UNIVERSITI TEKNOLOGI MARA

AN INTEGRATED BUILDING INFORMATION MODELLING-FACILITIES MANAGEMENT (BIM-FM) FRAMEWORK FOR INFORMATION QUALITY IN FACILITIES MANAGEMENT IN MALAYSIA: A SOCIO-TECHNICAL SYSTEMS APPROACH

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CONFIRMATION BY PANEL OF EXAMINERS

I certify that a Panel of Examiners has met on 8 June 2026 to conduct the final examination of Nur Aisyah binti Azmi on her Doctor of Philosophy thesis entitled "An Integrated Building Information Modelling-Facilities Management (BIM-FM) Framework For Information Quality In Facilities Management In Malaysia: A Socio-Technical Systems Approach" in accordance with Universiti Teknologi MARA Act 1976 (Akta 173). The Panel of Examiners recommends that the student be awarded the relevant degree. The Panel of Examiners was as follows:

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ABSTRACT

Facility Management (FM) plays a critical role in ensuring the functionality, efficiency, and sustainability of the built environment. In Malaysia, FM organizations face persistent challenges in maintaining high facility maintenance information quality (FMIQ) due to fragmented processes, inconsistent standards, and varying levels of digital maturity. Building Information Modelling (BIM) offers significant potential to address these gaps by enabling integrated, data-driven management across the facility lifecycle. Therefore, this research aims to develop an integrated BIM-FM framework for improving FMIQ by examining socio-technical factors and the moderating role of BIM Attributes in Malaysian FM organisations. Specifically, the objectives are to identifies the effects of social factors (people and organisation) and technical factors (technology and process) on FMIQ, identifies the moderating effects of BIM Attributes on these relationships. Then develops and validates an integrated BIM-FM framework based on the empirical findings. Anchored in Socio-Technical Systems theory, this research employed a quantitative, cross-sectional design using a structured questionnaire distributed to BIM and non-BIM FM organisations at the firm level. A total of 238 valid responses were analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM) to assess the measurement and structural models and test the proposed hypotheses. The results demonstrate that people, organisation, technology, and process have significant positive effects on FMIQ. BIM Attributes significantly moderate the effects of organisation and technology on FMIQ but do not significantly moderate the effects of people and process. These findings indicate that the effectiveness of BIM Attributes depends particularly on organisational readiness and technological capability. The research culminates in the development of an integrated BIM–FM framework, providing a strategic model for enhancing FMIQ through socio-technical alignment and digital integration. Theoretically, it extends STS theory by positioning BIM as a strategic moderator, offering nuanced insights into conditional relationships in FM. Practically, the findings offer actionable guidance for FM practitioners, policymakers, and industry stakeholders, supporting Malaysia's National Construction Policy 2030 (NCP) and RMK 13th Plan in advancing the nation's digital transformation agenda in facility management.

Keywords: Facility Management (FM), Building Information Modelling (BIM), BIM-FM, Information Quality, Socio-Technical System Theory (STS), Digital Transformation

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Abbreviations

ACC	Accuracy
BA	BIM Attributes
BAS	Building Automation System
BIM	Building Information Modelling
BIM–FM	Building Information Modelling–Facility Management
CAFM	Computer Aided Facility Management
CDE	Common Data Environment
CIDB	Construction Industry Development Board (Malaysia)
CMMS	Computerized Maintenance Management System
CITP	Construction Industry Transformation Programme
COMP	Completeness
CUR	Currency
D&B	Design and build
EMS	Energy Management System
EKSA	Ekosistem Kondusif Sektor Awam
FM	Facility Management
FMIQ	Facility Management Information Quality
FOR	Format
HVAC	Heating, Ventilation and Air Conditioning
IFMA	International Facility Management Association
IoT	Internet of Things
IQ	Information Quality
IR 4.0	Industrial Revolution 4.0

ISO	International Organization for Standardization
PWD	Jabatan Kerja Raya (Public Works Department)
KM	Knowledge Management
MEP	Mechanical, Electrical and Plumbing
MIPFM	Malaysian Institute of Property and Facility Managers
MyCREST	Malaysian Carbon Reduction and Environmental Sustainability Tool
ORG	Organization
ORG RES	Organizational Resources
PEO	People
PLS-SEM	Partial Least Squares Structural Equation Modelling
PRO	Process
PWD	Public Works Department
RMK	Rancangan Malaysia Ke 13
SPSS	Statistical Package for the Social Sciences
STS	Socio-Technical Systems
SYS QUAL	System Quality
SER QUAL	Service Quality
TAMP	Total Asset Management Plan
TRNG	Training
TWK	Teamwork

CHAPTER 1
INTRODUCTION

1.1 Research Background

Globally, many developed countries have made Building Information Modelling (BIM) a cornerstone of their construction and Facility Management (FM) practices. The United Kingdom, Finland, Sweden, and Australia, for example, have reached advanced stages of BIM adoption, bolstered by government mandates and clearly defined standards (Farea et al., 2024). Malaysia's BIM journey, in contrast, began more modestly primarily through pilot projects and sporadic early adopters, often led by public sector initiatives (Koh Yen Zi, 2024). In response to the risk of failing to meet global standards, Malaysia has intensified its efforts to systematically implement BIM throughout the industry in recent years. Policymakers have recognised BIM as a fundamental catalyst for productivity and innovation within the construction industry (Seng et al., 2025).

It has proven by the national initiative that aligns with wider digitalization efforts. The 13th Malaysia Plan (RMK-13) (2026–2030) highlights the importance of digital innovation, artificial intelligence (AI), and technology-enabled governance (Kementerian Ekonomi, 2025). Focus Area 1 envisions Malaysian as an AI-driven nation by 2030, facilitating the integration of digital technologies across various sectors. Moreover, the National Construction Policy (NCP) 2030 advocates for the integration of Industry 4.0 and the digital transformation of infrastructure delivery (Sajat et al., 2024). Within this context, BIM is characterized not only as modelling software but also as a digital asset platform that facilitates lifecycle information management.

Although utilization of BIM has advanced significantly in the design and construction phases, its incorporation into FM is still relatively nascent (Ashworth et al., 2019). FM represents the most prolonged and resource-intensive stage of the asset lifecycle, involving maintenance administration, spatial organization, energy optimization, compliance oversight, and operational decision-making (Alkhard, 2024). In contrast to construction, which is project-oriented and time-limited, FM is ongoing and heavily reliant on precise and dependable information (Lee et al., 2021).

High-quality information is the foundation of effective FM practice (Tsay et al., 2022a). Data that is accurate, complete, timely, consistent, and pertinent is necessary for daily operational decisions (Lee et al., 2021). However, FM organizations continue to encounter persistent information quality challenges (Aliu et al., 2024; Ashworth, Druhmann, et al., 2019). Asset data is frequently inadequately organized, obsolete, or incomplete for FM purposes (Alkhard, 2024a; Williams et al., 2024). Despite the existence of digital models, maintenance teams frequently re-survey buildings or rely on paper documentation (Munir, Kiviniemi, Finnegan, et al., 2020). In Malaysia, these challenges are compounded by the use of non-interoperable legacy systems, reliance on spreadsheets, paper-based documentation, and fragmented record-keeping systems (Azmi et al., 2023, 2024). Ultimately, this fragmentation undermines operational efficiency and asset performance by resulting in inconsistent, redundant, and unreliable data (Durdyev et al., 2022; Pinti & Codinhoto, 2022). The result is a structural disconnect between digital aspirations and operational realities.

In this context, BIM is often suggested as a solution for FM information issues (Lovell et al., 2024a; S. Matarneh & Elghaish, 2021). BIM serves as a comprehensive digital collection that incorporates geometric, technical, and operational data into a cohesive environment (Carbonari et al., 2018a). When properly executed, BIM–FM integration can improve data consistency, accuracy, accessibility, and lifecycle continuity (Otranto et al., 2025; Pinti & Codinhoto, 2022). While the advantages of BIM-FM information management are clear, realizing those benefits in practice requires more than just technology deployment. Past experiences have shown that simply introducing a new software or database as like a BIM into an organization will not automatically solve information problems (Bittu & Somnath, 2025). In fact, without proper organizational alignment, it can introduce new challenges. FM is a domain where processes are deeply intertwined with human factors lie the culture of the workplace, the skills and attitudes of staff, the established workflows, and the organizational structure all influence how a new system will be effectively used (Dimitrov, 2024; Naji et al., 2024a).

