the reasons why the DOI gained so much attention is that "getting a new idea adopted, even when it has an obvious advantage, is often very difficult." As conceived by Rogers, diffusion is "the process by which an innovation is communicated through certain channels over time among the members of a social system" (Roger,1983).

The theory proposes five (5) steps in an innovation-decision process: knowledge, persuasion, decision, implementation, and confirmation. Knowledge refers to the awareness of a prevalent innovation and some understanding of what the innovation does and how it works. Persuasion denotes an individual’s attitude (either favourable or unfavourable) towards innovation. Decision refers to the choice made by the individual (either consciously or unconsciously) to adopt or reject the innovation. Implementation is when the individual begins to use the innovation at a stage where the reinvention of the innovation is likely to occur. Confirmation refers to the final stage in which the individual evaluates their previous innovation-decision (the decision to either adopt or reject). This decision may be reversed if the individual encounters a clue that conflicts with their innovation-decision.

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METHODOLOGY

The purpose of this study is to analyze in detail the current state of awareness, integration benefits and barriers, and early BIM-FM integration enablers in Malaysian facilities management companies. The study uses a mixed-methods methodology, which combines qualitative and quantitative techniques. The combination of both approaches leads to a deeper understanding of the perspectives held by stakeholders and allows for triangulation of findings, which in turn assists in the process of developing a strategic framework through its contributions. Creswell and Plano Clark (2018) say that this method is particularly good for addressing complicated and not well-studied topics like BIM-FM integration, which needs to be understood in context and be able to be applied to other situations.

It obtained quantitative data from 109 valid survey responses and qualitative responses from nine semi-structured interviews with FM professionals at the strategic, managerial, and operational levels. The Innovation-Decision Process (IDP) model helped organised the analysis.

The study employed Rogers's Diffusion of Innovation (DoI) theory as a conceptual framework to examine the factors affecting the adoption of BIM-F in the initial phases of facilities management businesses. According to the findings of interview techniques and survey instruments, five innovative features drove the development of this BIM-FM conceptual framework, namely relative advantage, compatibility, complexity, trialability, and observability. Interview techniques and survey instruments, the construction of this BIM-FM conceptual framework was affected by five innovative characteristics. These attributes include relative advantage, compatibility, complexity, trialability, and observability.

RESULTS AND DISCUSSION

This section presents the integrated findings from the qualitative interviews and quantitative surveys. The results are organized thematically based on the Diffusion of Innovation (DoI) attributes and other emergent themes relevant to early BIM-FM integration.

Current Awareness of BIM-FM Integration in Malaysia

Both the qualitative and quantitative results of this study consistently demonstrate that the facilities management (FM) industry in Malaysia is currently in the early phases of developing the use of BIM solutions. The usage of BIM is still restricted to the stages of design and construction. Although FM practitioners' understanding of BIM has steadily increased, there is still very little actual BIM application in FM practice. The results of the interviews also showed that FM teams are rarely involved in the design phase or in the creation of BIM models, which leads to digital asset data and models that are not useful or relevant for operations and maintenance.

The awareness level of BIM-FM integration among Malaysian FM organizations was assessed across three key attributes: technical understanding, knowledge of BIM information requirements, and the actual uses of BIM. At the same time, the findings suggest a growing recognition of the value of BIM-FM integration and a generally positive perception among FM practitioners, but substantial gaps persist, particularly in terms of in-depth technical literacy.

The problems include a limited understanding of basic BIM standards and documentation, such as ISO 19650, AIR, and AIM, as well as confusion about how to use BIM in the early stages of FM processes. FM teams are unable to be proactive in the early stages of BIM projects because they have no structured implementation plans and don't know enough about the technology.

Respondents pointed out a number of systemic problems that led to these issues: there are no rules or policies requiring FM to be involved in project planning and design, communication between design teams and FM stakeholders is poor, and there aren't many trainings and capacity-building programs that focus on BIM. These results show that targeted actions are needed to make BIM-FM integration work better throughout the building's life. These actions could include comprehensive training programs, well-defined strategic frameworks, and policy measures that support the integration.

