BUILDING INFORMATION MODELLING (BIM) INTEGRATION WITH FACILITIES MANAGEMENT (FM) IN MALAYSIA: THE FACILITIES AND PROPERTY MANAGERS' PERSPECTIVE

NG YU XUAN

UNIVERSITI TUNKU ABDUL RAHMAN

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NG YU XUAN

A project report submitted in partial fulfilment of the requirements for the award of Bachelor of Science (Honours) Quantity Surveying

Lee Kong Chian Faculty of Engineering and Science
Universiti Tunku Abdul Rahman

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DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

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ABSTRACT

Over the years, the Building Information Modelling (BIM) in the construction industry has greatly enhanced by time from supporting stakeholders throughout the planning, design, construction, and operational phases. On the other hand, Facilities Management (FM) encompasses the administration, operation, maintenance and of buildings and facilities after construction completion. While the implementation rate of BIM in construction industry has been increasing steadily, its integration in FM industry, particularly during the operational and maintenance phases is still considered as being in its infancy. In Malaysia, the integration of BIM within FM is gradually gaining attention, however, there are rooms for improvement. This research aims to examine the BIM integration with FM in Malaysia, specially the current practices of FM, the drivers and challenges of BIM integration with FM. A quantitative research approach was employed using structured questionnaires distributed to facility managers and property managers in Malaysia. The data were analysed using non-parametric tests such as the Friedman test, Kruskal-Wallis H test and Mann Whitney U test to identify current practices of FM, drivers and challenges of BIM integration with FM. The results revealed that majority of respondents have integrated BIM into their FM practices. The top three driver of BIM integration with FM were identified as “Large-scale and high-tech buildings require advanced FM solutions through BIM integration”, “Demand for smarter facility operations” and “Top management support”. Meanwhile, the top three challenges of BIM integration with FM were “High cost associated with implementing BIM-FM technologies (i.e. software(s) and system upgrades)”, “Lack of awareness among top management regarding the benefits of integrating BIM in FM” and “High cost associated with training BIM and FM personnel”. The research highlights the need for strategic frameworks, regulatory support, and academic research to drive BIM-FM integration forward. By addressing the drivers and challenges of BIM integration with FM, this research provides a foundation for more advancement in BIM-FM integration and supports the development of a more sophisticated FM industry in Malaysia.

Keywords: building information modelling, facilities management, integration, FM practices, BIM drivers, BIM challenges

Subject Area: TH3301-3411 – Maintenance and Repair

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LIST OF SYMBOLS / ABBREVIATIONS

H_0	Null hypothesis
H_1	Alternative hypothesis
n	Frequency
2D	Two-dimensional
3D	Three-dimensional
AI	Artificial Intelligence
AIA	American Institute of Architects
BIM	Building Information Modelling
BREEAM	Building Research Establishment Environmental Assessment Method
BSI	British Standards Institute
CAD	Computer-aided Design
CIDB	Construction Industry Development Board
CLT	Central Limit Theorem
CMMS	Computerised Maintenance Management Systems
DT	Digital Twin
FM	Facility Management
GBI	Green Building Index
HVAC	Heating, Ventilation, and Air Conditioning
IFC	Industry Foundation Classes
IoT	Internet of Things
ISO	International Organisation for Standardisation
LEED	Leadership in Energy and Environmental Design
LOD	Levels of Development
LoD	Level of Detail
LOI	Level of Information
PC	Personal Computer
SPSS	Statistical Package for the Social Sciences

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Building Information Modelling (BIM) is an innovative management process that involves creating and administering digital elements throughout the lifecycle of a built asset, from planning, designing, and construction to the operation and maintenance stages (Nguyen, Nguyen and Tran, 2024). Over the years, the BIM integration in the construction industry has greatly enhanced by supporting stakeholders throughout the planning, design, construction, and operational phases. Previous researchers showed BIM’s potential to improve project outcomes across all phases, with benefits such as improved safety management, enhanced sustainability, and life cycle costing (Santos *et al.*, 2020; Figueiredo *et al.*, 2021; Yu *et al.*, 2021).

BIM adoption has reached a notable level in several developed and developing countries. Countries such as the United Kingdom, various European countries, and Singapore have led the way in BIM implementation with the government's leadership. The early stages of BIM development in Malaysia were marked by awareness and pilot projects, with initial efforts focused on the design phase. As more stakeholders recognized the benefits of BIM, its application expanded to include construction and facility phases. The Malaysia Building Information Modelling Report 2021 (CIDB, 2022) disclosed that the implementation rate of BIM in the construction industry has been increasing steadily, from 49% to 55% since 2019, reflecting growing awareness and investment in BIM technology. However, the integration of BIM in Facilities management (FM), particularly during the operational and maintenance phases, is still considered to be in its infancy.

FM encompasses the administration, operation, and maintenance of buildings and facilities after construction completion. It involves inspection and maintenance to ensure the constructed asset continues functioning effectively and safely over its lifespan (Igwe *et al.*, 2020). Traditionally, this has been done using traditional common systems such as Computerised Maintenance Management Systems (CMMS). This method is primarily focused on managing maintenance operations and tracking maintenance records. However, recent research indicates that BIM can significantly enhance FM by providing a comprehensive digital representation of facilities data. According to Lovell, Davies and Hunt (2024), BIM integration into FM can improve asset performance, operational efficiency, and decision-making processes during the building's lifecycle.

1.2 Problem Statement

Over the decades, BIM implementation has evolved significantly in certain developed and developing countries as more stakeholders recognised the benefits of BIM. According to Othman *et al.* (2021), the yardstick used to evaluate a project's success ought to integrate BIM across all phases of construction activities, including operational and maintenance activities. Therefore, various research studies have been done in recent years portrayed the potential of BIM integration with FM are aware. For example, researchers from Nigeria have contributed to the literature by identifying the barriers to BIM and FM practices in their country (Olapade and Ekemode, 2018; Ajayi, 2022; Okwe *et al.*, 2023). Similarly, researchers from other regions have explored the BIM's impact on FM performance such as Chew *et al.* (2020) who evaluated BIM technology in Singapore's FM industry and Asare and Anumba (2023) who investigated BIM for airport FM in United States. Meanwhile, Wang, Chong and Zhang (2024) from China investigated the impact of BIM-based integration management on mega project performance.

However, despite this growing body of international research, there remains a limited comprehensive research conducted in the Malaysian FM industry context. This research gap has led to a shortage of structured guidelines, best practices, and strategic approaches for integrating BIM effectively with FM. As a result, opportunities for improved asset performance, cost saving, sustainability and long-term operational efficiency may be missed (Hossan and Yeoh, 2018). Moreover, the existing literature remains heavily focused on the application of BIM during the design and construction phases, paying insufficient attention to its potential contributions during the operational and maintenance stages. Therefore, this study aimed to address this gap by examining the integration of BIM with FM in Malaysia, looking into the practices of FM personnel, identifying the key drivers and challenges of BIM integration with FM, and providing practical recommendations to improve FM practices through digital integration.

1.3 Research Aim

The research aim is to examine the BIM integration with FM in Malaysia.

1.4 Research Objectives

To achieve the aim of this research, the following research objectives have been formulated:

(i) To explore the current practices of FM in Malaysia.
(ii) To investigate the drivers of BIM integration with FM
(iii) To discover the challenges of BIM integration with FM

1.5 Research Significance

BIM integration with FM remains a poorly understood and unexplored area within the academic field. There were only a few formal research on the drivers of BIM integration with FM have been undertaken thus far in the Malaysian FM industry context. The existing studies are primarily focusing on the BIM adoption during the design and construction stages, leaving a significant gap between its potential values and challenges in the operational and maintenance stages.

In this research, drivers along with the challenges of BIM integration with FM were investigated. The findings will help academics to develop more targeted research agendas, focusing on optimising practices of BIM integration with FM, enhancing data management, and improving the project life cycle. Besides, the findings of this research will help to encourage digital transformation in the construction industry by encouraging academics to explore more adaptive solutions that can lead to more efficient and sustainable FM practices.

1.6 Research Scope

The research scope focused on examining BIM integration with FM in Malaysia. The targeted respondents were confined to facilities managers and property managers in Malaysia. Each respondent will be asked to complete a questionnaire via Google Forms to obtain the data and information required for this research. They were able to provide accurate feedback based on their perspectives to accomplish the aim of this research. The qualifications of respondents were not restricted, as long as they are facilities managers and property managers in Malaysia.

1.7 Chapter Outline

This research divided into five chapters. Chapter 1 describes the background of the research and the problem statement about BIM integration with FM. Besides, the aim and objectives, research significance, research scope and chapter outline are stated in this chapter.

Chapter 2 covers literature review and it presents the analysis of past research on BIM integration with FM. This chapter deeper explores the current practices in FM, driver and challenges of BIM integration with FM.

Chapter 3 highlights the research method used to conduct this research. The questionnaire design which included the details of both open-ended and closed-ended questions are distributed to the targeted respondents. The sample size is determined through the central limit theorem. To validate the data collected, various statistical tests were applied, including Cronbach's Alpha Reliability test, Friedman test, Kruskal-Wallis H test and Mann Whitney U test were used.

Chapter 4 reports the discoveries and outcomes of the research based on the responses to questionnaires. Tables are used to display the result and ease the analysis of information. Secondary data which is the data gathered by other researchers are used to support this research.

Chapter 5 summarises the overall research findings and determines whether the objectives of this research were met. Lastly, it highlights the implications and limitations of the research, and offers suggestions for improvements in future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In Chapter 2 analyses and summarises the previous studies related to Building Information Modelling (BIM) integration of Facilities Management (FM). The drivers and associated challenges of BIM integration with FM discussed in the following subchapter. In subchapter 2.2 and subchapter 2.3 discuss BIM and its integration in FM. Subchapter 2.4 and subchapter 5 present the discussion of driver and challenges of BIM integration with FM, respectively. The last chapter is ended by subchapter 2.6 with proposed conceptual framework.

2.2 Building Information Modelling (BIM)

BIM has revolutionised the construction industry and the usage of BIM is increasingly widespread in those developed countries. As stated by National Building Information Model Standard Project Committee (2023), BIM is a digital conceptualisation of the physical and functional attributes of a built asset that support decision-making. It can be beneficial in different ways, from visualisation, cost management, cost estimating tools, schedule management, facility and asset information management and operation stimulation tools.

2.3 Level of Development

Levels of Development (LOD) was established by the American Institute of Architects (AIA) to allow construction stakeholder in the AEC sector to specify the BIM model's detailing levels (BIMForum, 2023). LOD in BIM refers to the level of information and accuracy that should be included in a BIM model at various phases of the project lifecycle.

Level of Development is always linked with Level of Detail (LoD) and Level of Information (LOI). Level of Detail referred to the level of 7 geometrical information that required for the components when using the model whereas Level of Information referred to non-graphical attributes (Kjartansdóttir et al., 2017). Meanwhile, LOD established the extent to which project team members could use the model to the obtain information (Latiffi et al., 2015). In short, the

Level of Detail and Level of Information are the inputs to the elements, while LOD is the output of the projects.

The usage of LOD can be dated back to when a construction analysis software company adopted a technique that was similar to LOD to integrate digital models to project cost. During the design process, the company made all the metrics and details related to digital model that are accessible to everyone. At present, there are six levels in the LOD specification, from LOD 100 to LOD 500, with each level corresponded to a distinct stage of model development.

2.4 BIM Integration with FM

FM refers to the building phase that involve maintaining the building's system, improving its performance and adapting it to new requirements. The integration of BIM with FM is particularly impactful, as it allows for the use of building data throughout the operational and maintenance phase, leading to more effective management of the facility. Several FM practices are discussed in the following subchapter.

2.4.1 Energy Modelling, Estimation and Simulation

Energy efficiency is a major consideration in modern building design and operation. According to Carbonari, Stravoravdis and Gausden (2018), BIM provides a solution for integrating building energy performance software, which allows the building's energy performing to be stimulated before construction begins. This stimulation enables the stakeholders to access the selection of building design, materials and energy systems used in the building. For example, research by Tahmasebinia, *et al.* (2022) demonstrates how the BIM energy analysis and stimulation helps building owners to optimise energy usage in terms of the façade, HVAC system and solar panels systems. By identifying the inefficiencies early especially in the design stages, BIM will contribute to huge reduction in carbon emissions.

2.4.2 Maintenance Scheduling

Maintenance scheduling is an essential aspect of FM. Traditionally, the maintenance practices often rely on fixed schedule or reactive maintenance, whereby the FM teams are required to fix the building only when it fails.

However, with the integration of BIM, the BIM models can store historical data, which facilitates maintenance scheduling (Wills and Diaz, 2017). Meanwhile, BIM enables real-time integration with the building system with the help of digital technologies such as the Internet of Thing (IoT) and sensors (Valinejadshoubi, Moselhi and Bagchi, 2022). This ensures that the FM teams can access the latest building conditions and performance, and schedule the maintenance based on actual conditions rather than estimates.

2.4.3 Lifecycle Cost Analysis

Operational and maintenance phase is the most expensive phase of the building life cycle; therefore, lifecycle analysis is also one of the most important benefits of BIM in FM (Matos *et al.*, 2024). With the help of BIM, it can integrate all the necessary data including the construction costs, building energy performance and maintenance history to support more accurate lifecycle analysis (de Brito and Silva, 2020). By obtaining a more accurate lifecycle analysis, it allows the stakeholders to make smarter decisions in allocating financial resources to the repair, upgrades and replacement of the building system.

2.4.4 Real-Time Sensor Data for Predictive Maintenance

As previously discussed, BIM allows real-time data with the help of digital technologies such as IoT and sensors. By integrating this real time data, BIM able to monitor the building performance continuously, which can predict the maintenance required before the system failure occur. This predictive maintenance can help in prevent the risk of unexpected shutdown and costly repair before the problems escalate. For example, Gombé *et al.* demonstrated that wireless sensor network to monitor industrial systems, where alerts are sent to the FM teams upon detection of abnormal parameter to prevent faults and damages.

2.4.5 Data Sharing and Accessing

The integration of BIM into FM changes the traditional practices of documentation, control, maintenance and analysis, from paper-based to digital technologies (Naghshbandi, 2016). Before BIM, the original building data was often extracted from the paper format, which make it difficult to share, access and modify across project stakeholders. However, today, project files including all FM-related BIM are through digital format, open shared format or even cloud-based platform.

2.5 Drivers of BIM Integration with FM

With respect with BIM integration with FM, a body of research from different authors has provided a wide range of drivers. The driver of BIM integration with FM are categorised into six categories, which included regulatory and industry standards, technological advancements, asset information management, sustainability, skilled workforce and top management support are further discussed below, as summarised in Table 2.1.