Therefore, this research adopts a socio-technical systems (STS) perspective in seeking to integrate BIM into FM. STS is an organizational theory which posits that every enterprise comprises intertwined social and technical subsystems, and that optimal performance is achieved when these subsystems are jointly optimized and harmony (Bauer & Herder, 2009).

Applying STS to BIM-FM integration means acknowledging that deploying BIM tools alone, without adjusting the surrounding processes and human factors, is unlikely to yield the desired improvement in information quality (Azmi & Ismail, 2025a). By framing the BIM–FM integration through an STS lens, this research focusses on key socio-technical factors that will influence outcomes. On the social side, these include the competencies of FM personnel and the organizational structures. On the technical side, factors include the technology and process. Empirical evidence supports the importance of a socio-technical approach. A recent literature review by Azmi & Ismail, (2025) observed significant gaps in current FM practices when it comes to integrating BIM not due to the absence of technology, but often due to shortcomings in organizational readiness and knowledge management. Moreover, the review found that leveraging STS principles in BIM-FM initiatives can yield benefits like improved collaboration among stakeholders, enhanced operational efficiency in facility processes, greater adaptability to changing requirements, and more user-centered system designs (Azmi & Ismail, 2025).

Despite the clear need, there is currently no widely adopted framework in Malaysia that addresses how to integrate BIM into FM with a focus on enhancing information quality outcomes (Azmi et al., 2024). While general BIM guidelines exist for the design and construction phase and generic data governance models can be found in IT management literature, these do not sufficiently cater to the unique requirements of FM (Matarneh et al., 2020). This variation underscores the need for a flexible, readiness-based integration framework that can guide both advanced and novice organizations. Such a framework should ideally allow an organization to assess its current state and chart a path to progressively implement BIM in a way that improves its FM information quality. To address this gap, the present research develops and validates a BIM–FM Integration Framework grounded in Socio-Technical Systems theory. The framework systematically identifies the critical factors across the social, technical, and BIM attributes that influence Facility information quality.

In essence, it posits that improving FM information quality is a multi-dimensional challenge as it requires competent people and supportive organizations, robust technology infrastructure and well-defined processes, as well as appropriate use of BIM's attributes. The research further hypothesizes that BIM's presence as a moderator that is, if an organization has strong people, organization, process, and technology elements in place, deploying BIM will amplify the positive effects on information quality. Conversely, without those elements, simply having a BIM model will not automatically improve data quality. The development of this framework involved reviewing best practices and models from BIM adoption studies, data quality management literature, and STS theory applications, as well as gathering input from industry experts to ensure its practicality. This contributes not only to organizational performance but also to the broader national goals of modernizing the construction and FM industry, fostering innovation, and making informed decisions that enhance the built environment's value over its entire lifecycle.

1.2 Problem Statement

Malaysia's National Construction Policy 2030 (NCP) and the Thirteenth Malaysia Plan (RMK13) highlight the importance of digital transformation and enhanced information management within the built environment to bolster competitiveness and sustainability (Alaloul et al., 2020; Kementerian Ekonomi, 2025). In this agenda, FM is in charged with achieving operational excellence throughout the asset lifecycle, which relies significantly on the availability of dependable facility information. In FM practice, high-quality facility information is characterized by accuracy, completeness, timeliness, consistency, and accessibility which is crucial for effective maintenance planning, compliance management, risk mitigation, resource allocation, and service delivery (Atkin & Brooks, 2021a; Tsay et al., 2022a). FM information quality (FMIQ) serves as both an operational necessity and a vital performance criterion, influencing the capacity of FM organizations to align with national objectives for effective and sustainable asset management.

Despite its importance, Malaysian FM organizations persistently encounter deficiencies in FMIQ. Recent studies indicate that FM professionals often depend on insufficient, outdated, or inaccurate facility information, especially before and after handover, which hinders maintenance execution and hinders asset decision-making (Azmi et al., 2024; Matarneh & Elghaish, 2021). Inefficient documentation practices and isolated data storage result in inconsistent information updates, redundant asset records, and inadequate version control, leading to unnecessary delays and costly operational errors (Adepoju et al., 2022; Riazi et al., 2020). These conditions decrease the ability of FM teams to execute proactive maintenance, elevate operational risk exposure, and constrain strategic asset management, ultimately impacting user satisfaction and facility value (Adebisi et al., 2021; West et al., 2024).

Digitalisation, especially through BIM-FM, is frequently suggested as a primary solution to issues related to FMIQ (Hassanain, Al-Marzooq, et al., 2025; Pavón et al., 2021a). BIM offers a structured repository for information, facilitating continuity of lifecycle data (Lin et al., 2022). Globally, the integration of BIM and FM is recognized as a standard practice that enhances information accessibility and facilitates maintenance and asset management decision-making (Halim et al., 2022; Pavón et al., 2021b). In Malaysia, the implementation of BIM and other digital FM systems has not consistently resulted in enhanced facility information quality outcomes (Abdulqader et al., 2025; Azmi et al., 2024). Empirical evidence indicates that FM digital transformation is progressing slowly and unevenly, with a limited number of organizations implementing structured strategies and many lacking a definitive implementation roadmap (Abd Aziz et al., 2024; Azmi & Ismail, 2025; Hassanain, Zourob, et al., 2025). The adoption of BIM for FM remains constrained, frequently stop at the construction phase, which limits the operational application of BIM models for FM information requirements (CIDB, 2023; Durdyev et al., 2022). Despite the availability of BIM, interoperability limitations and inconsistent information standards hinder the provision of reliable and FM-ready information (Abdelalim et al., 2024; Alrubaidi, 2024). Consequently, facility information continues to be fragmented and inconsistent in quality, even with the availability of digital tools.

Existing BIM-FM frameworks provide useful guidance on BIM adoption, information exchange, asset data requirements, system integration, and implementation processes (Azmi & Ismail, 2025). However, they have limitations in addressing FMIQ. Many frameworks focus mainly on technology, such as software integration and data exchange, while giving less attention to the people and organisational factors that influence how information is created, updated, and used (Azmi & Ismail, 2025). In addition, some frameworks are designed for specific projects, building types, or more digitally advanced environments, making them less suitable for Malaysian FM organisations with different levels of BIM maturity. Most frameworks also focus on BIM implementation and its expected benefits rather than examining its actual impact on FMIQ. Furthermore, they often overlook how factors such as staff capability, organisational support, technology readiness, and standardised processes work together to influence information quality. As a result, existing BIM-FM frameworks do not fully explain why BIM produces different information-quality outcomes across organisations or the conditions under which it can be most effective.

These FMIQ problems persist partly because they are shaped by multiple interrelated conditions in FM organisations, particularly across people, organisational, technology, and process practices (Azmi et al., 2025; Jylhä & Suvanto, 2015). This is supported by the expert identified challenges in Table 1.3 which mentioned that weak FMIQ also stems from organisational, workforce-related constraints, technology limitations, process and standardization gaps. Further, it is supported by (Jylhä & Suvanto, (2015) and Azmi et al., (2025) that FMIQ is contingent upon the governance roles, workflows, and daily work practices of individuals and organizations, in addition to the system's capability. Research also indicates that FM organizations' consistent information practices are undermined by insufficient training, high staff attrition, limited collaboration, ineffective organizational structures, and inadequate resources (Musa et al., 2020; Wills, 2023; Azmi, 2024). Simultaneously, technical limitations, including fragmented systems, inadequate integration, heavy manual entry, and restricted mobile-enabled workflows, can impede timely updates and elevate error rates (Ismail et al., 2021; Bittu & Somnath, 2025). As a result, the root problem of FMIQ is multi-dimensional, involving interrelated issues in people capability, organisational governance, process standardisation, and technical system integration.