Potential Benefits of BIM-FM Integration in Malaysia

Survey findings indicate that 81% of respondents believe their organizations would benefit from early integration of Building Information Modelling (BIM) into Facility Management (FM) processes. Four key dimensions of benefit were identified. Firstly, performance improvement was highlighted, with respondents noting enhanced building performance, greater operational efficiency, improved data accuracy, and reduced duplication, all of which support strategic, real-time decision-making. Secondly, BIM-FM integration was perceived to enhance communication and collaboration by enabling better coordination among stakeholders and improving access to digital asset data from design through to operations. Thirdly, participants recognized the business value of BIM-FM in driving innovation, supporting new service delivery models, and strengthening organizational competitiveness. Lastly, integration was associated with cost and time efficiency, as it streamlines maintenance processes, reduces operational costs, and facilitates timely data retrieval, thereby supporting effective preventive maintenance planning and improved lifecycle management.

Obstacles of BIM-FM Integration

Notwithstanding the recognised benefits, the study revealed several critical barriers hindering BIM-FM integration. These challenges were categorised into three dimensions:

Organisational Challenges

The most prominent issue was the low level of BIM adoption and awareness in FM organisations. Participants cited limited client demand, lack of trained personnel, and cost constraints as impediments. These findings mirror the concerns raised by Ghosh et al. (2021), who reported a disconnect between BIM's strategic intent and organisational readiness in the FM domain.

Process Challenges

Inadequate guidelines, unclear workflows, and poor integration between design and O&M phases were among the top concerns. As highlighted by Kivits and Furneaux (2013), the absence of standard BIM FM workflows contributes to fragmented implementation efforts and limits the reusability of construction data in FM systems.

Technological Challenges

Lack of interoperability, incompatible file formats, and the use of diverse FM and BIM software platforms remain substantial barriers. This echoes the long-standing concern of a lack of open standards or BIM-FM data exchange (Eastman et al., 2011).

Collectively, these findings suggest that the success of BIM-FM integration is contingent not only on technological capability but also on institutional culture, capacity-building, and systemic process reform.

Adoption Factors

The study revealed that the application of Building Information Modelling (BIM) in Facility Management (FM) practices across Malaysian FM organisations is still in its infancy. Most participants lacked direct experience with BIM-FM, although a few were relatively more advanced. Current FM practices largely remain manual, even though systems like CMMS, CAFM, and BMS are in place. FM tasks such as asset tagging and work order preparation are still executed using Excel spreadsheets. Data for operations and maintenance (O&M) is often only received after the Defect Liability Period, typically in fragmented and non-integrated formats, such as paper-based as-built drawings and specifications, leading to inefficiencies, data loss, and rework.

A significant barrier to BIM-FM integration is the lack of early involvement of FM teams during the design and planning stages. This results in a disconnect between the asset information delivered and FM operational needs. Participants agreed that integrating FM teams earlier could enhance the design process and ensure more useful and structured asset information.

While BIM offers potential benefits such as digital data storage, centralised systems, remote accessibility, and improved efficiency, its adoption is hindered by several factors. These include high implementation and system upgrade costs, insufficient BIM knowledge among FM personnel, lack of government mandates, limited client demand, and organisational resistance to change.

The analysis also identified multiple organisational, technical, and external factors that influence early BIM-FM integration. These include:

1. Top Management Support: Leadership must actively support and promote BIM initiatives.
2. Business Strategy and Culture: BIM adoption must align with the company's strategic goals and operational context.
3. Awareness and Training: Limited exposure and lack of formal training hinder BIM-FM knowledge development.
4. Technical Capabilities: BIM systems must be integrated, scalable, and accessible across platforms, but are often hindered by software limitations and connectivity issues.
5. Client Demand: Clients play a critical role in driving BIM adoption; without their request or mandate, FMOs are unlikely to adopt BIM.
6. Financial Barriers: High costs for implementation, licensing, and training present major challenges.
7. Procurement and Tendering: Early FM involvement can improve cost estimation and procurement outcomes through better asset data availability.
8. External and Regulatory Support: A lack of enforcement from regulatory bodies has further delayed BIM-FM adoption in the FM sector.