Table 2.1: Drivers of BIM Integration with FM

Statements	Previous Studies
Regulatory and Industry Standards	
ISO 19650 provides essential guidelines to ensure consistency and clarity in BIM practices when integrating with FM ISO 19650 establishes policy requirements that guide organisations in best practices and compliance for BIM tool(s)/system(s) when integrating with FM Government and government-linked agencies are mandating BIM adoption in construction and FM Construction professional bodies and industry bodies are mandating BIM adoption in construction and FM Compliance with sustainability standards (e.g., LEED, BREEAM and the like) encourages BIM based energy management	Cavka, Staub-French and Poirier (2017); Munir *et al.* (2019); Matarneh *et al.* (2020); Carvalho *et al.* (2021); Ajayi, Oyebiyi and Alaka (2023); Malla, Tummalapudi and Delhi (2024)
Technological Advancements	
Open BIM promotes standardised data formats and enable seamless information exchange between different BIM and FM tool(s)/system(s) Open BIM allows project team including FM personnel to use preferred software(s) without any compatibility issues Open BIM provides real-time data on FM status to ensure synchronisation and facilitate fast decision-making among FM personnel Development of cloud and mobile solutions improves accessibility	Juan (2013); Musella *et al.* (2020); Theißen *et al.* (2020); Deng *et al.* (2021); Lin and Su (2023); Hakimi, Liu and Abudayyeh (2024); Abdelalim *et al.* (2025)

Table 2.1 (Continued)

Statements	Previous Studies
Growth in Internet of Things (IoT), Artificial Intelligence (AI), and Digital Twins is making BIM more valuable in FM	
Asset Information Management	
Asset information management within BIM-FM integration provides a single source asset data to enhance consistency and reliability in facilities operations	Cavka, Staub-French and Poirier (2017); Sacks *et al.* (2018); Matarneh *et al.* (2019); Muñoz Pavón (2021); Charef (2022); Kubecka and Nyvlt (2023); Alkhard (2024); Ehab, Mahdi and El-Helloty (2024); Congiu *et al.* (2024); Abugu (2025)
BIM allows better coordination in managing complex infrastructure	
Real-time monitoring of built assets minimises downtime and optimises facilities performance	
Automated monitoring and scheduling through BIM streamline maintenance operations in FM	
3D visualisation of asset information using BIM supports scenario analysis for better decision-making in FM	
BIM-driven information and models enhance space management in FM through accurate 3D as-built models	
BIM models assist FM personnel in planning for future facilities expansions	
Large-scale and high-tech buildings require advanced FM solutions through BIM integration	
Cost Savings and Efficiency	
Proactive asset management reduces operational and maintenance costs	Peng , Au-Yong and Myeda (2024).
Predictive maintenance powered by asset information management in BIM-FM anticipates potential failures and improves asset lifecycle management	
BIM tool(s)/system(s) forecast long-term expenditures and support more budgeting decisions	
Sustainability	
Demand for smarter facility operations	Fang (2021); Opuku and Lee (2022)
Energy modelling and performance analysis using BIM improves energy efficiency in FM	
BIM-driven FM improves sustainability by enabling data-driven decision-making	

Table 2.1 (Continued)

Statements	Previous Studies
Skilled Workforce	
Government initiatives through policies and training in promoting BIM integration with FM Availability of knowledgeable, trained and skilled new workforce in relation to BIM-FM integration via tertiary education programmes Financial investment by companies in BIM technologies and staff training for successful BIM-FM integration Top management support Shift in mindset among FM personnel for adopting BIM-enabled and driven FM integrated practices/systems	Ashworth (2016); Bataw, Kirkham and Lou (2016); Sacks *et al.* (2018); Zhang *et al.* (2020); Wu *et al.* (2021); Braun, Kropp and Boeva (2022); Klein *et al.* (2022); Ahmed *et al.* (2024); Nguyen *et al.* (2024); Poirier, Pavard and De Paula (2024)

2.5.1 Regulatory And Industry Standards

Regulatory and industry standards serve as fundamental to guide and standardise the practice of BIM integration in FM. One of the most influential standards is ISO 19650, which is an international standard developed by British Standards Institute (BSI). It is the first international standard that offers a framework for BIM to administrate information of a built asset. This standard defines BIM as a tool that managing and digitalising the physical and functional characteristics of a built asset, which provides decision-making throughout the asset lifecycle. The standard is developed into six standards. ISO 19650-1 refers to the ‘concept and principles’ of the BIM process for a building asset, ISO 19650-2 explains the process of information delivery from design to handover of the asset, ISO 19650-3 revolves about on the operational phase of the asset, ISO 19650-4 outlines requirements of information management and ISO 19650-5 sets out the requirement for asset management.

The adoption of ISO 19650 ensures consistency and clarity in BIM practices when integrating with FM. As BIM is progressively becoming more prevalent throughout construction industry, and the usage of standardised digital process and technologies is being used is rising to enhance efficiency, collaboration and information management throughout the lifecycle of a built asset. According to CIDB (2019), an open system that sets out the requirements of standardised processes and guidelines is a substantive guidance document in integrating BIM with FM. This document spelled out requirements for the production, management and distribution of construction information using BIM. Researchers also studied that ISO 19650 provides a common standard of practices and codes for information management to a successful BIM adoption in FM (Cavka, Staub-French and Poirier, 2017; Munir *et al.*, 2019; Ajayi, Oyebiyi and Alaka, 2023). Therefore, a well-developed international standard stands as a crucial driver in integrating BIM in FM practices (Malla, Tummalapudi and Delhi, 2024).

Government and government-linked agencies also playing active roles in promoting BIM integration with FM through mandates, policies and guidelines. For instance, the initiatives of CIDB to mandate the use of BIM in construction projects. This initiative drives the integration of BIM integration not only during design and construction, but also in operation and maintenance stages. At the same time, the construction professional bodies and industry bodies are also slowing recognising the importance of BIM in FM practice, which further drives the integration.

Compliance with sustainability also encourages BIM based energy management. Globally recognised green certifications such as LEED (Leadership in Energy and Environmental Design) and BREEAM (Building Research Establishment Environmental Assessment Method) and Green Building Index (GBI) in Malaysia promote the usage of BIM for energy resources management in FM. BIM helps the FM practitioners in exploring various design alternatives, which optimising building performances and FM processes, so that the building can achieve compliance with those green certification requirements (Matarneh *et al.* 2020). While BIM can help compliance with these sustainability standards, BIM can significantly minimise the resources of building energy modelling to analyse different design alternatives and improve building performances (Carvalho *et al.*, 2021).

2.5.2 Technological Advancements

Rapid advancement of technology also drives the integration of BIM in FM practices. BIM has moved the FM industry forward by increased interest in open BIM, through cloud storage of single shared models or standardised data formats to facilitate interoperability across all BIM and FM tools and systems.

Open BIM was initiated by buildingSMART and the major mainstream of open BIM is through the usage of open standards for example Industry Foundation Classes (IFC). Musella *et al.* (2020) and Theißen *et al.* (2020) explored various uses of open BIM in implementing the process of managing existing buildings after the construction stage. According to Juan (2013), open BIM is a data management and modelling that is independent of a specific format or software. It allows the information to be accessible from the model without disrupting the original design through IFC to realise information interaction. Through this open BIM format, professionals can work together and share data easily when using the IFC standard. The project teams are also able to use preferred software without any compatibility issues. Therefore, providing a standard language used in the procedure enables a more transparent engagement and guarantees that the project data will be accessible throughout the building life cycle while eliminating the repeated inputs of data.

In addition to Open BIM, the development of cloud and mobile technologies has significantly improved the data accessibility. The BIM model is used to retain the buildings or facilities information in a digital format, which facilitates the project team to update FM-related data into the 3D CAD environment. However, one of the limitations of the BIM models is the current use of PC desktops will limit the FM practitioners to utilise the BIM models on-site while performing their tasks. This will also limit the BIM model biggest advantage to illustrate the facilities clearly in the 3D models. Lin and Su (2023) reiterated in their findings that for the BIM to be practically useful on-site, the BIM models need to be compressed and transferred to a smaller size for the usage of mobile devices. This requirement has led to growing interest in mobile BIM applications, which support the FM practitioners to access the data, view the 3D models, and performing inspections directly from tablets and smartphones. With the development of BIM technology in the mobile solutions, this will have significant potential to drive its integration in FM.

At the same time, the growth in Internet of Things (IoT), Artificial Intelligence (AI), and Digital Twin (DT) technologies is further amplifying BIM's value in FM. Digital twin has emerged as a solution for enabling real-time data acquisition and transfer that allows enhanced monitoring, analysis and improved decision-making toward smart FM (Hakimi, Liu and Abudayyeh, 2024). It acts as central data where the building performance can be monitored through the real-time data analysis. Deng *et al.* (2021) further stated the emergence of DT technologies in BIM are always integrated with other technologies that using IoT sensors and AI simulation. By utilising the real data in BIM models, predictive analytics and scenario-based simulation by AI solution can help the FM practitioners to proactively respond to maintenance activities in buildings, resulting in more informed and timely decision making (Abdelalim *et al.*, 2025).

2.5.3 Asset Information Management (AIM)

BIM improves the coordination between the design team and FM team in managing complex infrastructure. When BIM is integrated with the FM, it enables effective asset information management (AIM) by providing a single source asset data. In AIM, a 3D model is used to describe the compiled data gathered from various sources to enable ongoing asset management , reflecting the as-is or built condition of the facilities. When the project information is transferred to the owner and design team during the FM stage, effective usage of BIM can streamline the information hand over and review, ensuring compliance with projects requirements (Cavka, Staub-French and Poirier, 2017). This therefore enhanced data consistency and reliability in facilities operations.

According to Alkhard (2024) and Abugu (2025), an AIM driven by BIM and enriched with real-time and analytic facilities data, can revolutionise asset management strategies. As discussed earlier, with the combination of technologies, BIM acts as central data where all the detailed information of the building performance can be monitored and continuously updated through the real-time data analysis. This allows for predictive maintenance strategies, thereby minimising downtime and optimising facilities performance. Moreover, these BIM data enable integration of maintenance schedules and requirements into the model, which trigger the automated monitoring and scheduling to streamline maintenance operations in FM (Ehab, Mahdi and El-Helloty, 2024).

In the past, most of the existing FM tools were either dependent on advanced 2D CAD software or required manual entry of numerical data into spreadsheets. Although studies have discovered that although there is no strictly necessity of 3D information in managing spaces and facility assets, but 3D models can enhance FM operation by improving the lifecycle value of the building assets (Matarneh *et al.*, 2019; Congiu *et al.*, 2024). This is done by deriving relevant as-built models and information that will be used throughout the lifecycle of the building asset and integrated into the FM systems.

Through the 3D visualisation of asset information, the FM personnel can conduct scenario-based analysis to evaluate various results and make better decision-making (Charef, 2022). This is particularly useful for the FM personnel to identify potential risks and plan solutions to mitigate the risks. Besides, BIM-driven information and models enhance space management in FM by providing accurate asset information, thereby allowing the FM teams to visualise and assess the spatial relationship more accurately (Sacks *et al.*, 2018). This also offers significant benefits when assisting FM personnel in planning for future facilities expansions (Kubecka and Nyvlt, 2023).

Large-scale and high-tech buildings require advanced FM solutions through BIM integration. As the buildings become larger and complex, there is an increasing demand for more technologically advanced FM solutions to ensure effective operations and maintenance. It becomes even more difficult to manage when the operation of buildings must tailor to meet the unique requirements from the clients, which often limit by the traditional FM systems. In this circumstances, the traditional FM systems are often not sufficient to manage the complexities of the buildings. The emerging of BIM, especially when integrated with other digital technologies such as IoT, AI and DT has significantly enhanced the potential of FM practices (Muñoz Pavón, 2021). Through the combination of these technologies into BIM, it improves the traditional FM system for more effective automate tasks and streamline the workflows, transforming such type of building into smarter and sustainable building.

2.5.4 Cost Savings and Efficiency

One of the major drivers of BIM-FM integration is the capability for proactive asset management, which plays a critical role in reducing long-term operational and maintenance costs. The integration of BIM in FM provides real-time data that helps to schedule maintenance effectively. Through the proactively real-time monitoring, regularly and timely maintenance are carried out before the asset failure occurs. This helps to reduce the reactive maintenance cost, especially when emergency repair associated with more resources and high cost. Therefore, this proactive maintenance driven by BIM could avoid sudden downtime of facilities, which will leading to a greater cost efficiency.

Besides, the use of BIM in asset information management helps to schedule predictive maintenance, which enhances the asset lifecycle by anticipating potential system failures. By integrating BIM with FM system, the real-time data analysis and historical trends can be used and interpreted to forecast the need of maintenance and trigger predictive maintenance (Peng , Au-Yong and Myeda, 2024). This therefore can optimise the asset longevity and replacement cycles, where both of them are essential for controlling lifecycle costs.

2.5.5 Sustainability

Sustainability has become a central focus in facility management as organisations strive to meet environmental goals while optimising building performance. The integration of BIM with FM has emerged as a powerful tool to achieving these objectives by promoting smarter facility operations and data-driven decision-making. One of the key contributions of BIM integration with FM is energy modelling and performance analysis. With the real-time data and analysis, BIM helps the FM to identify inefficiencies, develop energy saving strategies, stimulate energy consumption and improving the energy efficiency of the building (Fang, 2021). Over the time, these not only help in reduce the overall operational energy use and extend the building lifespan but eventually reducing the carbon emissions (Opuku and Lee, 2022). From carbon footprint perspective, BIM-FM integration contributes to a greener built environment.

2.5.6 Skilled Workforce

Government initiatives through policies and training in promoting BIM integration with FM serves as a fundamental driver in BIM integration with FM. According to Braun, Kropp and Boeva (2022), economic viability and government’s supervision has strong influence in driving BIM integration with FM. Strategic policies and standard forms such as mandates of BIM integration in FM projects, have compelled both the construction and facility management sectors to adapt. For example, BIM Guide published by the Construction Industry Development Board (CIDB) serves a guideline for the projects to follow, at the same time promoting the use of BIM.

Beyond the government initiatives, financial investment by the companies in BIM technologies and staff training for successful BIM-FM integration. Integrating new BIM technology into the current FM practices often required investment in licensed BIM software, hardware and most importantly the training for staff to use it. According to Ashworth (2016), the FM practitioners should have training with respect to the BIM process and management of BIM models and associated data to ensure they can be familiar with the processes and requirements during the transition and operation phases in BIM integration.

This financial investment by the companies is always closely tied with the support from top management. When the top management recognised the importance of BIM integration with FM, they are more likely to allocate resources and encourage their employees to participate in training and skill development. This can be supported by Ahmed *et al.* (2024), which highlights that the with the commitment from top management to upskill their employees, it helps to drive the adoption and integration of BIM in FM

Klein *et al.* (2022) revealed the necessary of skills to use BIM software effectively. The first step is to prepare and build a BIM model consisting of all the necessary information required for cost-related tasks (Sacks *et al.*, 2018). BIM is currently being used all over the world, and the utilisation rate of relevant software is also progressively rising. Many researchers discovered that the availability of BIM professionals is still the driver for BIM integration in FM (Nguyen *et al.*, 2024; Poirier, Pavard and De Paula, 2024). According to Zhang *et al.* (2020), shifting to BIM integration with FM from the traditional method requires more than just technical specifications, the high-quality BIM knowledge the FM talents equipped will also affect the successful implementation of BIM-FM integration.

While the awareness of top management is crucial to drive BIM-FM integration, shift in mindset of FM practitioners also important as they are the ones, most directly involved in practising the BIM integration and managing the facilities. Future of BIM-FM integration could provide new remedies to multiple crises facing the industry and change the method of professionals carrying out roles and responsibilities (Bataw, Kirkham and Lou, 2016). This transition will alter practices of FM practitioners from the fracture information and traditional paper approach to a BIM-enabled approach, learning new software and system. Besides, Wu *et al.* (2021) observed that although the FM practitioners are prepared to use BIM in their practices, nevertheless not all the stages can fully realise the benefits of BIM due to resistance in certain stage. Therefore, FM practitioners shall cultivate a proactive and open-minded attitude towards new digital tool, so that full potential of BIM can be released in FM.

2.6 Challenges of BIM Integration with FM

Despite the potential benefits by BIM integration with FM, incomprehensive integration happened due to a diverse challenge. Table 2.2 summarised the previous studies on the challenges based on four aspects, which are regulatory and contractual aspect, technological and data aspect, financial aspect and human and organisational aspect, as summarised in Table 2.2.