These patterns illustrate that FMIQ is influenced by the interaction between technical conditions (technology, processes) and social conditions (people, organization) Azmi et al., (2025). If responsibilities are unclear, staff are not trained, and validation processes are feeble, even the most advanced digital platforms are unable to provide high-quality information (Azmi et al., 2025). Similarly, FMIQ cannot be maintained by competent staff and strong governance if systems are fragmented, non-interoperable, and inadequately aligned with FM workflows (Dimitrov, 2024; Marjan Sadeghi, 2019). This problem's socio-technical nature implies the necessity of a theoretical framework that elucidates the collaborative impact of social and technical subsystems on FMIQ outcomes.

However, empirical research in Malaysia is scarce about the modelling of how these socio-technical elements effectively affect FMIQ, especially in the context of BIM–FM integration (Azmi & Ismail, 2025). Current research frequently analyzes BIM adoption obstacles, digital preparedness, or FM operational issues in isolation, lacking comprehensive exploration of the interconnections between workforce competence, organizational readiness, process governance, technology integration, BIM application, and measurable FMIQ results (Ismail et al., 2021; Azmi & Ismail, 2025). This gap hinders the formulation of evidence-based policies and systematic frameworks that could assist FM organizations in enhancing FMIQ and achieving national agenda transformation objectives.

Thus, an empirically demonstrated BIM-FM integrated framework, based on a socio-technical approach, is required to clarify and enhance FMIQ across Malaysian FM organizations. This research aims to offer practical suggestions for enhancing FMIQ by methodically analysing the interactions among people, organizations, processes, and technology, and how BIM attributes may reinforce these linkages.

1.3 Research Questions

Several research questions were developed for this research to understand better the facility management information quality (FMIQ) described in the literature. This research will seek to address the following four (4) primary research questions to meet the research objectives:

RQ1: What is the impact of social (people and organizational) and technical (technology and process) on FM information quality?

RQ2: What is the moderation effect of BIM Attributes on the relationship between social (people and organizational) and FM information quality?

RQ3: What is the moderation effect of BIM Attributes on the relationship between technical (technology and process) and FM information quality?

RQ4: How would BIM and FM integration improve the facility management information quality?

1.4 Research Objectives

The present research aims to develop an integrated BIM-FM framework for improving Facilities Management Information Quality by examining the influence of socio-technical factors and the moderating role of BIM Attributes in Malaysian

Facilities Management organisations. The current research attempts to meet the following research objectives:

RO1: To determine the impact of social (people and organizational) and technical (technology and process) on the FM information quality.

RO2: To determine the moderation effect of BIM Attributes on the relationship between social (people and organizational) and FM information quality.

RO3: To determine the moderation effect of BIM Attributes on the relationship between technical (technology and process) and FM information quality.

RO4: To develop and validate an integrated BIM-FM framework for FM information quality.

1.5 Research Need Analysis

To ensure the relevance and applicability of this research, an industry needs analysis was conducted among five industrial experts. According to Alordiah, (2023) and Cerbito (2024) ,conducting a needs analysis is crucial for identifying knowledge gaps, validating the importance of a research problem, and ensuring that research objectives address both academic and practical demands. This analysis aimed to identify critical challenges faced by the industry, key research needs, and potential dependent variables essential for addressing industry concerns. By aligning these needs with existing theoretical frameworks, this research contributes to the literature by bridging research gaps and providing insights into areas requiring further investigation to support industry development and sustainability.

A comprehensive summary of the experts' backgrounds is provided in Table 1.1, detailing their respective industry sectors, years of experience, and organizational roles. This information offers valuable context for understanding the depth and relevance of their insights, ensuring that the identified research focus areas are grounded in practical industry experience. By incorporating perspectives from professionals with diverse expertise, the research enhances its credibility and strengthens the alignment between academic research and industry needs.

Table 1.1
Summary of Experts' Background

Industry Experts	Years of Experience	Positions/Roles
1	13 years in FM 5 years in BIM in FM	Facility Manager
2	10 years in FM years in BIM in FM	Facility Manager
3	10 years in FM	Facility Manager
4	10 years in FM 5 years in BIM in FM	Director of Facility Management Organizaton
5	10 years in FM	Facility Manager

The critical challenges identified by the industry experts have been consolidated and categorized into specific themes, providing a structured view of industry concerns. This thematic categorization delivers comprehensive insights into the prominent issues affecting information quality in FM organizations. By methodically addressing these challenges, the research lays a robust foundation for the research problem, directly linking it to practical industry requirements. This approach not only bolsters the practical significance of the research but also aids in developing a framework that effectively addresses critical theoretical and practical gaps.

Table 1.2
Key Challenges Identified by Industry Experts

Category	Key Challenges Facilities Management Information Quality
Organizational Culture and Change Management	• FM information at handover is frequently incomplete, inaccurate, or outdated. • FM teams are often involved late in the project, leading to information that does not reflect operational realities. • Weak governance as no designated information manager, unclear responsibilities, multiple conflicting asset registers circulating.
Maintenance and Operational Inefficiencies	• Difficulty balancing scheduled maintenance with urgent corrective tasks due to poor data visibility. • Outdated or incorrect information leads to delays. For example, technicians spending days tracing pipes because drawings were not updated. • Missing historical data results in repeated failures and inefficient troubleshooting.

Category	Key Challenges Facilities Management Information Quality
Emerging Trends	• Digital maturity is inconsistent across organizations; some rely heavily on Excel and paper-based systems. • Fragmented systems (BMS, CMMS, asset registers) operate in silos, lack of integration causes duplicated work and delays. • Industry lacks a standardized FM information framework, causing each project to deliver information differently.
Workforce Capability and Competency	• Senior technicians have strong technical skills but weak digital literacy, resulting in poor or delayed documentation of maintenance activities. • Younger staff are familiar with digital tools but lack engineering knowledge, causing misclassification or mislabelling of assets. • Communication gaps between FM teams lead to missing or incorrect updates.
Information Fragmentation	• Information scattered across shared folders, WhatsApp groups, emails, and paper files makes version control difficult. • Major inconsistencies observed during audits. For example, wrong calibration dates, outdated asset ID tags, missing warranty records. • Handover data from contractors often arrives in unstructured formats, requiring extensive rework before use.
System and Technology Limitations	• Outdated maintenance systems requiring heavy manual data entry lead to errors and delays. • systems lack mobile interfaces, so technicians prefer personal notes or photos instead of official forms. • No real-time data capture. For example, BMS alerts not integrated with maintenance systems, causing preventable shutdowns.
Process Gaps and Lack of Standardization	• No standard SOP for updating, validating, or approving FM information across departments. • FM processes vary by building, leading to inconsistent practices. • Lack of audit mechanisms allows errors in the database to remain undetected for months.

These challenges underscore the necessity for further academic exploration to bridge critical gaps in industry knowledge and enhance the understanding of factors affecting information quality in facility management organizations in Malaysia (Zhi & Husain, 2024a). The complexities and evolving nature of these challenges indicate that existing theoretical frameworks may not fully capture the dynamic industry landscape, necessitating empirical research to develop more robust models and solutions. By addressing these gaps, academic research can provide valuable insights that inform industry best practices, improve organizational strategies, and contribute to the sustainable growth of facility management organizations in Malaysia.