Participants agreed that change must begin with mindset shifts at the management level, alongside improved training, leadership, and the development of a clear implementation framework. They emphasised the importance of trialability, centralized data systems, and a systematic approach for successful BIM-FM integration.

Framework Development

This section presents the empirical findings derived from both quantitative survey data and qualitative interviews with FM professionals in Malaysia. The data were analyzed using the theoretical lens of Rogers' (2003) Diffusion of Innovation (DoI) theory, and focusing only three sequential stages: Knowledge, Persuasion and Decision. These stages represent the early phases in which FM organizations become aware of, form attitudes toward, and decide whether to adopt BIM-FM integration. The analysis reveals critical gaps and influencing factors that shape innovation behaviour in Malaysian FMOs, forming the foundation of the proposed conceptual framework for early BIM-FM integration. The findings are synthesized to develop a DoI-based conceptual framework that captures the dynamic process of early BIM-FM integration adoption within Malaysian Facility Management Organizations (FMOs).

Knowledge Stage: Awareness and understanding of BIM-FM

The Knowledge stage marks the point at which FM professionals first learn about the existence, function, and potential of BIM-FM integration. However, the initial stage of the adoption process reveals limited awareness and fragmented understanding of BIM-FM integration among Malaysian FM professionals. Survey results indicate that over 60% of respondents had minimal exposure to structured BIM standards such as ISO 19650, Asset Information Requirements (AIR), and Asset Information Models (AIM). Many were unfamiliar with basic BIM terminologies and workflows, particularly those related to the operational and maintenance phase.

Further analysis revealed a lack of regulatory mandates and absence of national-level policy guidance as significant external barriers. Without institutional or legal pressure, many FM practitioners did not prioritize BIM-related knowledge acquisition. This knowledge gap significantly affects their preparedness for participating in BIM during early project stages.

Interview data further supported this, revealing that FM teams are rarely involved in the early project lifecycle, where BIM models are developed. This exclusion results in asset data that are not aligned with FM needs, making the digital handover process irrelevant or difficult to use.

Key barriers in this stage include:

1. Lack of technical training and formal education on BIM for FM use cases.
2. Absence of government regulation or policy compelling FMOs to adopt BIM.
3. Minimal cross-disciplinary collaboration between design/construction and FM departments.

This stage highlights the urgent need for capacity building, institutional support, and education strategies tailored to FM professionals to move beyond superficial awareness toward technical fluency

Persuasion Stage: Attitude Towards BIM-FM Adoption

Meanwhile, the persuasion stage involves the formation of attitudes positive or negative toward BIM-FM integration. While awareness was low, the attitudinal dimension showed a more nuanced picture, majority of FMO participants expressed generally favourable attitudes toward the concept of BIM as a tool enhance facility performance and decision-making. The positive perception of BIM's indicates that integration of BIM-FM at the early stage of BIM project brings long-term benefits for improving asset lifecycle performance, reduced redundancy in documentation. and data-driven decision-making. However, this optimism was tempered by several concerns, including:

1. High perceived costs of BIM implementation and maintenance.
2. Lack of internal expertise, resulting in low confidence in adopting digital tools.
3. Interoperability issues across various FM and BIM platforms; Cultural resistance to change, particularly in public FM organizations with bureaucratic structures.

Interview responses emphasized that organizational culture and leadership mindset significantly influenced the degree of openness toward BIM adoption. Progressive leaders tended to foster experimentation and training, whereas hierarchical or risk-averse cultures impeded innovation.