Table 2.2: Challenges of BIM Integration with FM

Statements	Previous Studies
Regulatory and Contractual Aspect	Abideen *et al.* (2022); Ghadiminia *et al.* (2022); Epasinghe and Jayasena (2018); Godager *et al.* (2022); Sacks *et al.* (2018); Ashworth, Dillinger and Körkemeyer (2023); Malla, Tummalapudi and Delhi (2024); Pan *et al.* (2024)
Lack of standard form for implementing BIM standards in FM	
Lack of a standard/universal approach for BIM data handover to FM personnel	
Lack of clear organisational policies, requirements, and guidelines for integrating BIM with FM	
Unclear legal liability boundaries among stakeholders in BIM-FM (e.g., determining responsibility if a facility failure occurs due to incorrect data)	
Uncertainty regarding ownership and responsibility of BIM data in FM operations	
Data security and privacy concerns related to BIM-FM integration	
Cloud-based BIM-FM systems may be vulnerable to cyber threats	

Table 2.2 (Continued)

Statements	Previous Studies
Technological and Data Aspect	
Complexity in integrating different BIM tool(s)/software(s) with FM tool(s)/software(s) due to data interoperability issues (i.e., lack of standardised formats) High data quality requirements in BIM models to support accurate FM decision-making Missing asset information, reducing the effectiveness of BIM in FM Often, as-built BIM models are not fully updated or detailed for FM use Risk of data loss during data translation and exportation between BIM and FM tool(s), software(s)/system(s) Large BIM model file sizes impacting FM data integrity and system performance Unclear BIM workflow causing fragmented information management in FM	Kamaruzzaman *et al.* (2018); Zhu *et al.* (2018); Matarneh (2020); Støre-Valen (2021); Desbalo *et al.* (2024); Otranto, Junior and Pellanda (2025)
Financial Aspect	
High cost associated with implementing BIM-FM technologies (i.e. software(s) and system upgrades) Additional costs for data migration from traditional FM system(s) High cost associated with training BIM and FM personnel Lack of validity and real cases demonstrating the truthful return of investment in BIM-FM integration	Wu *et al.* (2021); Durdyev *et al.* (2022); Boontae and Ussavadilokrit (2024); Safapour and Silwal (2024)
Human and Organisational Aspect	
Lack of awareness among top management regarding the benefits of integrating BIM in FM Lack of commitment and support from top management in integrating BIM and FM Resistance to BIM-FM integration from both BIM and FM personnel (e.g., workflow disruptions) Lack of proper training and resources for FM personnel to effectively integrate BIM Lack of competent personnel with relevant knowledge in both BIM and FM	Naghshbandi (2016); Horvath and Szabo (2019); Shojaei, Oti-Sarpong and Burgess (2023); Bello and Ayegba (2024); Ariffin *et al.* (2024)

2.6.1 Regulatory and Contractual Aspect

From a wider perspective, lack of standard or universal approach for BIM standard in FM remains one of the key regulatory and contractual challenges in BIM integration with FM. According to Godager *et al.* (2022), many projects were carried out without clear contract forms that define the BIM responsibilities in FM, which limiting the potential of BIM integration from being fully utilised in FM. The current construction industry refuses to shift its perspective from cost-driven to value-driven and from short-term outcomes to long-term performance, as they do not fully understand the requirements and obligations related to BIM-FM integration (Pan *et al.*, 2024). Ashworth, Dillinger and Körkemeyer (2023) also pointed out that it is important to have a step-by-step description of each information requirement in BIM models and FM systems. Such clarity is essential to make the stakeholder initiate the first step towards integrating BIM in their FM practices. Therefore, the absence of well-developed standard form complicates the process, hindering stakeholders to make the transition and changes.

Effective integration relies on a shared understanding of BIM and FM processes, and this can be difficult to achieve when different teams use varying terminologies and definition (Malla, Tummalapudi and Delhi, 2024). There is no widely recognised standard and approach for the BIM data structured and delivered from design and construction team to FM personnel during project handover. As a result, FM teams may receive inconsistent or non-interoperable BIM models which cannot be optimised for operation and maintenance stages (Abideen *et al.*, 2022).

Similar challenges happen when the organisations did not develop their organisational policies, requirements, and guidelines for integrating BIM with FM. Many organisations implement BIM without establishing internal guidelines tailored to their FM operations. Similar challenges happen as without clearly defined roles, data requirements, the FM teams may struggle to interpret the data, which hinders effective communication and collaboration among FM team. Therefore, the rationale for effective uptake of BIM-FM integration should be started from the organisational itself. Developing a structured organisational policies and guidelines can significantly improve the consistency of workflow between BIM and FM. In addition, without a clear performance measuring system in the organisation, it is challenging to justify the initial investment and return in BIM technology and to make its ongoing use in FM practices (Sacks *et al.*, 2018). As a result, stakeholder loses their interest in integrating BIM with their FM practices.

As a BIM is a single complex file created by the designer team and edited by other individuals involved in the construction process, making the ownership and responsibility of BIM data are difficult to justify (Dixit *et al.*, 2019). For example, it is difficult to determine responsibility if a facility failure occurs due to incorrect data provided by the design and construction team. This lack of clarity can cause disputes may lead to unutilised of BIM models.

Data security and privacy concerns also play major challenge in the regulatory and contractual aspect. According to Epasinghe and Jayasena (2018), the data security and protection is the firsthand issue in BIM-FM integration due to the accessibility of design data. The presence of digital technologies, coupled with FM systems that integrate to BIM, it is vulnerable to cyber threats and it creates a golden thread of information of the facility that is desirable to those malicious intention to gain unauthorised access to the facilities data (Ghadiminia *et al.*, 2022). Besides, confidential information such as electronic signatures on contractual documents can be easily replicated, thereby creating doubts about authenticity. Therefore, without a proper cybersecurity policy, the sensitive and confidential information may be exposed, and thereby discourage the FM industry to integrate with BIM.

2.6.2 Technological and Data Aspect

Complexity in integrating different BIM tools with FM systems become one of the major challenges in integrating BIM and FM. The lack of standardised data formats hinders seamless data exchange, which is critical for effective FM operations (Matarneh, 2020). For example, BIM software such Glodon Cubicost often produce date that is incompatible with FM systems such as Computerized Maintenance Management System (CMMS). While the solely use of BIM software itself is already complicated, it may lead to further data interoperability issues especially with different FM systems (Otranto, Junior and Pellanda, 2025). Such causes might be due to the incompatible data or lack of standardised formats for BIM data to translating to suit the FM systems' requirements.

Further challenge of BIM integration with FM is the quality of data delivered when integrating to FM system. According to Desbalo *et al.* (2024), the information transferred from the development and construction phase is frequently inconsistent, poorly documented or incomplete for operational and maintenance stage or FM practices. This missing asset information will therefore be reducing the effectiveness of BIM in FM. The FM team are impeded in their ability to carry out built asset management activities efficiently without precise and dependable information, which jeopardises the client's core competencies (Kamaruzzaman *et al.*, 2018). This may be developed further challenges when the as-built BIM models are not fully updated or detailed for FM use.

Besides, data loss during data translation and exportation between BIM and FM systems is another challenges. During the process of translating and exporting BIM models into FM system, data loss may be happened. This is not only due to the incompatible file, but also due to the nature of BIM data, which is always include large model file sizes (Zhu *et al.*, 2018). Consequently, the asset information may lose or could not be access.

Furthermore, unclear BIM workflow causing fragmented information management in FM also contribute to BIM-FM challenges. If the FM teams did not participate in design and construction phases, they often may have misunderstanding between what is modelled by the design and construction team (Støre-Valen, 2021). In practice, FM teams do not design a facility, but they should often participate in the design modelling process so that they can have better understanding to manage and operate the facility over its lifecycle. However, this collaboration is frequently overlooked, resulting in models that are well-suited for long-term asset management.

2.6.3 Financial Aspect

The integration of BIM with FM is often justified by the potential for long-term cost savings and efficiency gains. However, the financial implications of integrating BIM with FM and economic viability presents significant challenges for organisations, particularly in the early stages of implementation.

As the first step to integrate BIM with FM, high cost associated with implementing BIM-FM technologies. These high costs for the BIM software and hardware are particularly the main challenges that hinder the organisation to implement BIM-FM integration, especially those small-medium-sized companies (Wu *et al.*, 2021).

Apart from the initial investment, the organisation should also consider cost on training and upskilling of BIM and FM personnel (Durdyev *et al.*, 2022). As mentioned in previous chapter, a successful BIM-FM integration is highly dependent on the workforce competent or FM personnel. Therefore, sufficient investments should also be followed by the expansion of training activities for the FM personnel (Safapour and Silwal, 2024).

The organisations must also contend with additional costs related to data migration from traditional FM systems, especially in managing the old existing facilities. This process involves converting asset data and records into digital formats that suit with BIM model requirements. Such processes are even taking times when the facilities are large and complex.

The absence of valid case studies and demonstration to proof the return on investment of BIM technology for facility management also has been a significant challenge to widespread BIM-FM integration (Boontae and Ussavadilokrit, 2024). This lack of clarification of case studies has discouraged the top management to advocate BIM in the FM. Therefore, the government comes into the role of providing initiatives for BIM software to encourage BIM adoption.

2.6.4 Human and Organisational Aspect

The awareness among top management in relation to the potentials that BIM can bring to the FM procedures can drive the BIM integration in FM. (Naghshbandi, 2016; Bello and Ayegba, 2024). Many leaders from top management may not be familiar with how the BIM can support and enhance the FM operations and this lack of understanding contributes to lower focus during companies' strategic planning.

Lack of commitment and support from top management is also closely link to their awareness. The organisation may be aware of the benefits of BIM-FM integration; however, the implementation can be difficult if there are no resources allocated to this integration. Without their commitments such as providing financial investments in training and technologies and driving cultural changes, the integration of BIM with FM may be delayed or not practised. At the same time, the awareness of top management is crucial to drive BIM-FM integration, shift in mindset of FM practitioners also important as they are the ones, most directly involved in practising the BIM integration and managing the facilities (Ariffin *et al.*, 2024).

Furthermore, the integration of BIM with FM requires set of skills, with relevant technical BIM knowledge combined with FM experience. However, it is rarely to find competent personnel who are fully equipped in both areas. The gap between the technical BIM knowledge is one of the most decisive challenges to the integration of BIM with FM (Shojaei, Oti-Sarpong and Burgess, 2023). Therefore, Horvath and Szabo (2019) opined that organisations are required to improve and equip the workforce with essential technology competencies required in the future through structured training.

2.7 Proposed Conceptual Framework

In this research, BIM-FM integration was enhanced by FM practices, with 29 drivers and 23 challenges identified through the literature review. These drivers are closely correlated with existing challenges, where regulatory and industry standards often conflict with regulatory and contractual issues, while technological advancements and asset information management are hindered by technological and data challenges. Although cost savings and efficiency motivate BIM-FM integration, financial constraints remain a significant challenge. Similarly, sustainability goals and the availability for skilled workforce are often challenged by human and organisational resistance. These interrelated factors influence how effectively BIM can be integrated into FM practices. Figure 2.1 illustrated the conceptual framework of BIM integration with FM.

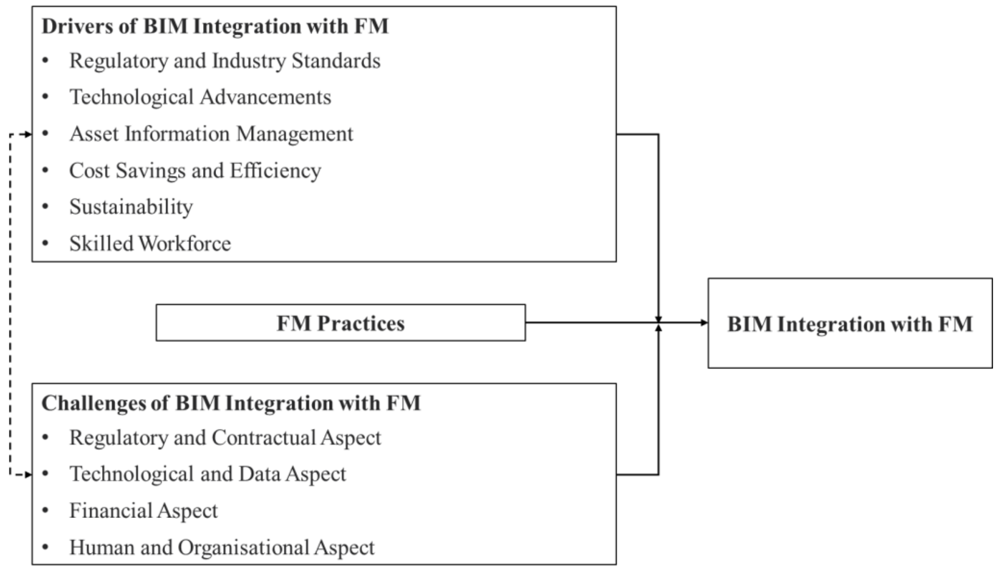

Figure 2.1: Proposed Conceptual Framework

CHAPTER 3

METHODOLOGY AND WORK PLAN

3.1 Introduction

This chapter reviews the, the research methodology and strategies employed in this research. Subchapter 3.2 and Subchapter 3.3 describe the design of the research questions. The sampling method used to calculate the required number of target respondent is explained in subchapter 3.4. Subchapter 3.5 discussed the methods of data analysis, followed by a summary of the chapter in subchapter 3.6.

3.2 Research Methodology

Research methodology is a systematic approach used to address research problems, serving as a foundation to understand how the research is conducted in a rigorous manner (Khan *et al.*, 2023). In this research, an exploratory approach was selected. The exploratory approach aimed to investigate various drivers and challenges of Building Information Modelling (BIM) integration with Facilities Management (FM) through the literature review and explore its current practices in the FM industry.

3.3 Research Strategies

Quantitative and qualitative research are the two dominant research methodologies used in the human and social sciences (Smith, 2024). This research applied a quantitative approach to gather statistical data on the current practices, drivers and challenges associated with BIM integration in FM. This approach was chosen because data can be collected from a large sample of construction professionals, thereby providing a solid input for analysis.

The data collection was carried out using a questionnaire comprising both opened-ended and closed-ended questions. Prior to launching the full-scale study, a pilot test was conducted to assess the clarity, relevance and acceptability of the questionnaire. Feedback from the pilot test was used to refine ambiguous questions and improve the overall design of the instrument, ensuring reliability and ease of completion.

The questionnaires were distributed through email and LinkedIn, using Google Forms as the primary platform for response collection. The collected data were analysed using Statistical Package for the Social Sciences (SPSS) to extract meaningful insights and support the research findings.

3.4 Questionnaire Design

The questionnaire is divided into five sections which are Section A, Section B, Section C, Section D and Section E. Section A through D contained closed-ended questions while Section E contained open-ended question. Multiple-choice measurement was adopted in Section A. Similarly, Section B, C and D employed multiple-choice grid measurement, Likert Scale. In Section B, the respondents were required to choose from "Never", "Rarely", "Occasionally", "Frequently" and "Always" to indicate their frequency of practices. In Section C and D, the respondents were asked to indicate their level of agreement level for each statement, ranging from "Strongly Disagree", "Disagree", "Neutral", "Agree" to "Strongly Agree". Figure 3.1 illustrated the questionnaire's design, which was derived from conceptual framework proposed in subchapter 2.6.