Table 1.3
Gaps in Existing Research

Research Need Category	**Specific Areas Identified**
Current Practice in FM	Inconsistent and incomplete FM information at handover, unclear roles and responsibilities, weak information governance, maintenance delays caused by outdated drawings, missing histories, and reactive practices, siloed teams and poor communication, lack of standardized FM processes across buildings.
Workforce Capability & Organizational Readiness	Significant gaps in FM personnel's digital skills, inconsistent documentation habits, reliance on informal communication, low management support for information governance, limited investment in training and structured FM information management roles.
Technology & System Limitations	Fragmented systems with no integration, outdated platforms requiring heavy manual data entry, no mobile tools for technicians; real-time data not captured or synchronized, lack of system interoperability leading to duplicated or conflicting information versions.
Information Quality & Data Fragmentation	Persistent issues with asset data accuracy, completeness, and timeliness, multiple conflicting asset registers, outdated as-built drawings, missing warranties and calibration records, unstructured data received during handover, poor version control and difficulty accessing reliable information.
Process & Standardization Gaps	Absence of standardized process for data updating, validation, and approval, inconsistent workflows between departments, lack of audit mechanisms, different asset classification and documentation formats across projects, FM not involved early enough to influence handover information standards.
Decision-Making Needs	Limited ability to make evidence-based decisions due to unreliable data, delays in maintenance planning, compliance reporting, and risk assessment, difficulty obtaining accurate real-time information for strategic asset management, need for structured models to improve FM decision-making quality.
Emerging Digital Trends	Digital maturity varies widely, FM organisations still rely heavily on manual systems, limited readiness to adopt BIM or structured digital FM practices, lack of integrated digital workflows, industry need for standardized frameworks to leverage BIM/data environments for improved FM information quality.

The research gaps summarised in Table 1.3 emerge directly from the challenges articulated by key industry experts and reflect systemic weaknesses in current FM information practices. This transition from practical challenges to the identification of research gaps illustrates that the concerns are not only operational inefficiencies but signify more profound theoretical and structural inadequacies within current FM practices. The ongoing challenges related to insufficient, incorrect, and uncoordinated asset information demonstrate that present FM information systems significantly fail to satisfy operational requirements.

Despite, the availability and adoption of new digital technologies and more structured documentation procedures, the quality of FM information remains inconsistent in practice. Numerous FM organisations persist in encountering erroneous equipment inventories, obsolete floor layouts, absent warranty data, and contradictory asset registers. The issue stems not just from technology constraints but also from uneven adoption and utilisation, with some personnel actively employing new systems while others persist in traditional or informal ways. The gaps between technological availability and actual use underscore a significant research gap, indicating that enhancements in FM information quality rely not solely on technology, but also on individuals, organisational preparedness, and process alignment.

Furthermore, the absence of FM-specific standards, organised procedures, and decision-making frameworks signifies another domain for scholarly investigation. Despite the promotion of BIM and other digital tools as facilitators of lifecycle information management, current evidence, including insights from FM experts, indicates that these solutions do not inherently address problems of data fragmentation, process inconsistency, or inadequate governance. Indeed, in the absence of well-defined processes and competent personnel, the presence of digital technologies has somewhat of an impact on FM performance.

Therefore, this research serves as a bridge between academic inquiry and industry practice, ensuring that findings are not only theoretically sound but also actionable for business leaders and policymakers. Through empirical validation, the research aims to enhance the understanding of key factors influencing facility management information quality, ultimately fostering productivity, competitiveness, and long-term sustainability within Malaysia's facility management sector. Hence, table below is the summary of the gap, research questions and problem statement of the research.

Table 1.4
Thematic Gap, Research Questions, and Problem Statement

Thematic Gap	Research Questions	Problem Statement Connection
Limited empirical evidence on the impact of social (people and organizational) and technical (technology and process) factors on FM information quality	RQ1: What is the impact of social (people and organizational) and technical (technology and process) on FM information quality?	There is a lack of comprehensive studies examining how social and technical factors affect information quality in Malaysian FM organizations.
Insufficient research on the moderating role of BIM attributes (BA) in FM information quality relationships.	RQ2: What is the moderation effect of BIM Attributes on the relationship between social (people and organizational) and FM information quality? RQ3: What is the moderation effect of BIM Attributes on the relationship between technical (technology and process) and FM information quality?	The moderating effect of BIM attributes in strengthening the relationship between social and technical factors and FM information quality remains underexplored.
Fragmented adoption of BIM and digital solutions in FM, with limited integration into FM processes and information management.	RQ4: How would BIM and FM integration improve the facility management information quality?	The adoption and integration of BIM into FM for enhancing information quality is limited and lacks clear, evidence-based guidance in the Malaysian context.

1.6 Introduction to Industry

Facility Management (FM) is a multidisciplinary field that integrates people, place, process, and technology to ensure the functionality, comfort, safety, and efficiency of the built environment (Babinskė & Apanavičienė, 2020; Ghorbani & Dubler, 2023). In Malaysia, the FM industry has grown rapidly since the early 2000s, evolving from traditional building maintenance to a more strategic and integrated management of Facility and assets (Kamaruzzaman & Zawawi, 2010). The increasing complexity of buildings and infrastructure, coupled with rising stakeholder expectations for sustainability, cost efficiency, and regulatory compliance, has spurred the professionalization of FM in both the public and private sectors (Ismail et al., 2021).

The Malaysian government, through the Construction Industry Development Board (CIDB) and other agencies, has recognized FM as a critical component for sustaining national development, enhancing asset value, and supporting digital transformation agendas (Zi, 2024). The FM industry today encompasses a wide range of services, including operations and maintenance, space management, environmental sustainability, and increasingly, digital technologies like Building Information Modelling (BIM) and smart facility management systems (CIDB, 2023; Musa et al., 2020).

According to the CIDB and recent industry reports, the FM sector in Malaysia is substantial, comprising thousands of organizations ranging from large multinational companies to local SMEs specializing in various FM domains (Hamid et al., 2021a). The sector covers commercial, healthcare, educational, industrial, and governmental Facility. As of 2022, it was estimated that there are over 2,000 registered FM service providers in Malaysia, employing more than 100,000 professionals and technical staff nationwide (Cream, 2021). The market size of the Malaysian FM industry has been projected to exceed RM15 billion by 2025, driven by urbanization, infrastructure investments, and the adoption of digital FM solutions (Zul Azhan, 2025).

FM organizations in Malaysia are diverse in terms of ownership, service specialization, and technological adoption. They range from in-house FM departments within large corporations and government agencies to outsourced FM service providers catering to multiple clients. The industry is characterized by its multidisciplinary workforce, including engineers, surveyors, IT professionals, and facility managers. Increasingly, FM organizations are embracing technology, such as Computer-Aided Facility Management (CAFM) systems, Internet of Things (IoT), and BIM, to improve service delivery and information quality (Amos et al., 2020; Hamid et al., 2021). However, challenges persist, including skill gaps, inconsistent standards, fragmented processes, and varying levels of digital maturity among organizations (Azmi et al., 2024). The shift towards integrated FM and the drive for sustainable, smart building management continue to shape the competitive landscape of the industry (Ashworth et al., 2019).

The relevance of researching FM organizations in Malaysia is underscored by the critical role FM plays in ensuring operational efficiency, asset longevity, and stakeholder satisfaction in the built environment. With the advent of digital technologies like BIM, FM organizations are increasingly required to manage complex information flows, coordinate multidisciplinary teams, and adopt best practices for data quality and integration (Abdelalim et al., 2024).

This research is particularly pertinent as it investigates the impact of social (people and organizational) and technical (technology and process) factors on FM information quality, considering both BIM users and non-users at the firm level. By examining the moderating role of BIM attributes, this research seeks to contribute new knowledge on how digital transformation can enhance FM information quality. Insights from this research are expected to inform both academic understanding and industry practice, supporting Malaysia's vision for a resilient, high-performing built environment.

1.7 Scope of the Research

This research investigates the relationships between social factors, technical factors, BIM Attributes, and Facility Management Information Quality. The social factors comprise People and Organisation, while the technical factors consist of Technology and Process. To achieve the research objectives, the study focuses specifically on facility management information practices within Malaysia. The scope is limited to Grade 7 facility management organisations registered with the Construction Industry Development Board Malaysia (CIDB). These organisations represent various sectors, allowing the study to capture a broad range of FM practices and information-related challenges. Through this focus, the research aims to support the improvement of FM information quality and contribute to more effective, reliable, and sustainable facility management practices.

The target population of this study consists of Grade 7 facility management organisations in Malaysia that are officially registered with CIDB. This population was selected because CIDB registration indicates that the organisations are formally recognised and active within Malaysia's construction and facility management ecosystem. Focusing on registered Grade 7 FM organisations also provides access to organisations that are more likely to manage large-scale and complex facilities and to have established organisational, technological, and operational practices.