Decision Stage: Organizational Commitment to Adopt

In the decision stage, organizations evaluate available information and determine whether to proceed with

BIM-FM integration. This stage is strongly influenced by strategic, financial, and contextual factors. Survey and interview data indicate that few FMOs have made a formal decision to adopt BIM-FM on an organizational scale. The decision to adopt or not is shaped by:

1. Top management support: Leadership buy-in is a prerequisite for any allocation of resources toward BIM adoption.
2. Client mandates: FMOs are more likely to consider BIM if it is a contractual requirement or client-driven demand.

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3. Organizational readiness: Many FMOs lack the internal capacity (e.g., trained personnel, IT infrastructure) to support BIM implementation.
4. Trialability concerns: There is significant reluctance to adopt BIM without prior pilot testing, as FM managers fear failure and disruption of existing operations.
5. Cost-benefit ambiguity: Most FMOs have not conducted quantifiable assessments of BIM's return on investment, making it difficult to justify adoption to stakeholders.

These findings show the FMO is hesitant to implement BIM-FM without pilot testing phase, combined with a business case analysis, which is critical to building organizational confidence at the decision point. Moreover, a majority of FMOs had not conducted cost-benefit analyses, resulting in uncertainty about the return on investment. This lack of empirical justification weakened the confidence of decision-makers and delayed formal adoption.

From these insights, a stage-wise conceptual framework emerges, illustrating how FMOs in Malaysia move through the early phases of BIM-FM adoption as shown in Table 1.

Table 1: DoI Key Insights and Barriers Identified in BIM-FM Adoption

DoI Stage	Key Insights	Barriers Identified
Knowledge	Awareness is limited; understanding of BIM-FM standards (e.g., ISO 19650) is poor	Lack of training, absence of regulations, exclusion from BIM development
Persuasion	Positive attitudes about BIM benefits exist	Concerns over cost, complexity, resistance to change
Decision	Strategic adoption remains tentative	Need for leadership support, trialability concerns, weak ROI justification

DoI attributes and the influence on BIM-FM adoption

The adoption dynamics across all five stages were influenced by the five key attributes proposed in DoI theory. Table 2 summarizes the meaning of each attribute in the BIM-FM context and empirical evidence supporting its relevance.

Table 2: DoI Attributes and Empirical Evidence in BIM-FM Adoption

Attribute	Meaning in BIM-FM Context	Empirical Insight
Relative Advantage	Perceived improvement over legacy FM systems	81% of participants agreed BIM-FM early improves performance and accuracy
Compatibility	Fit with current workflows and organizational systems	Existing FM tools are not integrated with BIM environments
Complexity	Perceived difficulty in learning or operating BIM-FM tools	Technical knowledge gaps and poor BIM-FM workflows identified
Trialability	Ability to test BIM-FM on a small scale before full adoption	Limited pilot projects and testing mechanisms increase risk perception
Observability	Visibility of successful outcomes and benefits	Lack of documented case studies or benchmarks reduces confidence

CONCLUSION

The findings are synthesized into a DoI-based conceptual framework that illustrates the pathways, barriers, and enablers of early BIM-FM integration in Malaysian FMOs. The conceptual framework based on the first three stages of Rogers' Diffusion of Innovation (DoI) theory Knowledge, Persuasion, and Decision highlights the progressive challenges and influences impacting early BIM-FM integration in Malaysia. Limited awareness and technical understanding at the Knowledge stage hinder FM professionals' ability to engage meaningfully in BIM processes. At the Persuasion stage, despite a generally positive outlook on BIM's potential, adoption is slowed by cultural resistance, skill gaps, and perceived complexity. In the Decision stage, the lack of strategic commitment, trialability options, and clear cost-benefit evidence further discourages formal adoption. These interconnected stages emphasize the need for structured awareness programs, leadership support, and early FM involvement to advance BIM-FM integration.

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