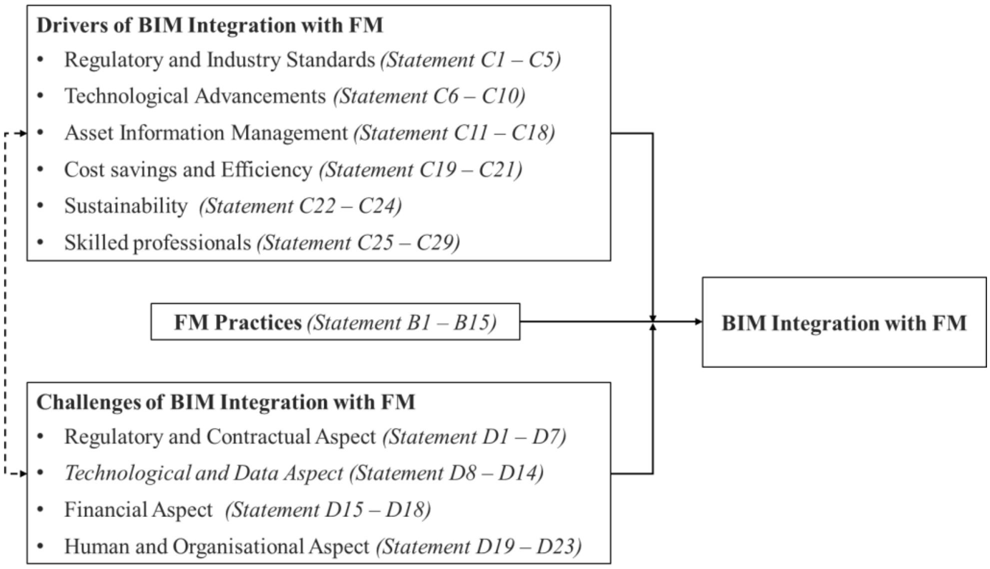

Figure 3.1: Conceptual Framework for Questionnaire Design

3.4.1 Section A: Respondents' Demographic

In Section A, multiple-choice measurement is adopted to collect the respondents' background information. Respondents were required to complete their profiles by providing details such as their years of experience, number of facilities managed, types of facilities managed, duration of integrating BIM in their FM practices and thier opinion on the necessity of integrating BIM with FM.

3.4.2 Section B: Current Practices in FM

Section B was designed to discover the current practices in FM. This section consisted of 15 statements of FM practices compiled from the literature review as presented in Table 3.1. The respondents were required to choose from "Never", "Rarely", "Occasionally", "Frequently" and "Always" to indicate their frequency of practices.

Table 3.1: FM Practices

Code	Statements
B1	Project files including all FM-related BIM data are shared in paper-based format
B2	Project files including all FM-related BIM data are shared in digital format using specific software
B3	Project files including all FM-related BIM data are shared in open data format via IFC standard (data can be exchanged between different BIM as well as FM software)
B4	Project files including all FM-related BIM data are shared via cloud-based platform for real-time collaboration
B5	Project files including all FM-related BIM data are accessible to FM personnel only
B6	Project files including all FM-related BIM data are accessible to all project stakeholders including FM personnel
B7	Project files including all FM-related BIM data are modifiable by FM personnel only
B8	Project files including all FM-related BIM data are modifiable by all project stakeholders including FM personnel
B9	BIM is used to store and manage as-built BIM models, as-built information, including asset details, spatial layouts and building components
B10	BIM tools/systems are integrated with FM tools/systems to facilitate building operation
B11	BIM tools/systems are integrated with FM tools/systems for energy modelling, estimation and simulation to monitor building energy performance and efficiency improvements
B12	BIM tools/systems are integrated with FM tools/systems for maintenance scheduling
B13	BIM-enabled FM tools/systems are used to trigger maintenance requests based on equipment condition automatically

Table 3.1 (Continued)

Code	Statements
B14	BIM tools/systems are integrated with FM tools/systems for lifecycle cost analysis based on historical data provided for cost estimation and decision making
B15	Advanced integration where BIM is combined with real-time sensor data for predictive maintenance and operational efficiency

3.4.3 Section C: Drivers of BIM Integration with FM

The questions in Section C were related to the drivers for BIM integration with FM, which had been investigated through literature reviews. Table 3.2 consisted of 29 statements regarding the drivers that initiated BIM integration with FM.

Table 3.2: Drivers of BIM Integration with FM

Code	Statements
	Regulatory and Industry Standards
C1	ISO 19650 provides essential guidelines to ensure consistency and clarity in BIM practices when integrating with FM
C2	ISO 19650 establishes policy requirements that guide organisations in best practices and compliance for BIM tool(s)/system(s) when integrating with FM
C3	Government and government-linked agencies are mandating BIM adoption in construction and FM
C4	Construction professional bodies and industry bodies are mandating BIM adoption in construction and FM
C5	Compliance with sustainability standards (e.g., LEED, BREEAM and the like) encourages BIM based energy management
	Technological Advancements
C6	Open BIM promotes standardised data formats and enable seamless information exchange between different BIM and FM tool(s)/system(s)
C7	Open BIM allows project team including FM personnel to use preferred software(s) without any compatibility issues
C8	Open BIM provides real-time data on FM status to ensure synchronisation and facilitate fast decision-making among FM personnel
C9	Development of cloud and mobile solutions improves accessibility
C10	Growth in Internet of Things (IoT), Artificial Intelligence (AI), and Digital Twins is making BIM more valuable in FM
	Asset Information Management (AIM)
C11	Asset information management within BIM-FM integration provides a single source asset data to enhance consistency and reliability in facilities operations
C12	BIM allows better coordination in managing complex infrastructure

Table 3.2 (Continued)

Code	Statements
C13	Real-time monitoring of built assets minimises downtime and optimises facilities performance
C14	Automated monitoring and scheduling through BIM streamline maintenance operations in FM
C15	3D visualisation of asset information using BIM supports scenario analysis for better decision-making in FM
C16	BIM-driven information and models enhance space management in FM through accurate 3D as-built models
C17	BIM models assist FM personnel in planning for future facilities expansions
C18	Large-scale and high-tech buildings require advanced FM solutions through BIM integration
	Cost Savings and Efficiency
C19	Proactive asset management reduces operational and maintenance costs
C20	Predictive maintenance powered by asset information management in BIM-FM anticipates potential failures and improves asset lifecycle management
C21	BIM tool(s)/system(s) forecast long-term expenditures and support more budgeting decisions
	Sustainability
C22	Demand for smarter facility operations
C23	Energy modelling and performance analysis using BIM improves energy efficiency in FM
C24	BIM-driven FM improves sustainability by enabling data-driven decision-making
	Skilled Workforce
C25	Government initiatives through policies and training in promoting BIM integration with FM
C26	Availability of knowledgeable, trained and skilled new workforce in relation to BIM-FM integration via tertiary education programmes
C27	Financial investment by companies in BIM technologies and staff training for successful BIM-FM integration
C28	Top management support
C29	Shift in mindset among FM personnel for adopting BIM-enabled and driven FM integrated practices/systems

3.4.4 Section D: Challenges of BIM Integration with FM

Section D is designed to discover the challenges in BIM integration with FM. Table 3.3 presented 23 statements on the challenges of BIM integration with FM as shown in Table 3.3.

Table 3.3: Challenges of BIM Integration with FM

Code	Statements
	Regulatory and Contractual Aspect
D1	Lack of standard form for implementing BIM standards in FM
D2	Lack of a standard/universal approach for BIM data handover to FM personnel
D3	Lack of clear organisational policies, requirements, and guidelines for integrating BIM with FM
D4	Unclear legal liability boundaries among stakeholders in BIM-FM (e.g., determining responsibility if a facility failure occurs due to incorrect data)
D5	Uncertainty regarding ownership and responsibility of BIM data in FM operations
D6	Data security and privacy concerns related to BIM-FM integration
D7	Cloud-based BIM-FM systems may be vulnerable to cyber threats
	Technological and Data Aspect
D8	Complexity in integrating different BIM tool(s)/software(s) with FM tool(s)/software(s) due to data interoperability issues (i.e., lack of standardised formats)
D9	High data quality requirements in BIM models to support accurate FM decision-making
D10	Missing asset information, reducing the effectiveness of BIM in FM
D11	Often, as-built BIM models are not fully updated or detailed for FM use
D12	Risk of data loss during data translation and exportation between BIM and FM tool(s), software(s)/system(s)
D13	Large BIM model file sizes impacting FM data integrity and system performance
D14	Unclear BIM workflow causing fragmented information management in FM
	Financial Aspect
D15	High cost associated with implementing BIM-FM technologies (i.e. software(s) and system upgrades)
D16	Additional costs for data migration from traditional FM system(s)
D17	High cost associated with training BIM and FM personnel
D18	Lack of validity and real cases demonstrating the truthful return of investment in BIM-FM integration
	Human and Organisational Aspect
D19	Lack of awareness among top management regarding the benefits of integrating BIM in FM
D20	Lack of commitment and support from top management in integrating BIM and FM
D21	Resistance to BIM-FM integration from both BIM and FM personnel (e.g., workflow disruptions)
D22	Lack of proper training and resources for FM personnel to effectively integrate BIM
D23	Lack of competent personnel with relevant knowledge in both BIM and FM

3.4.5 Section E: Additional Comments/Suggestions

Section E includes an optional open-ended question, allowing the respondents to share additional comments or suggestions regarding current industry practices. This section also encourages the respondents to propose ways to enhance BIM integration with FM and to overcome the challenges associated with the Malaysian FM industry.

3.5 Sampling Determination

The subsequent subsections included the sampling method, sampling size and targeted respondents.

3.5.1 Sampling Method

The research employed the convenience sampling method, a non-probability sampling technique that allows data to be collected in a short timeframe. The target respondents in this research are facilities managers and property managers in Malaysia. Questionnaires are distributed to these respondents via Google Forms, using email and LinkedIn as the distribution channels.

3.5.2 Sampling Size

The Cochran formula was applied to calculate the minimum sample size required for the research and to determine the desired level of confidence and error margin. In this research, a high confidence level of 95% (Z = 1.96) was assumed, which means only a 5% error margin (e = 0.05) was allowed for this research.

$$n = \frac{Z^2 p(1-p)}{e^2}$$

$$n = \frac{1.96^2(0.5)(1-0.5)}{0.05^2} = 384 \tag{3.1}$$

where

n = sample size

Z = Z-value at 95%, 1.96

p = estimated ratio of population, 0.5

e = error margin, 5%

Besides, Central Limit Theorem (CLT) was applied to justify the sufficiency of the sample size. This method suggests that the sample mean distribution is approximately normal if the sample size, n is 30 or more. Therefore, a sample size of thirty was required for the independent variable, which is years of experience.

3.6 Data Analysis

The collected data were imported into SPSS to perform further statistical data analysis. The following section discusses the Cronbach's Alpha Reliability test, Friedman test, Kruskal-Wallis H test and Mann-Whitney U test.

3.6.1 Cronbach's Alpha Reliability Test

This test was used in this research to examine the consistency of the data. This test measures internal consistency and stability between the answers to the questionnaire (Sileyew, 2019). If the Cronbach's Alpha coefficient achieved is 0.70 or above, it means that there is low or no bias between the answers to the questionnaire and the overall results are acceptable. Table 3.4 shows the relationship between Cronbach's Alpha coefficient and the level of reliability.

Table 3.4: Relationship between Coefficient Alpha and Reliability Level

Category	Alpha Coefficient Range	Reliability Level
1	Lesser than 0.60	Poor
2	0.60 – 0.69	Moderate
3	0.70 – 0.79	Good
4	0.80 – 0.89	Very Good
5	Equal to or higher than 0.95	Excellent

3.6.2 Friedman Test

Friedman test is a non-parametric test to acquire the mean ranking of the sample means collected. The non-parametric method was adopted as it provides a more generalised result rather than using the mean value in the previous alpha test. In this research, this test was employed to investigate the significant differences among the current practices in FM, drivers of BIM integration with FM and their challenges. The null hypothesis denoted by H_0 while alternative hypothesis denoted by H_1 were established. H_0 refers to the statement of agreement level regarding current practices in FM, drivers and challenges of BIM integration with FM was accepted, while H_1 refers to the statement of agreement level regarding current practices in FM, drivers and challenges of BIM integration with FM was rejected.

3.6.3 Kruskal-Wallis H Test

Kruskal-Wallis H test is a non-parametric method to compare three or more groups of independent groups on the dependent variable. This test does not assume data to be normally distributed, making it particularly suitable for data measured on ordinal scales or for datasets that do not meet parametric assumptions (Ostertagova, Ostertag and Kováč, 2014).

In this research, the test was used to examine the statically differences in respondents' perceptions towards the drivers of BIM integration with FM. The "Years of Working Experience" is the independent variables and a total of four groups were tested including "Less than 5 years" and "6–10 years", "11–15 years" and "More than 15 years" to determine the significant differences among respondents' groups on the drivers of BIM integration with FM. If the calculated probability or p-value of the results falls lower than 0.05, it shows a significant difference between the four groups. This indicates that the null hypothesis is rejected with confidence. The results were then compared with previous literature reviews to reinforce the existing theories or establish new knowledge.

3.6.4 Mann-Whitney U Test

Mann-Whitney U test is the non-parametric method to identify two independent groups of independent groups on a dependent variable (Nachar, 2008). This method is similar to the Kruskal-Wallis H Test, but it has differed in the number of groups they can examine.

In this research, the test was used to examine the statically differences in respondents' perceptions towards the challenges of BIM integration with FM. A total of two groups were tested, including respondents who "Have Integrated" and “Have Not Integrated” BIM with FM in managing facilities to determine the significant differences among respondents’ groups on the challenges of BIM integration with FM. If the calculated probability or p-value of the results falls lower than 0.05, it shows a significant difference between the two groups. This indicates that the null hypothesis is rejected with confidence. The results were then compared with previous literature reviews to reinforce the existing theories or establish new knowledge.

3.7 Summary of Chapter

Quantitative approach was used to collect the data on the current practices in FM, drivers and challenges of BIM integration with FM. The questionnaire is divided into five sections, ensuring that all the questions are aligned with the research objectives. The convenience sampling method was used in this research and the target respondents are facilities managers and property managers in Malaysia. Lastly, a total of four tests are conducted to interpret the collected data.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

Chapter 4 presents the findings from the questionnaire survey. All the data collected were analysed using the Statistical Package for the Social Science (SPSS) to derive meaningful insights for discussion. Subchapter 4.2 and subchapter 4.3 discuss the survey response analysis and the respondents' profile. Subchapter 4.4 discusses the practices in Facilities Management (FM), followed by exploration of the drivers and challenges of Building Information Modelling (BIM) integration with FM in subchapter 4.5 and subchapter 4.6 respectively. Lasty, subchapter 4.7 provides a summary of the chapter.

4.2 Survey Response Analysis

This research collected 117 responses by distributing Google Forms via email and LinkedIn. Although the calculated sample size was 384, the shortfall was primarily due to practical constraints, including time limitations, respondents' availability and the specialised nature of the research topic, which focuses on BIM integration with FM. While the sample size of 117 responses did not meet the targeted sample size, it still considered acceptable. This is because each of the three demographic subgroups analysed exceeded the minimum threshold of 30 required for the Central Limit Theorem to apply.

4.3 Respondents' Profile

The demographic of the respondents is presented in Table 4.1. The data collected includes years of working experience, number of facilities managed, and types of facilities managed.

Table 4.1: Demographic Profile of the Respondents

Categeries	Frequency (n)	Percentage (%)
Years of Working Experience		
Less than 5 years	46	39.30
6–10 years	35	29.90
11–15 years	19	16.20
More than 15 years	17	14.50
Number of Facilities Managed		
1–2 facilities	28	23.90
3–4 facilities	29	24.80
5–6 facilities	8	6.80
More than 6 facilities	52	44.40
Types of Facilities Managed		
Residential	34	29.10
Commercial	81	69.20
Industrial	50	42.70
Healthcare	10	8.50
Education	15	12.80
Public infrastructure	11	9.40
Multimedia studios	1	0.90

Based on the data collected, the majority of respondents have less than 5 years of working experience in the field, accounting for 39.30% (46 respondents), followed by 29.90% (35 respondents) with 6–10 years of working experience. Those with 11–15 years and more than 15 years of working experience represent 16.20% (19 respondents) and 14.50% (17 respondents) respectively. This indicates that most of the participants are early- to mid-career professionals.

In terms of the number of facilities managed, the largest group of respondents, 44.40% (52 respondents) manage more than 6 facilities. Meanwhile, 24.80% (29 respondents) manage 3–4 facilities, 23.90% (28 respondents) manage 1–2 facilities, and only 7.00% (8 respondents) manage 5–6 facilities.