The selection of FM organisations from different sectors enables the study to obtain diverse and relevant insights into current information management practices and the challenges affecting FM Information Quality. This scope also supports Malaysia's broader efforts to improve digitalisation, data quality, productivity, and sustainability within the built environment sector. Methodologically, this research adopts a quantitative cross-sectional design. Data were collected at a single point in time from Grade 7 facility management organisations registered with CIDB. A structured questionnaire was used to obtain numerical data on People, Organisation, Technology, Process, BIM Attributes, and FM Information Quality. The collected data were then analysed statistically to examine the proposed direct and moderating relationships in the research model.

1.8 Definition of Key Terms

The following definitions on key constructs and terms are used in this research to facilitate a common understanding of the studied elements.

Table 1.5
Definitions of Key Constructs and Terms

Variables	**Definitions**
People	People (PEO) refer to the characteristics or conditions of a single or group of practitioners performing their related tasks (Salahuddin et al., 2020).
Organisational	Organisational (ORG) condition of the work system in which the practitioners perform their tasks (Salahuddin et al., 2020).
Technology	Technology (TEC) used by practitioners to support their services (Salahuddin et al., 2020).
Process	Process (PRO) refers to the activities that support the accomplishment of work goals (Kashif Ali & Abdul Waheed 2024).
BIM Attributes	BIM Attributes (BA) refer to application areas of Facility management BIM could be implemented and beneficial (Becerik-Gerber et al., 2012).
Information Quality	Information quality (IQ) is defined as the completeness, accuracy, format and currency of information produced by the information system (Akter et al., 2017).

1.9 Significance of Research

The present research synthesizes diverse knowledge from the literature on facility management information quality. The significance of this research can be discussed from both theoretical and practical perspectives.

1.9.1 Theoretical Significance

Theoretically, this research contributes to the body of knowledge on Facility Management Information Quality by integrating social and technical factors within a Socio-Technical Systems perspective. The study examines how people, organisation, technology, and process influence FM Information Quality, while also considering the moderating role of BIM Attributes.

This research also contributes to BIM-FM and information quality literature by proposing an integrated framework that explains how BIM-FM integration can support better information quality in facility management. The framework provides a basis for future studies to further examine socio-technical factors, BIM Attributes, and information quality in different FM contexts.

1.9.2 Practical Significance

Practically, this research provides guidance for FM organizations to improve the quality of facility information used for maintenance, asset management, operations, and decision-making. The framework helps organizations identify key areas that need attention, including staff capability, organizational support, technology readiness, process standardization, and BIM-FM integration.

The findings can assist facility managers, asset owners, BIM practitioners, and policymakers in planning more effective digital information management strategies. By improving FM Information Quality, organizations can support better operational efficiency, reduce information-related errors, and enhance long-term asset performance.

1.10 Organization of Thesis

The current research is subdivided into six chapters, each organised in accordance with the research process used in the current research.

Table 1.6
Organization of Thesis

Chapter	Description
Chapter 1: Introduction	Chapter 1 discusses the background of the research, the problem statement, the research question, the research objectives, the research's theoretical and practical contributions, the research's scope, and the definition of key terms.
Chapter 2: Literature Review	Chapter 2 featured a literature review for all research variables, including PEO, ORG, TEC, PRO, BA and IQ. This chapter also discusses the underlying and supporting theories for the suggested research framework.
Chapter 3: Research Methodology	Chapter 3 consisted of the research framework, hypothesis development, research design, operational definitions, instrumentation, unit of analysis, sampling, data collection procedures, and the data analysis techniques applied in the proposed research.
Chapter 4: Result and Data Analysis	Chapter 4 discusses descriptive, multilevel, confirmatory factor analysis and the PLS-SEM results. Additionally, it discusses the reliability and validity of the measures adopted to conduct the research.
Chapter 5: Discussion of Findings	Chapter 5 discusses each of the research's hypotheses in light of its findings.
Chapter 6: The BIM-FM Integrated Framework for Facility Management Information Quality	Chapter 6 presents the proposed BIM-FM integration framework developed based on the research's findings. It illustrates how social (people and organization) and technical (technology and process) factors interact with BIM attributes to influence FM information quality. The chapter includes expert validation, suggestions for implementation, and potential for industry application to enhance FM performance.
Chapter 7: Conclusion and Recommendation	Chapter 7 present the conclusion summarises the research's theoretical and practical implications and suggests future research possibilities for prospective researchers.

1.11 Chapter Summary

This chapter highlights the importance of Facility Management Information Quality (FMIQ) in supporting maintenance, asset management, decision-making, sustainability, and building performance. Despite national initiatives such as the National Construction Policy 2030 and the Thirteenth Malaysia Plan, many Malaysian FM organisations still face problems with incomplete, inaccurate, outdated, and fragmented facility information. International studies show that BIM can improve information management and FM operations when supported by clear information requirements, integrated systems, digital standards, and early FM involvement. However, BIM in Malaysia is still mainly used during design and construction, with limited application in FM. Existing BIM-FM frameworks also have limitations because they often focus on technology, BIM adoption, or specific projects, while giving less attention to information quality and the combined role of people, organisation, technology, and process. Therefore, this study views FMIQ as a socio-technical issue and applies Socio-Technical Systems theory to examine how People, Organisation, Technology, and Process influence FMIQ, with BIM Attributes acting as a moderator. Chapter 1 also presents the research background, problem statement, research gap, aim, objectives, questions, scope, significance, and the need for an integrated BIM-FM framework to improve FMIQ in Malaysian FM organisations. The next chapter discusses the first part of the review of BIM -FM literature.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This research aims to ascertain the predictive value of people (PEO), organisation (ORG), technology (TEC), process (PRO) and BIM Attributes (BA). This chapter reviews significant literature in light of the current research's design and the conceptual underpinnings of the dependent, independent, and moderating variables employed in the investigation. Subsequently, it delineates the theoretical foundation, gaps identification, and formation of the research model. Lastly, the chapter concludes with the development of hypotheses for empirical testing.

2.2 Facilities Management in Malaysia

Facility Management (FM) is a multidisciplinary profession dedicated to ensuring the functionality, safety, comfort, and efficiency of the built environment (Litvin, 2022). Global standards have formalized FM’s scope and purpose as the organizational function which integrates people, place and process within the built environment with the purpose of improving the quality of life of people and the productivity of the core business (Temeljotov Salaj & Lindkvist, 2021) . This definition, embraced by bodies like the International Facility Management Association (IFMA) and the British Institute of Facility Management (BIFM) underscores FM’s role in aligning Facility with an organization’s mission and users’ needs. In essence, FM bridges people, places, and processes to support core operations at both strategic and day-to-day levels (Butt & Zafar, 2025).

The scope of Facility management is broad, encompassing a wide range of services and asset types (Atkin & Brooks, 2021). Practitioners distinguish between hard FM and soft FM services. Hard FM refers to the management of physical assets and building systems. Soft FM covers support services that improve the occupant experience, such as cleaning, security, landscaping, catering, waste management and mail services (Ibrahim et al., 2025). Beyond this dichotomy, FM includes asset management, space planning, move management, safety and compliance, and real estate administration, among other functions (Ismaeil, 2024; Twum-Bobie et al., 2024). In practice, a FM department may oversee everything from routine building maintenance and repairs to optimizing space utilization and managing vendor contracts. This interdisciplinary breadth means FM integrates principles of engineering, architecture, business management, and human factors to balance the supply of Facility with organizational demand (Özyılmaz et al., 2025) . Common terminology in the field reflects these components such as operations and maintenance (O&M), preventive maintenance, service level agreements (SLAs), occupancy planning, and hard/soft services are all part of FM's lexicon.