Among the facilities managed, commercial buildings are the most commonly managed, with 69.20% (81 respondents). This is followed by industrial buildings (42.70%, 50 respondents), residential buildings (29.10%, 34 respondents), educational institutions (12.80%, 15 respondents), public infrastructure (9.40%, 11 respondents), healthcare facilities (8.50%, 10 respondents) and multimedia studios (0.90%, 1 respondent), which are the least common.

4.3.1 Necessity to Integrate BIM and FM

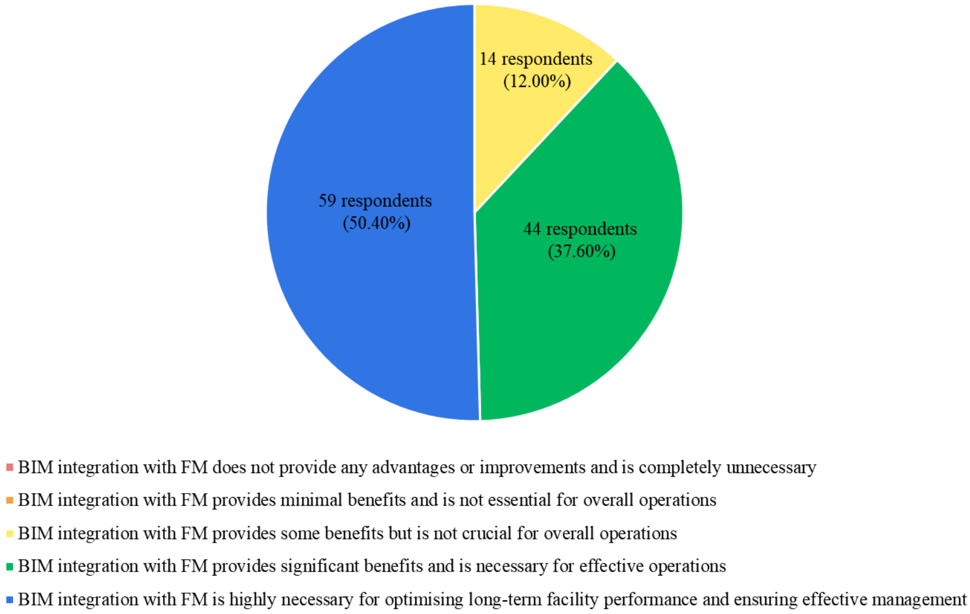

Figure 4.1: Necessity to Integrate BIM and FM

Figure 4.1 illustrates the necessity to integrate BIM and FM. When asked about the necessity of integrating BIM with FM, 50.40% (59 respondents) believed that it is highly necessary for optimising long-term facility performance. 37.60% (44 respondents) considered BIM to provide significant benefits and is necessary for effective facility operations. Meanwhile, only 12.00% (14 respondents) felt that although BIM offers some benefits, it is not crucial for overall operations. Noticeably, none of the respondents viewed BIM integration with FM as providing minimal or no advantages.

4.4 Practices in FM

In this subchapter, the general information of respondents who have integrated BIM with FM and the current practices in FM are discussed.

4.4.1 Integration of BIM with FM

Based on Table 4.2, out of 117 respondents, 73.5% (86 respondents) have integrated BIM into their FM practices, while 26.5% (31 respondents) have not yet done so. In the respondents' opinion, they agreed that integrating BIM with FM is a good step for a better FM era, especially those new facilities. However, FM tools like Computerised Maintenance Management Systems (CMMS) remain their preferred choice in their practices, especially managing existing or older facilities due to lower costs, flexibility and familiarity. Additional analysis was conducted on 86 respondents who have integrated BIM with FM. The duration of BIM integration with FM is tabulated in Table 4.2.

Table 4.2: Respondents Who Have Integrated BIM with FM

Categeries	Frequency (n)	Percentage (%)
Integration of BIM with FM		
Have Integrated	86	73.50
Have Not Integrated	31	26.50
Year of Working Experience		
Less than 5 years	34	39.53
6–10 years	22	25.58
11–15 years	17	19.77
More than 15 years	13	15.12
Duration of Integration		
Less than 1 year	19	22.09
1–5 years	56	65.12
6–10 years	5	5.81
More than 10 years	6	6.98

Based on Table 4.2, 34 respondents (39.53%) with less than 5 years of working experience constituted the largest group who have integrated BIM in their FM practices. This is followed by 22 respondents (25.58%) with 6–10 years of working experience, 17 respondents (19.77%) with 11–15 years of working experience and 13 respondents (15.12%) with more than 15 years of working experience.

In terms of the duration of BIM-FM integration, 56 respondents (65.12%) have integrated BIM with FM for 1–5 years and 19 respondents (22.09%) have done so for less than 1 year. A smaller group of respondents have integrated BIM with FM for a longer period, with 6 respondents (6.98%) more than 10 years and only 5 respondents (5.81%) for 6–10 years.

This data revealed that many professionals who have integrated BIM are relatively new to FM, both in terms of their career experience and their use of BIM in FM. This suggests that newer professionals are more inclined to integrate BIM in their FM practices due to recent academic exposure and the growing of BIM as standard practice in recent years in the industry (Aziz *et al.*, 2016).

4.4.2 Current Practices in FM

The respondents' current practices in FM were analysed in this section. The Cronbach's Alpha reliability test conducted on the 15 statements of current practices in FM yielded a Cronbach's Alpha value of 0.982, demonstrating a high level of internal consistency and reliability of the data. Table 4.3 summarises the mean ranking of current practices in FM using Friedman test.

Table 4.3: Mean Ranking of Current Practices in FM

Code	Statements	Mean Rank	Chi-square	Asymp. Sig.
B2	Project files including all FM-related BIM data are shared in digital format using specific software	9.18	100.333	0.000
B10	BIM tools/systems are integrated with FM tools/systems to facilitate building operation	8.82		
B12	BIM tools/systems are integrated with FM tools/systems for maintenance scheduling	8.64		
B5	Project files including all FM-related BIM data are accessible to FM personnel only	8.50		
B11	BIM tools/systems are integrated with FM tools/systems for energy modelling, estimation and simulation to monitor building energy performance and efficiency improvements	8.44		
B13	BIM-enabled FM tools/systems are used to trigger maintenance requests based on equipment condition automatically	8.33		
B7	Project files including all FM-related BIM data are modifiable by FM personnel only	8.12		
B4	Project files including all FM-related BIM data are shared via cloud-based platform for real-time collaboration	8.09		
B6	Project files including all FM-related BIM data are accessible to all project stakeholders including FM personnel	8.06		

Table 4.3 (Continued)

Code	Statements	Mean Rank	Chi-square	Asymp. Sig.
B9	BIM is used to store and manage as-built BIM models, as-built information, including asset details, spatial layouts and building components	7.94		
B15	Advanced integration where BIM is combined with real-time sensor data for predictive maintenance and operational efficiency	7.71		
B8	Project files including all FM-related BIM data are modifiable by all project stakeholders including FM personnel	7.46		
B14	BIM tools/systems are integrated with FM tools/systems for lifecycle cost analysis based on historical data provided for cost estimation and decision making	7.42		
B3	Project files including all FM-related BIM data are shared in open data format via IFC standard (data can be exchanged between different BIM as well as FM software)	7.16		
B1	Project files including all FM-related BIM data are shared in paper-based format	6.15		

Practice B2 = “Project files including all FM-related BIM data are shared in digital format using specific software” received the highest mean rank, showing that it is the most commonly practiced among the respondents. This aligned with literature that emphasises that there is a growing shift toward digitalisation in FM practices, where with the help of software facilitates data management and data accessibility (Hou, Ho and Yau, 2024).

Meanwhile, practice B10 = “BIM tools/systems are integrated with FM tools/systems to facilitate building operation” was ranked second highest mean rank, showing that the respondents recognised the importance of BIM-FM integration. However, its second-place ranking might also indicate that despite the awareness of the importance of BIM-FM integration, full integration of BIM with FM is not yet implemented due to several challenges.

In contrast, practice B1 = “Project files including all FM-related BIM data are shared in paper-based format” received the lowest mean rank in the current practices in FM. The indicated that the traditional documentation method is being slowly phased out. The respondents were in favour of more efficient digital methods as traditional paper-based methods are seen as inefficient in modern advanced FM and prone to error. This lowest ranking is also consistent with the highest ranking of practice B2, which highlighted the industry's transitions toward more advanced BIM integration with FM.

4.5 Drivers of BIM Integration with FM

There are 29 statements of drivers that were examined to determine the most significant drivers influencing BIM integration with FM. The data demonstrated a high level of internal consistency with a Cronbach's Alpha value of 0.961. Table 4.4 summarises the mean ranking of drivers of BIM integration with FM based on six categories using Friedman test.

Table 4.4: Mean Ranking of Drivers of BIM with FM in Six Categeries

Code	Statements	Mean Rank	Chi-square	Asymp. Sig.
	Regulatory and Industry Standards			
C2	ISO 19650 establishes policy requirements that guide organisations in best practices and compliance for BIM tool(s)/system(s) when integrating with FM	13.59	146.24	0.000
C1	ISO 19650 provides essential guidelines to ensure consistency and clarity in BIM practices when integrating with FM	13.47		
C4	Construction professional bodies and industry bodies are mandating BIM adoption in construction and FM	13.30		
C5	Compliance with sustainability standards (e.g., LEED, BREEAM and the like) encourages BIM based energy management	13.23		
C3	Government and government-linked agencies are mandating BIM adoption in construction and FM	13.18		
	Technological Advancements			
C9	Development of cloud and mobile solutions improves accessibility	14.62		

Table 4.4 (Continued)

Code	Statements	Mean Rank	Chi-square	Asymp. Sig.
C10	Growth in Internet of Things (IoT), Artificial Intelligence (AI), and Digital Twins is making BIM more valuable in FM	14.61		
C8	Open BIM provides real-time data on FM status to ensure synchronisation and facilitate fast decision-making among FM personnel	13.91		
C6	Open BIM promotes standardised data formats and enable seamless information exchange between different BIM and FM tool(s)/system(s)	13.85		
C7	Open BIM allows project team including FM personnel to use preferred software(s) without any compatibility issues	13.70		
	Asset Information Management (AIM)			
C18	Large-scale and high-tech buildings require advanced FM solutions through BIM integration	16.70		
C13	Real-time monitoring of built assets minimises downtime and optimises facilities performance	16.38		
C17	BIM models assist FM personnel in planning for future facilities expansions	16.29		
C14	Automated monitoring and scheduling through BIM streamline maintenance operations in FM	16.01		
C12	BIM allows better coordination in managing complex infrastructure	15.84		
C11	Asset information management within BIM-FM integration provides a single source asset data to enhance consistency and reliability in facilities operations	15.47		
C16	BIM-driven information and models enhance space management in FM through accurate 3D as-built models	15.41		
C15	3D visualisation of asset information using BIM supports scenario analysis for better decision-making in FM	15.00		

Table 4.4 (Continued)

Code	Statements	Mean Rank	Chi-square	Asymp. Sig.
	Cost Savings and Efficiency			
C20	Predictive maintenance powered by asset information management in BIM-FM anticipates potential failures and improves asset lifecycle management	16.05		
C19	Proactive asset management reduces operational and maintenance costs	15.57		
C21	BIM tool(s)/system(s) forecast long-term expenditures and support more budgeting decisions	14.52		
	Sustainability			
C22	Demand for smarter facility operations	16.58		
C24	BIM-driven FM improves sustainability by enabling data-driven decision-making	15.12		
C23	Energy modelling and performance analysis using BIM improves energy efficiency in FM	14.80		
	Skilled Workforce			
C28	Top management support	16.54		
C29	Shift in mindset among FM personnel for adopting BIM-enabled and driven FM integrated practices/systems	16.36		
C27	Financial investment by companies in BIM technologies and staff training for successful BIM-FM integration	15.96		
C25	Government initiatives through policies and training in promoting BIM integration with FM	14.74		
C26	Availability of knowledgeable, trained and skilled new workforce in relation to BIM-FM integration via tertiary education programmes	14.22		

The most widely agreed driver of BIM integration with FM was C18 = "Large-scale and high-tech buildings require advanced FM solutions through BIM integration". This underscored the critical role of AIM in current FM practices. As the buildings become more technologically advanced and complex, traditional FM approaches are often inadequate to meet the operational demands. This is supported by Tsay, Staub-French and Poirier (2022), who emphasised BIM's significant potential to enhance AIM, especially in large commercial and industrial facilities that require multi-million-dollar operation costs. In these contexts, BIM can lead to substantial cost savings by enabling quicker, more reliable digital information and documentation in FM.

The second-ranked driver, C22 = "Demand for smarter facility operations" falls under the category of sustainability. Sustainability has become a crucial topic in built environment, increasing the pressure on FM teams to reduce energy use and minimise the environmental impact in their FM practices. This push for smarter operations that driven by the combined use of technologies such as Artificial Intelligence (AI), Internet of Things (IoT) and Big Data. One of the respondents shared that BIM could serve as an efficient and effective solution for FM, especially when the FM systems grow increasingly complex due to clients' requirements for more "fancy and unique" features. He noted that these complexities could be addressed through the assistance of AI in the FM industry, which can support human limitations such as realist evaluation. This view aligned with Pavón *et al.* (2021), who stated that with the combined use of these technologies, transformation of outdated large buildings into more efficient and sustainable ones without large investments can be realised. Furthermore, Malagnino *et al.* (2021) also found that the operation and maintenance phase is where BIM-IoT integration offers the most significant benefits, which improve energy performance, resource efficiency, and environmental strategies.

Driver C3 = "Government and government-linked agencies are mandating BIM adoption in construction and FM" received the lowest mean rank, making it the least agreed-upon driver among all the drivers in this research. There are several reasons for this lowest ranking. Although the Malaysian government has mandated BIM adoption in construction projects, these mandates have pertained specifically to BIM Level 2, which focuses on 3D models and basic information coordination. Instead, full integration into FM workflows requires BIM Level 3. Besides, unlike AIM and sustainability drivers which are directly contribute to performance improvement and cost savings, government mandates are often seen as lacking immediate direct value for organisations (Xie, Shen and Zajac, 2020). Therefore, the respondents may perceive driver C3 as the least strategic driver of BIM integration with FM.

Kruskal-Wallis H test was conducted to determine whether there is a statistically significant difference in the drivers of BIM integration with FM among three groups based on years of working experience, which are “Less than 5 years” and “5–10 years” and “More than 10 years”. The original groups of “11–15 years” and “More than 15 years” were combined into “More than 10 years” because their individual sample sizes (19 and 17 respondents, respectively) did not achieve the minimum sample size requirement of 30 samples for Central Limit Theorem to apply. By combining these groups, the resulting sample size (36 respondents) satisfied this requirement, thereby supporting the validity of the statistical analysis. Two hypotheses are generated:

(i) Null hypothesis (H_0): There is no difference between years of working experience towards the drivers of BIM integration with FM.

(ii) Alternative hypothesis (H_1): There is a difference between years of working experience towards the drivers of BIM integration with FM.

An alpha value of 0.05 was adopted with two degrees of freedom. The null hypothesis is rejected when asymptotic significance obtained less than 0.05. Table 4.5 summarised the results of the Kruskal-Wallis H test on the drivers of BIM integration with FM among respondent groups with different years of working experience.