Modern organizations increasingly recognize FM as a strategic function vital to performance and sustainability(Alhammadi & Opoku, 2025). Facility managers not only keep buildings running but also align the workplace with business objectives. By providing safe, comfortable, and efficient environments, FM directly supports employee well-being and productivity (Rehan, 2025). Strategic FM function enhances an organization's performance by ensuring the workplace enables the core business, by maximizing the value extracted over assets' life cycles, and by fostering sustainable practices that meet both economic and environmental objectives (Lok et al., 2018).

Facility management has evolved significantly from its origins in maintenance and custodial services to a technology-enabled, data-driven discipline. Analytics dashboards consolidate information on occupancy patterns, maintenance history, and resource use, enabling evidence-based decisions that improve service quality and reduce costs (Yusuff Taofeek Adeshina, 2021) .

2.2.1 Growth and Development

Facility Management (FM) has evolved from a traditionally maintenance-centered function into a multidisciplinary profession that plays a vital role in aligning the built environment with organizational performance (Litvin, 2022) . The growth of FM globally has been significantly influenced by economic globalization, technological advancement, and the shift toward sustainability, asset optimization, and lifecycle cost management (Atkin & Brooks, 2021; Abbass et al., 2025). Historically, the concept of FM began gaining traction in the United States during the 1970s and 1980s, primarily in response to the increasing complexity of commercial building operations (Azman et al., 2014). The International Facility Management Association (IFMA), founded in 1980, formalized FM as a profession and provided a platform for global standardization and knowledge sharing (Lewis et al., 2018). Over the following decades, FM expanded beyond maintenance tasks to include space planning, project management, sustainability, and workplace strategy, particularly with the emergence of integrated workplace management systems (IWMS) and digital tools such as Building Information Modelling (BIM) and Computerized Maintenance Management Systems (CMMS) (Ashworth et al., 2019).

In the context of developing nations like Malaysia, FM's growth was initially centered around public sector infrastructure, especially through the Public Works Department (PWD) and government-linked companies (GLCs). The increasing demand for better asset performance, efficient public service delivery, and sustainable operations spurred the adoption of FM practices in the 1990s and early 2000s (Aloiso, 2018; Opoku & Lee, 2022). The Malaysian government's emphasis on lifecycle asset management was further supported by policies such as the Public Sector Conducive Ecosystem (EKSA), Total Asset Management Plan (TAMP), and strategic roadmaps like the Construction Industry Transformation Programme (CITP) 2016–2020 and its successor Construction 4.0 Strategic Plan (2021-2025) (CIDB, 2023). Furthermore, the 13th Malaysia Plan (2026–2030) has accelerated the growth of FM by emphasizing the importance of digitalisation, green infrastructure, and public asset optimization (Kementerian Ekonomi, 2025). In parallel, the industry has witnessed increasing interest in certification, professional training, and the standardization of FM practices through the adoption of ISO 41001:2018, which defines the structure and requirements for effective FM systems (Butt & Zafar, 2025).

Another critical driver of FM development is the integration of digital technology. The incorporation of BIM, IoT, and cloud-based platforms is transforming FM from a reactive to a predictive and strategic discipline (Signorini & Pomè, 2025). This shift is reshaping the role of FM professionals, who are now expected to manage not only physical infrastructure but also digital information to support decision-making and improve operational efficiency. Despite these advancements, the FM sector in Malaysia still faces developmental challenges such as fragmented adoption across sectors, limited awareness in the private sector, and a shortage of skilled FM professionals with digital and sustainability-related competencies (Azmi et al., 2023). Nonetheless, with increasing government support, professional recognition, and industry collaboration, the trajectory of FM in Malaysia is set toward a more integrated and value-driven future.

2.2.2 Practice

The practice of Facility Management (FM) encompasses a wide range of integrated processes and services that support the functionality, safety, sustainability, and efficiency of the built environment. FM practitioners are responsible for aligning physical spaces and infrastructure with the strategic needs of organizations by managing resources, services, and systems throughout the building life cycle (Atkin & Brooks, 2021). FM practices can be broadly categorized into two main domains:

i. Hard FM services, which involve the management of physical and technical systems such as heating, ventilation, and air-conditioning (HVAC), electrical systems, fire safety systems, plumbing, and structural maintenance.
ii. Soft FM services, which focus on the support services that enhance user experience and building operations, including cleaning, security, landscaping, waste management, pest control, and mail services.

Globally, the scope of FM practice has expanded to incorporate strategic planning, workplace experience, energy optimization, sustainability goals, space utilization, and post-occupancy evaluation (Durmus et al., 2025). The emergence of digital technologies such as Building Information Modelling (BIM), Internet of Things (IoT), and Computerised Maintenance Management Systems (CMMS) has shifted FM practice from a reactive and cost-centered model toward a proactive, value-driven, and data-informed approach (Signorini & Pomè, 2025). In Malaysia, FM practices have historically been influenced by government led initiatives and public sector needs. The Public Works Department (PWD) remains one of the main agencies involved in structured FM service delivery, particularly for public buildings and infrastructure.

Private sector FM practices in Malaysia have also matured, especially in high-value sectors such as healthcare, commercial real estate, higher education, and industrial complexes. Outsourcing of FM services is common in Malaysia, particularly for cost efficiency and access to technical expertise (Kadir et al., 2025). However, the practice of FM still varies significantly in terms of maturity, with some organizations practicing basic maintenance while others integrate advanced digital tools and strategic FM planning (Signorini & Pomè, 2025). Moreover, the adoption of ISO 41001:2018 has provided a global benchmark for FM practices. This international standard emphasizes a systematic approach to managing Facility aligned with organizational objectives and stakeholder needs (Mahabir & Pun, 2022). It promotes continual improvement in FM processes and the integration of FM into organizational governance structures.

Despite this, the FM practice in Malaysia still faces several operational challenges such as lack of centralized data, low technology adoption among SMEs, limited training opportunities, and inconsistent service quality standards across different sectors (Azmi et al., 2023).

2.2.3 Guidelines

Guidelines and frameworks for facility management (FM) offer organized references that help firms plan, implement, monitor, and improve FM processes. These recommendations bring FM services into compliance with international best practices, stakeholder expectations, legal requirements, and strategic objectives. Formalizing FM guidelines helps the discipline become more standardized and professional across different industries and geographical areas (Atkin & Brooks, 2021). The government's efforts to improve infrastructure management and service delivery, especially in public buildings, have coincided with the evolution of FM principles in Malaysia. FM practices are supported nationwide by a number of policy guidelines and standards.

The regulations for facility maintenance in Malaysia are based on a systematic framework of asset and facility management policies designed to promote efficiency, accountability, and sustainability in both public and private sectors. The Government Asset Management Policy (Dasar Pengurusan Aset Kerajaan, DPAK), the Government Comprehensive Asset Management Manual (Manual Pengurusan Aset Menyeluruh, MPAM), the Government Immovable Asset Management Procedure (Tatacara Pengurusan Aset Tak Alih, TPATA), and the MySPATA system (Sistem Pengurusan Aset Tak Alih) represent the four principal guidelines and instruments established by the Malaysian government for the efficient management of assets and Facility (Mohd Ruslly et al., 2023). These frameworks establish standardized processes across ministries and agencies, encompassing asset planning, registration, operation, maintenance, monitoring, and disposal, thereby facilitating lifecycle-based management and systematic reporting (Mohd Ruslly et al., 2023). Their collective efforts constitute the foundation of the public sector's strategy for facility maintenance, aligning with international standards such as ISO 55000 and ISO 41001:2018. This alignment ensures that Malaysian facility management policies adhere to global benchmarks for quality and accountability (Zhi & Husain, 2024a).

These developments are directly supported by Malaysia’s 13th Malaysia Plan (RMK-13, 2026–2030), specifically Focus 1: Towards an AI-Driven Nation, which highlights the importance of enhancing the adoption of Artificial Intelligence (AI) across all sectors (Kementerian Ekonomi, 2025). RMK-13 emphasizes the importance of adopting AI, enhancing digital infrastructure, and implementing data-driven decision-making as essential components for improving national productivity, competitiveness, and sustainability. For Facility management, this involves the utilization of AI-enabled Building Information Modelling platforms, predictive analytics, and digital twins to enhance proactive maintenance, ensure compliance monitoring, and optimize energy usage. The RMK-13 strategies, which focus on enhancing AI adoption in asset management, strengthening digital trust and data ecosystems, and developing AI talent for technical domains, are pertinent to FM organizations as they move towards smart, technology-enabled lifecycle management of assets.