Table 4.5: Kruskal-Wallis Test on Drivers of BIM Integration with FM among Respondent Groups with Different Years of Working Experience

Code	Statements	Less than 5 years (n = 46)		5–10 years (n = 35)		More than 10 years (n = 36)		Asymp. Sig.
		Mean Rank	Rank	Mean Rank	Rank	Mean Rank	Rank	
	Regulatory and Industry Standards							
C1	ISO 19650 provides essential guidelines to ensure consistency and clarity in BIM practices when integrating with FM	53.39	22	62.13	11	58.95	14	0.580
C2	ISO 19650 establishes policy requirements that guide organisations in best practices and compliance for BIM tool(s)/system(s) when integrating with FM	57.71	12	62.73	7	57.32	19	0.654
C3	Government and government-linked agencies are mandating BIM adoption in construction and FM	60.26	9	65.70	1	54.90	29	0.242
C4	Construction professional bodies and industry bodies are mandating BIM adoption in construction and FM	61.21	7	64.26	3	55.41	28	0.367
C5	Compliance with sustainability standards (e.g., LEED, BREEAM and the like) encourages BIM based energy management	52.11	24	59.29	21	60.92	6	0.527
	Technological Advancements							
C6	Open BIM promotes standardised data formats and enable seamless information exchange between different BIM and FM tool(s)/system(s)	59.89	10	62.30	10	56.90	21	0.680
C7	Open BIM allows project team including FM personnel to use preferred software(s) without any compatibility issues	60.39	8	62.80	6	56.47	26	0.579
C8	Open BIM provides real-time data on FM status to ensure synchronisation and facilitate fast decision-making among FM personnel	61.76	5	61.80	14	56.61	23	0.630
C9	Development of cloud and mobile solutions improves accessibility	49.03	29	57.73	24	62.71	2	0.185

Table 4.5 (Continued)

Code	Statements	Less than 5 years (n = 46)		5–10 years (n = 35)		More than 10 years (n = 36)		Asymp. Sig.
		Mean Rank	**Rank**	**Mean Rank**	**Rank**	**Mean Rank**	**Rank**	
C10	Growth in Internet of Things (IoT), Artificial Intelligence (AI), and Digital Twins is making BIM more valuable in FM	51.58	25	59.00	22	61.24	4	0.460
	Asset Information Management (AIM)							
C11	Asset information management within BIM-FM integration provides a single source asset data to enhance consistency and reliability in facilities operations	53.05	23	61.84	13	59.21	11	0.498
C12	BIM allows better coordination in managing complex infrastructure	62.50	4	62.80	5	55.83	27	0.423
C13	Real-time monitoring of built assets minimises downtime and optimises facilities performance	59.05	11	62.63	8	56.97	20	0.634
C14	Automated monitoring and scheduling through BIM streamline maintenance operations in FM	61.39	6	61.97	12	56.63	22	0.615
C15	3D visualisation of asset information using BIM supports scenario analysis for better decision-making in FM	65.11	2	60.14	19	56.52	25	0.484
C16	BIM-driven information and models enhance space management in FM through accurate 3D as-built models	57.68	13	58.09	23	59.90	8	0.929
C17	BIM models assist FM personnel in planning for future facilities expansions	63.11	3	56.73	27	59.02	13	0.718
C18	Large-scale and high-tech buildings require advanced FM solutions through BIM integration	66.32	1	57.50	26	57.63	18	0.503
C19	Proactive asset management reduces operational and maintenance costs	50.47	27	57.54	25	62.38	3	0.289

Table 4.5 (Continued)

Code	Statements	Less than 5 years (n = 46)		5–10 years (n = 35)		More than 10 years (n = 36)		Asymp. Sig.
		Mean Rank	**Rank**	**Mean Rank**	**Rank**	**Mean Rank**	**Rank**	
C20	Predictive maintenance powered by asset information management in BIM-FM anticipates potential failures and improves asset lifecycle management	56.32	18	59.77	20	59.38	10	0.907
C21	BIM tool(s)/system(s) forecast long-term expenditures and support more budgeting decisions	53.97	21	60.96	16	59.43	9	0.677
	Sustainability							
C22	Demand for smarter facility operations	57.53	14	60.94	17	58.37	16	0.887
C23	Energy modelling and performance analysis using BIM improves energy efficiency in FM	50.82	26	63.31	4	59.07	12	0.282
C24	BIM-driven FM improves sustainability by enabling data-driven decision-making	49.58	28	60.76	18	60.87	7	0.272
	Skilled Workforce							
C25	Government initiatives through policies and training in promoting BIM integration with FM	56.76	16	62.47	9	57.75	17	0.718
C26	Availability of knowledgeable, trained and skilled new workforce in relation to BIM-FM integration via tertiary education programmes	55.61	19	61.20	15	58.80	15	0.789
C27	Financial investment by companies in BIM technologies and staff training for successful BIM-FM integration	57.18	15	64.36	2	56.57	24	0.466
C28	Top management support	56.74	17	56.41	28	61.12	5	0.722

Table 4.5 (Continued)

Code	Statements	Less than 5 years (n = 46)		5–10 years (n = 35)		More than 10 years (n = 36)		Asymp. Sig.
		Mean Rank	**Rank**	**Mean Rank**	**Rank**	**Mean Rank**	**Rank**	
C29	Shift in mindset among FM personnel for adopting BIM-enabled and driven FM integrated practices/systems	54.32	20	54.80	29	62.75	1	0.328
	Average Mean Rank	**57.06**	**-**	**60.76**	**-**	**58.61**	**-**	**-**

(a) No Significant Difference in Drivers of BIM Integration with FM among Respondent Groups with Different Years of Working Experience

Refer to Table 4.5, the results showed that there is no significant difference in the drivers of BIM integration of FM drivers of BIM integration with FM among respondent groups with different years of working experience. The null hypothesis for all the drivers failed to reject as the asymptotic significance values were greater than 0.05. This indicates that the respondents, regardless of their years of working experience, share the similar perceptions on the drivers of BIM integration with FM.

(b) Respondents with Higher Years of Working Experience Tend to Have Greater Recognition on Drivers of BIM Integration With FM

Based on the average mean ranks from the Kruskal-Wallis H test, respondents with 5–10 years of working experience exhibited the highest recognition on the drivers of BIM integration with FM (mean rank = 60.76), followed by those with more than 10 years of working experience (mean rank = 58.61). Respondents with less than 5 years of working experience showed the lowest mean rank (57.06), indicating a comparatively lower awareness or emphasis on the drivers of BIM integration with FM.

This trend may be attributed to the mid-career professionals (5–10 years) being at a stage where they possess both sufficient practical exposure and up-to-date technical knowledge, enabling them to better understand and integrate BIM in FM contexts. In contrast, less experienced professionals may lack industry exposure, while more experienced individuals may not be as actively engaged with emerging technologies.

(c) Respondents with Higher Years of Working Experience Tend to Manage More and More Diverse Types of Facilities

The pattern observed in subchapter 4.5 (b) is further supported by the number and types of facilities managed across the respondent groups with different years of working experience. As presented in Figure 4.2, among those with less than 5 years of working experience, 39 out of 46 respondents are managing 4 or fewer facilities and only 7 respondents are managing more than 6 facilities. In contrast, respondents with 5–10 years of working experience reported slightly more consistent across all facilities, with 16 out of 35 respondents managing more than 6 facilities. Notably, respondents with more than 10 years of working experience showed the highest proportion of facilities managed, reported 29 out of 36 respondents managing more than 6 facilities.

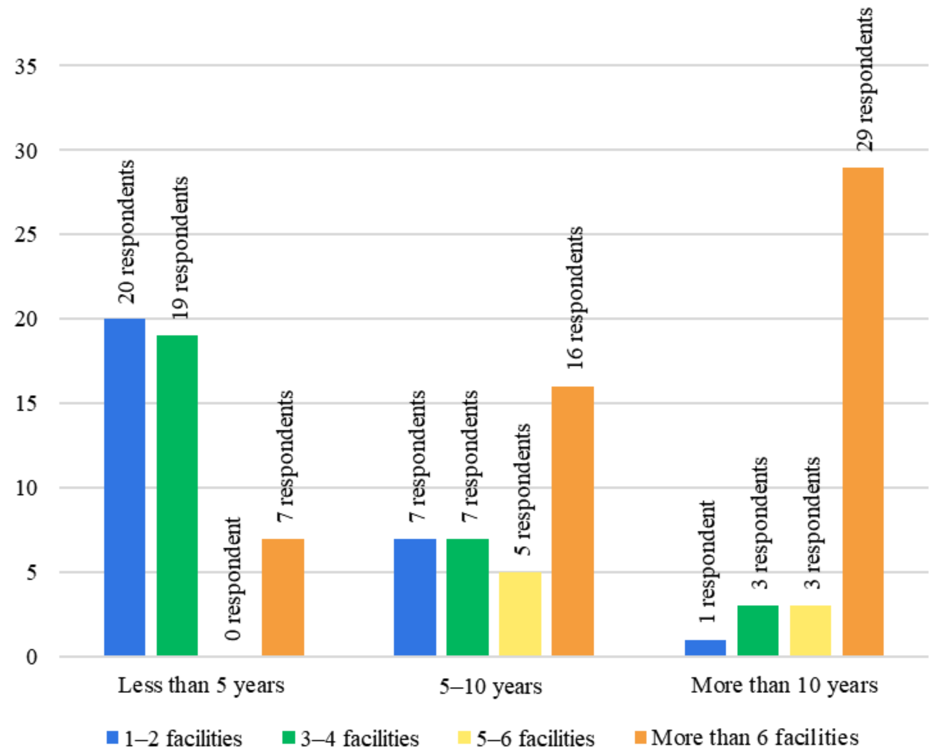

Figure 4.2: Number of Facilities Managed across Respondent Groups with Different Years of Working Experience

In addition to number of facilities managed, the diversity of facilities managed also increases with experiences as shown in Figure 4.3. Respondents with 5–10 years of working experience and more than 10 years of working experience tends to have more even distributed pattern and wider scope across the types of facilities managed such as residential, commercial, industrial, healthcare, education and public infrastructure. Meanwhile, respondents with less than 5 years of working experience are more concentrated on residential, commercial, and industrial facilities. This distribution showed that the less experienced respondents often have limited exposure, causing a lower recognition of the driver of BIM integration with FM, as they are less likely to encounter the complex and varied operational requirements that benefit from BIM integration.

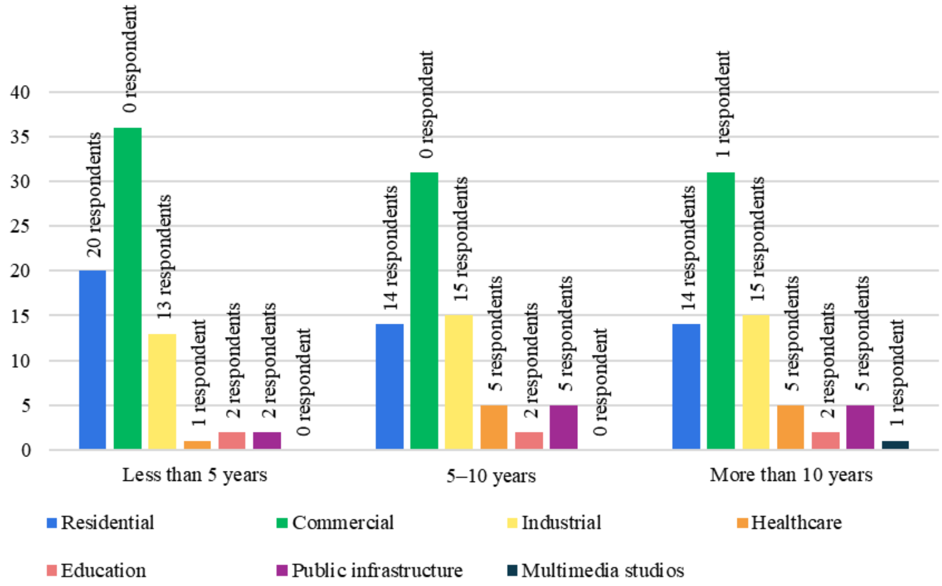

Figure 4.3: Types of Facilities Managed across Respondent Groups with Different Years of Working Experience

4.6 Challenges of BIM Integration with FM

There are 23 statements of challenges were examined to determine the most significant challenges influencing BIM integration with FM. The data demonstrated a high level of internal consistency with Cronbach's Alpha value of 0.972. Table 4.6 summarises the mean ranking of challenges of BIM integration with FM based on four categories using Friedman test.

Table 4.6: Mean ranking of challenges of BIM with FM

Code	Statements	Mean Rank	Chi-square	Asymp. Sig.
	Regulatory and Contractual Aspect			
D1	Lack of standard form for implementing BIM standards in FM	11.55	158.555	0.000
D5	Uncertainty regarding ownership and responsibility of BIM data in FM operations	11.37		
D3	Lack of clear organisational policies, requirements, and guidelines for integrating BIM with FM	11.35		
D2	Lack of a standard/universal approach for BIM data handover to FM personnel	11.29		
D7	Cloud-based BIM-FM systems may be vulnerable to cyber threats	11.17		
D6	Data security and privacy concerns related to BIM-FM integration	11.01		
D4	Unclear legal liability boundaries among stakeholders in BIM-FM (e.g., determining responsibility if a facility failure occurs due to incorrect data)	10.81		
	Technological and Data Aspect			
D8	Complexity in integrating different BIM tool(s)/software(s) with FM tool(s)/software(s) due to data interoperability issues (i.e., lack of standardised formats)	12.16		
D10	Missing asset information, reducing the effectiveness of BIM in FM	12.05		
D14	Unclear BIM workflow causing fragmented information management in FM	11.90		
D9	High data quality requirements in BIM models to support accurate FM decision-making	11.56		
D13	Large BIM model file sizes impacting FM data integrity and system performance	11.05		
D12	Risk of data loss during data translation and exportation between BIM and FM tool(s), software(s)/system(s)	11.01		
D11	Often, as-built BIM models are not fully updated or detailed for FM use	10.92		

Table 4.6 (Continued)

Code	Statements	Mean Rank	Chi-square	Asymp. Sig.
	Financial Aspect			
D15	High cost associated with implementing BIM-FM technologies (i.e. software(s) and system upgrades)	14.40		
D17	High cost associated with training BIM and FM personnel	13.54		
D18	Lack of validity and real cases demonstrating the truthful return of investment in BIM-FM integration	13.14		
D16	Additional costs for data migration from traditional FM system(s)	12.88		
	Human and Organisational Aspect			
D19	Lack of awareness among top management regarding the benefits of integrating BIM in FM	13.86		
D20	Lack of commitment and support from top management in integrating BIM and FM	13.01		
D23	Lack of competent personnel with relevant knowledge in both BIM and FM	12.51		
D22	Lack of proper training and resources for FM personnel to effectively integrate BIM	12.47		
D21	Resistance to BIM-FM integration from both BIM and FM personnel (e.g., workflow disruptions)	10.99		

Challenge D15 = “High cost associated with implementing BIM-FM technologies (i.e. software(s) and system upgrades)” under financial aspects was ranked the most significant challenge in integrating BIM with FM. High implementation cost often includes high license costs and continuous system updates costs (Fateh and Aziz, 2022). While the cost of BIM and FM software is difficult to justify and can range significantly, these financial burdens are especially significant especially for small to medium-sized companies with limited budgets. One respondent highlighted that BIM is an expensive tool in the FM industry as all aspects need to be monitored and observed to ensure the quality of the system is up to the standards that FM needs. This reflects the broader concern that not only are initial investments substantial, but maintaining a high-performing, standards-compliant system also requires continuous financial commitment. Therefore, the consensus around this challenge arises because cost is the fundamental constraint and yet the first step to integrate BIM with FM. This can be proven as all the financial related challenges were listed in the top six challenges in this research.

The second-ranked challenge was D19 = “Lack of awareness among top management regarding the benefits of integrating BIM in FM”. Top management plays a key role in approving budgets, training, and strategic direction. However, if they are unaware of BIM’s long-term value, they are unlikely to support or invest in its adoption (Villena-Manzanares, García-Segura, and Pellicer, 2021). Without top management’s awareness and commitment, efforts to implement BIM-FM may stall, even if FM practitioners are willing to integrate . The respondents shared that awareness of BIM usage in FM should be increased and added that there needs to be more promotion on BIM in the built environment. This highlighted the critical need to aware the top management, who are the decision makers, to advocate this integration in their organisations.