Meanwhile, National Construction Policy 2030 (NCP 2030), developed by the Construction Industry Development Board (CIDB), set out a thorough framework to enhance the competitiveness, productivity, and sustainability of Malaysia's construction sector throughout the full asset lifecycle. The policy emphasizes the implementation of digital construction practices, particularly Building Information Modelling (BIM), as a key facilitator for enhancing integration, transparency, and efficiency in the built environment. NCP 2030 emphasizes the necessity of shifting from conventional, project-centric delivery to value-oriented and lifecycle-focused asset management, acknowledging that the operational phase plays a crucial role in sustained performance and value of Facility. The policy implicitly specifies Facility Management (FM) as a vital sector dependent on precise, standardized, and interoperable building information. NCP 2030 strongly promotes the use of BIM and digital transformation throughout the sector. Yet, comprehensive guidance on the implementation of BIM- FM operations is still limited. This gap highlights the necessity for empirical research to investigate how BIM attributes can enhance FMIQ across the operational lifecycle of Facility. To provide a structured overview of the national guidelines and policies that support Facility Management (FM) practice and digital transformation in Malaysia, Table 2.1 summarises the key frameworks and strategic initiatives relevant to BIM adoption and FM information delivery.

Table 2.1
National Guidelines and Policies Relevant to Facilities Management

Policy / Guideline	**Key Provisions Related to FM**	**Relevance to BIM and FM**
Government Asset Management Policy (DPAK)	Establishes principles for lifecycle asset planning, utilisation, maintenance, and disposal	Requires systematic asset information management, creating the foundation for BIM-enabled FM databases
Government Comprehensive Asset Management Manual (MPAM)	Provides detailed procedures for asset planning, operation, monitoring, and reporting	Emphasizes structured information flow and documentation that can be enhanced through BIM platforms
Government Immovable Asset Management Procedure (TPATA)	Regulates registration, maintenance, monitoring, and disposal of government buildings	Supports lifecycle-based FM processes that rely on accurate and updated building information
MySPATA System	Centralised system for managing government immovable assets	Highlights the need for integrated digital information sources, which BIM can complement for FM use
13th Malaysia Plan (RMK-13, 2026–2030)	Focus 1: AI-driven nation; promotes digital infrastructure, data-driven decision-making, and smart asset management	Encourages the use of AI-enabled BIM, digital twins, and predictive analytics to improve FM information quality and decision-making
National Construction Policy 2030 (NCP 2030)	Promotes digital construction, BIM adoption, lifecycle value, and integrated asset management	Reinforces BIM as a strategic tool beyond construction, supporting FM

2.2.4 Issues in the Current Facilities Management Practice

Despite the growing professionalization and strategic significance of Facility Management (FM), the industry faces numerous ongoing and emerging challenges. The issues are evident in global FM practice and are particularly pronounced in the

Malaysian context, impacting the delivery, quality, and value generation of FM services.

a) Fragmented Data and Information Flow

Facility Management frequently experiences fragmented information flow, particularly during the transition from construction to operational phases. FM teams often encounter incomplete as-built documentation, unstructured data, or legacy paper-based records, which complicates the development of precise maintenance schedules or asset registers (Zhu et al., 2021a). The lack of a common data environment (CDE) leads to data fragmentation across departments, causing redundant efforts, inconsistent asset histories, and delays in decision-making (Jaskula et al., 2024). According to Tajudin et al., (2022), inadequate information transfer is a fundamental cause of inefficiencies in public asset management in Malaysia.

b) Low Adoption of Digital Technologies

The low adoption of digital technologies, including Building Information Modelling (BIM), Internet of Things (IoT), digital twins, and cloud-based platforms, represents a critical issue in contemporary facility management (FM) practice. These technologies have been demonstrated to improve asset visibility, predictive maintenance, and information quality on a global scale (Ashworth et al., 2019; Azmi et al., 2024; Signorini & Pomè, 2025). Factors encompass substantial initial investment, insufficient awareness, inadequate training, and organizational resistance to change (Ikediashi et al., 2025; Low et al., 2021).

c) Skills Shortage and Professional Gaps

The facility management (FM) sector faces a persistent challenge due to a shortage of skilled professionals and gaps in essential competencies needed to address evolving industry demands (Azmi et al., 2023; Signorini & Pomè, 2025). Facility management has evolved from a maintenance-focused field to a strategic, multidisciplinary profession that incorporates sustainability, technology, and lifecycle asset management (Durmus et al., 2025). The rate of professional development and training has not consistently aligned with rapid technological advancements, resulting in notable skill mismatches (Goulart et al., 2022). Research indicates that Facility management professionals frequently lack adequate preparation in digital literacy, data-driven decision-making, and the integration of advanced technologies, especially in domains like Building Information Modelling (BIM), Internet of Things (IoT), and predictive analytics (Kamal et al., 2025).

d) Lack of Standardization in Service Delivery

A significant challenge facing facility management (FM) practice is the absence of standardization in service delivery. Facility Management (FM) is acknowledged worldwide as a profession necessitating standardized practices to guarantee efficiency, quality, and accountability across various sectors, including healthcare, education, commercial real estate, and public infrastructure (Atkin & Brooks, 2021a). In numerous regions, such as Malaysia, the delivery of FM services frequently exhibits fragmentation, characterized by considerable discrepancies in operational procedures, performance benchmarks, and reporting mechanisms among organizations (Hamid et al., 2021; Lindholm et al., 2025). This inconsistency undermines service quality and complicates performance benchmarking and the implementation of continuous improvement.

e) Ineffective Communication and Stakeholder Coordination

Communication and coordination among stakeholders are essential for the success of facility management operations. Facility management encompasses a variety of stakeholders, such as facility managers, building owners, service providers, contractors, tenants, and regulatory bodies, whose interests and responsibilities require careful alignment (Atkin & Brooks, 2021). Industry evidence indicates that communication gaps and misalignment of expectations are persistent challenges in FM, frequently resulting in delays, inefficiencies, and disputes (Hadjioannou, 2023; Lindholm et al., 2025). The coordination of multidisciplinary teams throughout the asset lifecycle is complicated, particularly in the absence of structured communication frameworks and collaborative platforms.

f) Policy and Regulatory Gaps

Policy and regulatory frameworks significantly influence the effectiveness of facility management (FM) practices by establishing governance structures, compliance requirements, and performance standards (Atkin & Brooks, 2021a; Temeljotov Salaj & Lindkvist, 2021). Nonetheless, regulatory gaps and inconsistent enforcement persist, obstructing the advancement of the FM sector both globally and in Malaysia. Numerous countries globally have developed sophisticated regulatory frameworks that facilitate lifecycle asset management, establish sustainability benchmarks, and provide professional certification for Facility management practitioners (Mawed, 2024a). Even in mature markets, the sector faces challenges due to fragmented policies and ambiguous mandates regarding the integration of FM into wider infrastructure and sustainability strategies (Durmus et al., 2025).

Table 2.2
Summary Table of Current Issues in FM Practice

No	Issue	Sources
1.	Fragmented Data	(Zhu et al., 2021a) (Jaskula et al., 2025).(Tajudin et al., 2021)
2.	Low Technology Adoption	(Ashworth et al., 2019; Azmi et al., 2024; Signorini & Pomè, 2025). (Ikediashi et al., 2025; Low et al., 2021).
3.	Skills Gap	(Azmi et al., 2023; Signorini & Pomè, 2025) (Durmus et al., 2025). (Goulart et al., 2022) (Kamal et al., 2025).
4.	Lack of Standardization of Delivery	(Atkin & Brooks, 2021) (Kamaruzzaman et al., 2021) (Lindholm et al., 2025)
5.	Ineffective Communication and Stakeholder Coordination	(Atkin & Brooks, 2021) (Hadjioannou, 2023) Lindholm et al., 2025).
6.	Policy and Regulatory Gaps	(Atkin & Brooks, 2021; Temeljotov Salaj & Lindkvist, 2021) (Mawed, 2024a) (Durmus et al., 2025).