Challenge D4 = “Unclear legal liability boundaries among stakeholders in BIM-FM (e.g., determining responsibility if a facility failure occurs due to incorrect data)” was ranked the lowest among all the challenges, which can be perceived as less directly impactful challenges among the respondents. This is because many respondents may not be experienced with liability disputes and therefore did not aware of this challenge. Furthermore, while BIM-FM implementation is not widely spread in all facilities across Malaysia, legal liability concerns may not become prominent yet. As a result, stakeholders are more focused on overcoming immediate practical barriers such as financial and organisational support. Thus, although challenges D4 is a valid long-term concern, it does not yet command the same level of attention or concern.

Mann-Whitney U test was conducted to determine whether there is a statistically significant difference in the challenges of BIM integration with FM among two respondent groups that “Have Integrated” and “Have Not Integrated” BIM with FM in managing facilities. Two hypotheses are generated:

(i) Null hypothesis (H_0): There is no difference between respondent groups that “Have Integrated” and “Have Not Integrated” BIM with FM in managing facilities towards the challenges of BIM integration with FM.

(ii) Alternative hypothesis (H_1): There is a difference between respondent groups that are “Have Integrated” and “Have Not Integrated” BIM with FM in managing facilities towards the challenges of BIM integration with FM.

An alpha value of 0.05 was adopted with two degrees of freedom. The null hypothesis is rejected when the asymptotic significance is less than 0.05. Table 4.7 summarises the results of the Mann-Whitney U test on the challenges of BIM integration of FM across the respondent groups that are “Have Integrated” and “Have Not Integrated” BIM with FM in managing facilities.

Table 4.7: Mann Whitney U Test on the Challenges of BIM Integration of FM

Code	Statements	Have Not Integrated (n = 31)		Have Integrated (n = 86)		Asymp. Sig.
		Mean Rank	Rank	Mean Rank	Rank	
	Regulatory and Contractual Aspect					
D1	Lack of standard form for implementing BIM standards in FM	49.50	23	62.42	1	0.037*
D2	Lack of a standard/universal approach for BIM data handover to FM personnel	53.44	17	61.01	7	0.208
D3	Lack of clear organisational policies, requirements, and guidelines for integrating BIM with FM	54.31	14	60.69	10	0.298
D4	Unclear legal liability boundaries among stakeholders in BIM-FM (e.g., determining responsibility if a facility failure occurs due to incorrect data)	57.18	8	59.66	16	0.680
D5	Uncertainty regarding ownership and responsibility of BIM data in FM operations	53.08	18	61.13	6	0.197
D6	Data security and privacy concerns related to BIM-FM integration	56.89	10	59.76	14	0.639
D7	Cloud-based BIM-FM systems may be vulnerable to cyber threats	52.71	19	61.27	5	0.168
	Technological and Data Aspect					
D8	Complexity in integrating different BIM tool(s)/software(s) with FM tool(s)/software(s) due to data interoperability issues (i.e., lack of standardised formats)	57.40	7	59.58	17	0.721
D9	High data quality requirements in BIM models to support accurate FM decision-making	53.87	15	60.85	9	0.249
D10	Missing asset information, reducing the effectiveness of BIM in FM	55.06	13	60.42	11	0.373
D11	Often, as-built BIM models are not fully updated or detailed for FM use	53.73	16	60.90	8	0.239
D12	Risk of data loss during data translation and exportation between BIM and FM tool(s), software(s)/system(s)	51.68	20	61.64	4	0.108

Table 4.7 (Continued)

Code	Statements	Have Not Integrate (n = 31)		Have Integrated (n = 86)		Asymp. Sig.
		Mean Rank	Rank	Mean Rank	Rank	
D13	Large BIM model file sizes impacting FM data integrity and system performance	50.95	21	61.90	3	0.073
D14	Unclear BIM workflow causing fragmented information management in FM	55.45	12	60.28	12	0.425
	Financial Aspect					
D15	High cost associated with implementing BIM-FM technologies (i.e. software(s) and system upgrades)	59.29	4	58.90	20	D15
D16	Additional costs for data migration from traditional FM system(s)	63.87	1	57.24	23	D16
D17	High cost associated with training BIM and FM personnel	60.27	2	58.54	22	D17
D18	Lack of validity and real cases demonstrating the truthful return of investment in BIM-FM integration	59.60	3	58.78	21	D18
	Human and Organisational Aspect					
D19	Lack of awareness among top management regarding the benefits of integrating BIM in FM	58.45	5	59.20	19	0.907
D20	Lack of commitment and support from top management in integrating BIM and FM	56.95	9	59.74	15	0.654
D21	Resistance to BIM-FM integration from both BIM and FM personnel (e.g., workflow disruptions)	56.26	11	59.99	13	0.529
D22	Lack of proper training and resources for FM personnel to effectively integrate BIM	50.66	22	62.01	2	0.069
D23	Lack of competent personnel with relevant knowledge in both BIM and FM	58.08	6	59.33	18	0.834
	Average Mean Rank	**44.09**	**-**	**47.77**	**-**	**-**

Note: * indicates the mean rank difference is statistically significant at 0.05 significance level

(a) Respondents Who Have Integrated BIM with FM Perceived Stronger Agreement on Regulatory and Contractual Related Challenges

Refer to Table 4.8, there was only one challenge that showed that statistically significant difference in the challenges of BIM integration with FM, which is D1 = “Lack of standard form for implementing BIM standards in FM” (Asymp. Sig. = 0.037) from the regulatory and contractual aspect. Since this asymptotic significance value is less than the significance threshold of 0.05, the alternative hypothesis for D1 is accepted, implying a significant difference in perceptions between the groups. For all other challenges (D2 to D23), the null hypothesis is failed to be rejected, indicating no statistically significant differences.

The significant difference observed for challenge D1 is attributed to the variance in the mean rank between the two respondent groups regarding the challenges of BIM integration with FM. According to Table 4.8, challenge D1 was ranked the highest (mean rank of 62.42) by the respondents who have integrated BIM with FM in managing facilities, while it was ranked the lowest (mean rank of 49.50) by the respondents who have not integrated BIM with FM in managing facilities. This indicates that the respondents who have integrated BIM with FM in managing facilities have a higher agreement level on the lack of standard form as a challenge to integrate BIM with FM than those who have not integrated.

The statistically significant difference in perceptions regarding the challenge D1 can be attributed to the direct experiences of respondents who have integrated BIM with FM in their practices. Insights gathered from the open-ended questions revealed that many respondents expressed their concern about lack of standards for BIM data. This issue aligns with the findings of Hassanain *et al.* (2023), who noted that respondents who have implemented BIM often encounter challenges such as fragmented standards, lack of legal regulations pertaining to the use of BIM in the FM industry, thereby hindering its effective integration and long-term usability in FM contexts. This also supported by Bello and Ayegba (2025), who emphasised that incomplete policy frameworks and policy enforcement systems could influence the integration of BIM with FM.

In contrast, for those who have not integrated BIM with their FM practices perceived that challenge D1 is the least important challenge. This is because they did not practise BIM-FM integration but practised their working based on the traditional method. They may not fully comprehend the importance of standard form which can help them to standardise the procedure, assuming that existing frameworks are sufficient for BIM-FM integration. This can also be seen when those who have not integrated BIM with FM agreed that the major challenge of this integration is challenge D16 = "Additional costs for data migration from traditional FM system(s)".

(b) Respondents who Have Not Integrated BIM with FM Perceived Stronger Agreement on Financial Related Challenges

Based on the average mean ranks in Table 4.8, respondents who have integrated BIM with FM in their practices perceived a higher concern (average mean rank = 47.77) towards the challenges of BIM integration with FM in their practices than compared to those who have not integrated (average mean rank = 44.09). However, a closer look at the top-ranked concerns among those who have not integrated BIM with FM shows a clear trend. From Table 4.8, their top four perceived challenges are all rooted in the financial aspect, which are:

(i) Additional costs for data migration from traditional FM system(s) (mean rank = 63.87)

(ii) High cost associated with training BIM and FM personnel (mean rank = 60.27)

(iii) Lack of validity and real cases demonstrating the truthful return of investment in BIM-FM integration (mean rank = 59.60)

(iv) High cost associated with implementing BIM-FM technologies (i.e. software(s) and system upgrades) (mean rank = 59.29)

This indicated that the financial aspect is the dominant challenge for those who have not integrated BIM with FM. These respondents tend to express concerns regarding additional and high-anticipated costs and lack of funding in BIM-FM integration. Without experience of BIM-FM integration, they may perceive that the initial investment in technologies and training as prohibitively high, while the return on investment is unproven. This statement is echoed in the open-ended feedback received, where one respondent remarked that the risk of investing in BIM-FM integration as it may only be sustained or reliable for several years due concurrent fast changing of technology and innovation in the market. Meanwhile, the respondent also opined that for those existing buildings or older buildings, the implementation is associated with greater challenges especially on additional cost for data transition and personnel exposure.

In contrast, respondents who have integrated BIM with FM acknowledge a broader range of challenges beyond the finance aspect, including regulatory and contractual aspects, technological and data aspects and human and organisational aspects. For this group, they ranked the financial-related challenges as the lowest among all categories, suggesting that once financial barriers are overcome, more nuanced operational and systemic issues become more prominent.

4.7 Summary of Chapter

This chapter presented and discussed the findings derived from the questionnaire survey. 117 responses were collected from the facilities managers and property managers across Malaysia. The Cronbach's Alpha Test was conducted, and the results confirmed the reliability of the statements related to current practices, drivers and challenges. Friedman test, Kruskal-Wallis H test and Mann Whitney U test were also conducted to support the findings in the current practices of FM, the drivers, and challenges of BIM integration with FM. Overall, the results provided a comprehensive understanding of the respondents' agreement level regarding current practices, drivers and challenges in integrating BIM with FM.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

Chapter 5 presents the conclusions and recommendations of the research. The accomplishment of objectives is presented in subchapter 5.2, followed by research contribution in subchapter 5.3. Meanwhile, research contributions and limitations are discussed in subchapter 5.4 and subchapter 5.5, respectively.

5.2 Accomplishment of Research Objectives

All three research objectives were successfully achieved, and the accomplishments are summarised in subchapter 5.2.1 to subchapter 5.2.3.

5.2.1 Objective 1: To explore the current practices of FM in Malaysia

The first objective was achieved by evaluating and ranking 15 statements of current practices in Facilities Management (FM). The result revealed that 73.50% (86 respondents) have integrated Building Information Modelling (BIM) into their FM practices, while 26.50% (31 respondents) have not yet done so. Among those who have integrated BIM in their FM practices, the majority have less than 5 years of working experience, followed by those with 5–10 years of working experience, 11–15 years of working experience and more than 15 years of working experience. In terms of the duration, most respondents (65.12%) have integrated BIM with FM for 1–5 years and 22.09% have done so for less than 1 year, while a smaller group of respondents have integrated BIM with FM over 6 years. The result obtained from Friedman test revealed that the top three current practices in FM, as shown in Table 5.1.

Table 5.1: Top Three Practices in FM

Statements	Rank
Project files including all FM-related BIM data are shared in digital format using specific software	1
BIM tools/systems are integrated with FM tools/systems to facilitate building operation	2
BIM tools/systems are integrated with FM tools/systems for maintenance scheduling	3

5.2.2 Objective 2: To investigate the drivers of BIM integration with FM

The second objective was achieved by evaluating and ranking 29 drivers of BIM integration with FM. The result obtained from the Friedman test revealed that the top three drivers of BIM integration with FM, as shown in Table 5.2.

Table 5.2: Top Three Drivers of BIM Integration with FM

Statements	Rank
Asset Information Management (AIM)	
Large-scale and high-tech buildings require advanced FM solutions through BIM integration	1
Sustainability	
Demand for smarter facility operations	2
Skilled Workforce	
Top management support	3

Further analysis using Kruskal-Wallis H test showed that there is no significant difference in the perception of these drivers between respondent groups with different years of working experience. This suggests that, while there may be slight variations in responses, the differences are not statistically meaningful. Therefore, the drivers of BIM integration with FM appear to be commonly acknowledged across all respondent groups with different years of working experience. Besides, the research also found that respondents with higher years of working experience tend to have greater recognition on the drivers of BIM integration with FM.

5.2.3 Objective 3: To discover the challenges of BIM integration with FM

The third objective was achieved by evaluating and ranking 23 challenges of BIM integration with FM. The result obtained from the Friedman test revealed that the top three challenges of BIM integration with FM, as shown in Table 5.3.

Table 5.3: Top Three Challenges of BIM Integration with FM

Statements	Rank
Financial Aspect	
High cost associated with implementing BIM-FM technologies (i.e. software(s) and system upgrades)	1
Human and Organisational Aspect	
Lack of awareness among top management regarding the benefits of integrating BIM in FM	2
Financial Aspect	
High cost associated with training BIM and FM personnel	3

Further analysis using Man Whitney U test showed that one of the challenges, “Lack of standard form for implementing BIM standards in FM” showed a significant difference in perception between respondent groups who have integrated and have not integrated BIM in their FM practices. This suggests that for this challenge, the level of agreement varies meaningfully between the two groups. Respondents who have integrated BIM in their FM practices perceived stronger agreement on lack of standard form is the main challenge of BIM integration with FM over those who have not integrated. On the other hand, respondents who have not integrated BIM in their FM practices perceived stronger agreement on financial-related challenges as the main challenge of BIM integration with FM.

5.3 Research Implications

When BIM adoption becomes mandatory in all construction projects, the integration of BIM-FM becomes more important. In this research reveals that the necessity of BIM-FM integration is increasingly recognised as more FM practitioners begin to integrate BIM in their practices.

5.3.1 Implications for Industry

This research reveals the FM practitioners' current perceptions and expectations surrounding the integration of BIM within the Malaysian FM industry. It revealed that while BIM-FM integration is currently being practised to some extent, this integration has significant room for improvement, especially in managing older and existing facilities. Therefore, this research provides a better insight on the drivers of BIM-FM integration and challenges that may be faced by the FM practitioners in integrating BIM in their practices. In the respondents' opinion, they agreed that integrating BIM with FM is a good initiative for a better FM practice, especially in managing new facilities development. By addressing the drivers and challenges of BIM integration with FM in this research, this will be a great start and pave the way for a more advanced FM industry.

5.3.2 Implications for Regulatory Bodies

This research investigated the drivers of BIM integration with BIM and its challenges in the Malaysian FM industry context. To increase the awareness of BIM usage in the FM industry, developing a structural implementation framework is crucial. The regulatory bodies may refer to this research to develop more practical strategies to support effective BIM-FM integration across both new and existing facilities. This includes setting minimum BIM standards for FM, providing initiative to support the integration and governing the collaboration among stakeholders through regulatory frameworks.

5.3.3 Implications for Academia

While international researchers have investigated the challenges of this integration in their countries, this research revealed different findings due to the uniqueness of local practices, regulations and resources available in the Malaysian FM industry context. Therefore, it can serve as a stepping stone for future researchers to investigate in a deeper meaning, such as the drivers and challenges of BIM-FM integration in different types of facilities so that future FM practitioners are better equipped to implement and drive BIM in their FM practices.

5.4 Research Limitations

Certain limitations must be acknowledged. Quantitative approach was the only approach used to collect the data, which may limit the generalisability of the research, and it may have limited the deeper insight from the FM practitioners. The second limitation is the sample size. The targeted sampling size was 384 as determined by the Cochran formula, but the actual number of responses received was 117. Although this number still provides useful insights, the smaller sample size reduces the statistical power and may not fully reflect the wider population of FM practitioners in Malaysia. Lastly, in conducting Kruskal-Wallis H test, two original groups of "11–15 years" and "More than 15 years" were combined into one group "More than 10 years" because their individual sample sizes did not meet the minimum sample size requirement of 30 for the central limit theorem to apply. This data grouping therefore, may introduce biases that may influence the results and interpretation.

5.5 Research Recommendations

For future research, there are several recommendations to address the limitations identified in this research. First, future research should incorporate qualitative approaches such as interviews to provide richer insights into the real-world experiences of FM professionals. Besides, to improve the sample size and reliability of the research, future studies should achieve a greater sample size. This can be done by distributing questionnaires through several channels and a longer data collection period to improve the response rate. It is also important to ensure that the diversity of respondents by including respondents from various sectors with different years of working experience and from different regions across Malaysia.

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APPENDICES

Appendix A: Questionnaire

Building Information Modelling (BIM) Integration with Facilities Management (FM) in Malaysia: The Facilities and Property Managers' Perspective

Dear Sir/Madam,

I am a final-year undergraduate student pursuing Bachelor of Science (Honours) Quantity Surveying in Universiti Tunku Abdul Rahman (UTAR). I cordially invite you to participate in my research on **"Building Information Modelling (BIM) Integration with Facilities Management (FM) in Malaysia: The Facilities and Property Managers' Perspective"**. The aim of this research is to examine BIM integration with FM in Malaysia.

This questionnaire is structured into five sections:
Section A: Demographic Information
Section B: Current Practices in Facilities Management
Section C: Drivers of Building Information Modelling Integration with Facilities Management
Section D: Challenges of Building Information Modelling Integration with Facilities Management
Section E: Additional Comments/Suggestions

I would be grateful if the questionnaire is completed by **23 March 2025** to facilitate the data analysis. It will take you approximately 10 minutes to complete. All the data collected from this questionnaire will be kept strictly private and confidential; solely for this research and academic purposes.

Should you have any inquiries or require additional information regarding this questionnaire, please do not hesitate to contact me at ngyx29@1utar.my. Your support in completing this questionnaire will greatly assist me in my education endeavour. Thank you.

Your sincerely,
Ng Yu Xuan

* Indicates required question

Section A: Demographic Information

1. How many years of experience do you have in the area of Facilities Management (FM)?

Mark only one oval.

- Less than 5 years
- 5–10 years
- 11–15 years
- More than 15 years

2. How many facilities have you managed? *

Mark only one oval.

- 1–2 facilities
- 3–4 facilities
- 5–6 facilities
- More than 6 facilities

3. What type of facilities do you manage? (Please select all that apply) *

Check all that apply.

- [ ] Residential (e.g., condominiums)
- [ ] Commercial (e.g., office buildings, shopping malls, hotels, mixed-used development)
- [ ] Industrial (e.g., factories, warehouses)
- [ ] Healthcare (e.g., hospitals, medical centers)
- [ ] Education (e.g., private schools, universities)
- [ ] Public infrastructure (e.g., airports, railway stations)
- [ ] Other: ____________________

4. Have you integrated Building Information Modelling (BIM) to assist you in managing facilities?

Mark only one oval.

- ⬭ Yes
- ⬭ No

5. What is your view on the necessity of integrating Building Information Modelling (BIM) with Facilities Management (FM)?

Mark only one oval.

- ⬭ BIM integration with FM does not provide any advantages or improvements and is completely unnecessary
- ⬭ BIM integration with FM provides minimal benefits and is not essential for overall operations
- ⬭ BIM integration with FM provides some benefits but is not crucial for overall operations
- ⬭ BIM integration with FM provides significant benefits and is necessary for effective operations
- ⬭ BIM integration with FM is highly necessary for optimising long-term facility performance and ensuring effective management

Section B: Current Practices in Facilities Management

6. How long have you integrated Building Information Modelling (BIM) practices in managing your facilities?

Mark only one oval.

- None
- Less than 1 year
- 1–5 years
- 6–10 years
- More than 10 years

7. How frequent do you practice the following? *

Mark only one oval per row.

	Never	Rarely	Occasionally	Frequently	Always
Project files (including all FM-related BIM data) are shared in paper-based format					
Project files (including all FM-related BIM data) are shared in digital format using specific software					
Project files (including all FM-related BIM data) are shared in open data format via IFC standard (data can be exchanged between different BIM as well as FM softwares)					
Project files (including all FM-related BIM data) are shared via cloud-based platform for real-time collaboration					
Project files (including all FM-related BIM data) are					

accessible to FM personnel only	◯	◯	◯	◯	◯
Project files (including all FM-related BIM data) are accessible to all project stakeholders (including FM personnel)	◯	◯	◯	◯	◯
Project files (including all FM-related BIM data) are modifiable by FM personnel only	◯	◯	◯	◯	◯
Project files (including all FM-related BIM data) are modifiable by all project stakeholders (including FM personnel)	◯	◯	◯	◯	◯
BIM is used to store and manage as-built BIM models, as-built information, including asset details, spatial layouts and building components	◯	◯	◯	◯	◯
BIM tool(s)/system(s) are integrated with FM tool(s)/system(s) to facilitate building operation	◯	◯	◯	◯	◯
BIM tool(s)/system(s) are integrated with FM tool(s)/system(s) for energy modeling, estimation and simulation to monitor building energy performance and efficiency improvements	◯	◯	◯	◯	◯
BIM tool(s)/system(s) are integrated with FM tool(s)/system(s) for maintenance scheduling	◯	◯	◯	◯	◯

BIM-enabled FM tool(s)/system(s) are used to trigger maintenance requests based on equipment condition automatically	◯	◯	◯	◯	◯
BIM tool(s)/system(s) are integrated with FM tool(s)/system(s) for lifecycle cost analysis based on historical data provided for cost estimation and decision making	◯	◯	◯	◯	◯
Advanced integration where BIM is combined with real-time sensor data for predictive maintenance and operational efficiency	◯	◯	◯	◯	◯

Section C: Drivers of Building Information Modelling Integration with Facilities Management

8. To what extent do you agree with the following statements regarding **regulatory and industry standards** as a driver of Building Information Modelling (BIM) integration with Facilities Management (FM)?

***Note: *ISO 19650** is an international standard that offers a framework of BIM to administrate information of a built asset.*

Mark only one oval per row.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
ISO 19650* provides essential guidelines to ensure consistency and clarity in BIM practices when integrating with FM	⬭	⬭	⬭	⬭	⬭
ISO 19650* establishes policy requirements that guide organisations in best practices and compliance for BIM tool(s)/system(s) when integrating with FM	⬭	⬭	⬭	⬭	⬭
Government and government linked agencies are mandating BIM adoption in construction and FM	⬭	⬭	⬭	⬭	⬭
Construction professional bodies and industry bodies are mandating BIM adoption in construction and FM	⬭	⬭	⬭	⬭	⬭
Compliance with sustainability standards (e.g., LEED, BREEAM and the like) encourages BIM-based energy management	⬭	⬭	⬭	⬭	⬭

9. To what extent do you agree with the following statements regarding **technological advancements** as a driver of Building Information Modelling (BIM) integration with Facilities Management (FM)?

*__Note: *Open BIM__ is a collaborative approach to BIM through open standard such as IFC, that allowed information to be accessible from the model without disrupting the original design.*

Mark only one oval per row.

	Strongly Disagree	Disagree	Neutral	Agree	Strongl Agree
Open BIM* promotes standardised data formats and enables seamless information exchange between different BIM and FM tool(s)/system(s)	⬭	⬭	⬭	⬭	⬭
Open BIM* allows project team including FM personnel to use their preferred software(s) without any compatibility issues	⬭	⬭	⬭	⬭	⬭
Open BIM* provides real-time data on FM status to ensure synchronisation and facilitate fast decision-making among FM personnel	⬭	⬭	⬭	⬭	⬭
Development of cloud and mobile solutions improves accessibility	⬭	⬭	⬭	⬭	⬭
Growth in Internet of Things (IoT), Artificial Intelligence (AI), and Digital Twins makes BIM more valuable in FM	⬭	⬭	⬭	⬭	⬭

10. To what extent do you agree with the following statements regarding **asset information management** as a driver of Building Information Modelling (BIM) integration with Facilities Management (FM)?

Mark only one oval per row.

	Strongly Disagree	Disagree	Neutral	Agree	Strongl Agree
Asset information management within BIM-FM integration provides a single source asset data which enhances consistency and reliability in facilities operations	◯	◯	◯	◯	◯
BIM allows better coordination in managing complex infrastructure	◯	◯	◯	◯	◯
Real-time monitoring of built assets minimises downtime and optimises facilities performance	◯	◯	◯	◯	◯
Automated monitoring and scheduling through BIM streamline maintenance operations in FM	◯	◯	◯	◯	◯
3D visualisation of asset information using BIM supports scenario analysis for better decision-making in FM	◯	◯	◯	◯	◯
BIM-driven information and models enhance space management in FM through accurate 3D as-built models	◯	◯	◯	◯	◯
BIM models assist FM personnel in planning for future facilities expansions	◯	◯	◯	◯	◯
Large-scale and high-tech buildings require advanced FM solutions through BIM	◯	◯	◯	◯	◯

integration

11. To what extent do you agree with the following statements regarding **cost savings and efficiency** as a driver of Building Information Modelling (BIM) integration with Facilities Management (FM)?

Mark only one oval per row.

	Strongly Disagree	Disagree	Neutral	Agree	Strongl Agree
Proactive asset management reduces operational and maintenance costs	⬭	⬭	⬭	⬭	⬭
Predictive maintenance powered by asset information management in BIM-FM anticipates potential failures and improves asset lifecycle management	⬭	⬭	⬭	⬭	⬭
BIM tool(s)/system(s) forecast long-term expenditures and support more budgeting decisions	⬭	⬭	⬭	⬭	⬭

12. To what extent do you agree with the following statements regarding **sustainability** as a driver of Building Information Modelling (BIM) integration with Facilities Management (FM)?

Mark only one oval per row.

	Strongly Disagree	Disagree	Neutral	Agree	Strongl Agree
Demand for smarter facility operations	⬭	⬭	⬭	⬭	⬭
Energy modelling and performance analysis using BIM improves energy efficiency in FM	⬭	⬭	⬭	⬭	⬭
BIM-driven FM improves sustainability by enabling data-driven decision-making	⬭	⬭	⬭	⬭	⬭

13. To what extent do you agree with the following statements regarding **skilled workforce** as a driver of Building Information Modelling (BIM) integration with Facilities Management (FM)?

Mark only one oval per row.

	Strongly Disagree	Disagree	Neutral	Agree	Strongl Agree
Government initiatives through policies and training in promoting BIM integration with FM	⬭	⬭	⬭	⬭	⬭
Availability of knowledgeable, trained and skill new workforce in relation to BIM-FM integration via tertiary education progammes	⬭	⬭	⬭	⬭	⬭
Financial investment by companies in BIM technologies and staff training for successful BIM-FM integration	⬭	⬭	⬭	⬭	⬭
Top management support	⬭	⬭	⬭	⬭	⬭
Shift in mindset among FM personnel for adopting BIM-enabled and driven FM integrated practices/systems	⬭	⬭	⬭	⬭	⬭

Section D: Challenges of Building Information Modelling Integration with Facilities Management

14. To what extent do you agree that the following challenges arising from **regulatory and contractual aspect** will impact Building Information Modelling (BIM) integration with Facilities Management (FM)?

Mark only one oval per row.

	Strongly Disagree	Disagree	Neutral	Agree	Strongl Agree
Lack of standard form for implementing BIM standards in FM	⬭	⬭	⬭	⬭	⬭
Lack of a standard/universal approach for BIM data handover to FM personnel	⬭	⬭	⬭	⬭	⬭
Lack of clear organisational policies, requirements and guidelines for integrating BIM with FM	⬭	⬭	⬭	⬭	⬭
Unclear legal liability boundaries among stakeholders in BIM-FM (e.g., determining responsibility if a facility failure occurs due to incorrect data)	⬭	⬭	⬭	⬭	⬭
Uncertainty regarding ownership and responsibility of BIM data in FM operations	⬭	⬭	⬭	⬭	⬭
Data security and privacy concerns related to BIM-FM integration	⬭	⬭	⬭	⬭	⬭
Cloud-based BIM-FM systems may be vulnerable to cyber threats	⬭	⬭	⬭	⬭	⬭

15. To what extent do you agree that the following challenges arising from **technological and data aspect** will impact Building Information Modelling (BIM) integration with Facilities Management (FM)?

Mark only one oval per row.

	Strongly Disagree	Disagree	Neutral	Agree	Strongl Agree
Complexity in integrating different BIM tool(s)/software(s) with FM tool(s)/software(s) due to data interoperability issues (i.e. lack of standardised formats)	⬭	⬭	⬭	⬭	⬭
High data quality requirements in BIM models to support accurate FM decision-making	⬭	⬭	⬭	⬭	⬭
Missing asset information, reducing the effectiveness of BIM in FM	⬭	⬭	⬭	⬭	⬭
Often, as-built BIM models are not fully updated or detailed for FM use	⬭	⬭	⬭	⬭	⬭
Risk of data loss during data translation and exportation between BIM and FM tool(s), software(s)/system(s)	⬭	⬭	⬭	⬭	⬭
Large BIM model file sizes impacting FM data integrity and system performance	⬭	⬭	⬭	⬭	⬭
Unclear BIM workflow causing fragmented information management in FM	⬭	⬭	⬭	⬭	⬭

16. To what extent do you agree that the following challenges arising from **financial aspect** will impact Building Information Modelling (BIM) integration with Facilities Management (FM)?

Mark only one oval per row.

	Strongly Disagree	Disagree	Neutral	Agree	Strongl Agree
High cost associated with implementing BIM-FM technologies (i.e. software(s) and system upgrades)	⬭	⬭	⬭	⬭	⬭
Additional costs for data migration from traditional FM system(s)	⬭	⬭	⬭	⬭	⬭
High cost associated with training BIM and FM personnel	⬭	⬭	⬭	⬭	⬭
Lack of validity and real cases demonstrating the truthful return of investment of BIM-FM integration	⬭	⬭	⬭	⬭	⬭

17. To what extent do you agree that the following challenges arising from **human and organisational aspect** will impact Building Information Modelling (BIM) integration with Facilities Management (FM)?

Mark only one oval per row.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Lack of awareness among top management regarding the benefits on integrating BIM in FM	⬭	⬭	⬭	⬭	⬭
Lack of commitment and support from top management in integrating BIM and FM	⬭	⬭	⬭	⬭	⬭
Resistance to BIM-FM integration from both BIM and FM personnel (e.g., workflow disruptions)	⬭	⬭	⬭	⬭	⬭
Lack of proper training and resources for FM personnel to effectively integrate BIM	⬭	⬭	⬭	⬭	⬭
Lack of competent personnel with relevant knowledge in both BIM and FM	⬭	⬭	⬭	⬭	⬭

Section E: Additional Comments/Suggestions

18. Please share, if you have any other comments/suggestions on the current practice drivers and challenges of Building Information Modelling (BIM) integration with Facilities Management (FM) in the Malaysian facilities management industry.

Consent of Participation

By clicking "Submit" under this questionnaire survey, I confirm that:

1. I have read and understand all the questions put forth for this research under this questionnaire and have had the opportunity to clarify/ask questions which have been answered fully by Ng Yu Xuan via ngyx29@1utar.my.

2. I understand that all data collected through this questionnaire shall be kept strictly private and confidential. All data collected is solely for this research and academic purposes only.

3. I understand that my participation is voluntarily and I am free to withdraw at any time by notifying Ng Yu Xuan in writing without giving any reason.

4. I understand that Privacy Notice of UTAR which is made available at https://www2.utar.edu.my/PrivacyNotice_English.jsp.