The challenges outlined Table 2.2 demonstrate that FM practices in Malaysia are persistently hindered by fragmented data flow, minimal digital adoption, competency deficiencies, inconsistent service processes, inadequate coordination, and regulatory inefficiencies. These factors result in poor FMIQ, characterized by information that is incomplete, outdated, inconsistent, and challenging to access for operational purposes (Atkin & Brooks, 2021a; Tajudin et al., 2021). Despite previous research identifying these challenges, a significant gap persists such as the current literature rarely positions FMIQ as the primary measure of performance and fails to empirically clarify the interactions of these issues in influencing M throughout the FM lifecycle, particularly within BIM-FM contexts (Azmi et al., 2025; Signorini & Pomè, 2025). Consequently, organizations frequently tackle issues in isolation such as implementing tools, providing training, or modifying procedures, without complete understanding on which socio-technical aspects most significantly influence FMIQ or how BA could improve information quality. This gap leads the current research to create a socio-technical BIM–FM integrated framework that explains and enhances FMIQ in Malaysian FM organizations.

2.2.5 Opportunities and Demands

The development of Facility Management (FM) is intricately connected to organizations' capacity to manage, process, and utilize information efficiently (Mawed, 2024a). As Facility management transitions to a more strategic and data-driven field, the quality of information emerges as a fundamental requirement and a significant opportunity for enhancing value and performance. The rapid adoption of digital technologies represents a significant opportunity in Facility management today (Santos et al., 2024a).

The integration of Building Information Modelling (BIM), Internet of Things (IoT), sensor networks, and data analytics is transforming the design, operation, and maintenance of Facility (Krämer & Besenyoi, 2018). Digital FM platforms facilitate real-time monitoring, predictive maintenance, and enhanced decision-making, effectively tackling persistent inefficiencies and reactive strategies inherent in traditional FM (Zhang et al., 2019; Kassem et al., 2015). In Malaysia, government initiatives, including the Construction 4.0 Strategic Plan emphasize the importance of BIM-enabled asset management as a strategic priority.

Currently, there is an increasing demand in Facility management for the integration of lifecycle information, spanning design and construction to operation and disposal. Access to comprehensive, consistent, and reliable data throughout all stages allows Facility management professionals to enhance asset utilization, predict maintenance requirements, and plan for replacements with greater efficacy (Motawa & Almarshad, 2013; Su et al., 2011). Azmi et al., (2024)highlight that information quality, particularly data accuracy and completeness, is essential for lifecycle costing and total asset management, which are prioritized in Malaysian public sector policy and align with international best practices.

The emergence of flexible workplaces and smart buildings has increased the demand for Facility management to provide user-centric services informed by real-time data. Occupants anticipate timely assistance, tailored environments, and clear communication concerning facility operations (Toochukwu, 2025). High-quality information allows FM teams to anticipate user needs, respond promptly to requests, and assess service satisfaction, thereby enhancing occupant experience and increasing building value (Whyte, 2019). As Facility management (FM) increasingly assumes a strategic role within organizations, senior management depends on precise, comprehensive, and prompt information to inform investment decisions, resource allocation, and performance measurement (Atkin & Brooks, 2021a; Twum-Bobie et al., 2024). Talamo & Bonanomi, (2015) conducted a research indicating that FM teams exhibiting superior information quality surpassed their counterparts in cost control, maintenance efficiency, and asset value optimization.

The emerging opportunities and increasing demands in FM highlight that high-quality information is now a strategic necessity, transcending its previous status as merely an operational concern. Digital transformation, lifecycle asset management, regulatory compliance, and sustainability necessitate that FM organizations produce, access, and utilize precise, timely, and integrated data (Ba et al., 2024). Evidence from the literature indicates that possessing robust processes or skilled personnel is frequently inadequate when information systems are fragmented, inaccessible, or inconsistent (Azmi et al., 2023; Goulart et al., 2022). BIM serves as a significant moderator by fundamentally altering the interactions among people, organizations, technology, and process factors that affect information quality in Facility management. BIM facilitates the digital integration of data throughout the asset lifecycle, dismantling silos and improving the accessibility, completeness, and reliability of FM information (Abdelalim et al., 2024; Munir et al., 2019a). This research will investigate the factors influencing information quality in facility management, emphasizing the integration of Building Information Modelling (BIM) in response to evolving opportunities and demands.

2.3 Building Information Modelling (BIM)

2.3.1 Definition of Building Information Modelling (BIM)

Building Information Modelling (BIM) has evolved from a design-driven concept into a broader framework for managing information across the whole lifecycle of a facility. Scholars and professional bodies now recognise that BIM is much more than a 3D modelling tool as it is a socio-technical system that integrates data on building geometry, materials, systems and processes to inform decisions during construction and operation. The table below summarises how different authors from 2021–2025 describe BIM's role in Facility management (FM). By comparing these perspectives, it shows the focus has shifted from digital modelling to real-time data, lifecycle integration and practical adoption challenges.

Table 2.3
Definition of BIM

Author(s)	Definition/Perspective
(Al-Kasasbeh et al., 2021)	BIM provides real-time, detailed data on spatial layouts, systems, and equipment for optimising FM activities.
(Ehab et al., 2024)	BIM integrates system and material information into a single model, improving maintenance planning and efficiency.
(Okwe et al., 2022)	BIM improves lifecycle management, but adoption faces financial, technical, and organisational barriers in FM contexts.
(Borkowski, 2023)	Digital representation of physical & functional characteristics; serves as a common knowledge resource for decision-making across a facility's entire life-cycle.
(Satyanaga et al., 2023)	BIM is not just software; it is a process using specific software, involving the creation of 3D intelligent models and changes to workflows that enhance collaboration among stakeholders.
(Jane, 2024)	Digital representation of a building's physical & functional characteristics, encompassing the entire life-cycle from planning and design to construction and operation; often implemented through 3D modelling and information modelling.
(Manzoor et al., 2025)	BIM offers a comprehensive digital representation of a building, with detailed information about components, systems and infrastructure; serves as a centralised repository for accurate as-built documentation used in operation and maintenance.

The seven definitions can be grouped into three overlapping themes which are representation, integration, and practice. Although each author emphasises different attributes, there is a clear evolution from focusing on static models to embracing dynamic, collaborative processes. Borkowski (2023), Jane (2024) and Manzoor et al. (2025) foreground BIM as a digital representation of a building's physical and functional characteristics that spans the entire lifecycle. Borkowski (2023) highlights completeness and accessibility which the model should be sufficiently rich to support all lifecycle processes and be a reliable knowledge resource for decision-making. Jane (2024) extends this by emphasizing that BIM's scope runs "from planning and design to construction and operation" reinforcing the life-cycle perspective. Manzoor et al. (2025) refine the idea, framing BIM as a comprehensive repository that not only represents but also stores detailed information about components, systems and infrastructure.

Al-Kasasbeh et al., (2021) and Ehab et al., (2024) shift the emphasis from static representation to integration and data richness. Al-Kasasbeh et al., (2021) describe BIM as a platform that integrates real-time data from IoT sensors to provide continuous insight into spatial layouts, mechanical systems and equipment performance. This real-time integration allows facility managers to monitor conditions like HVAC performance or energy consumption and adjust operations proactively. Ehab et al., (2024) meanwhile, stress that BIM integrates geometric data with materials, dimensions and energy performance into a single model, codifying the building process into data. Their view underscores BIM's role as a single source of truth, where disparate datasets are consolidated, improving maintenance planning and cost estimation. These perspectives highlight that BIM is not only a model but also an information system linking design data with operational performance, bridging static and dynamic information.

Satyanaga et al. (2023) and Okwe et al., 2022) introduce a socio-technical dimension. Satyanaga et al. argue that BIM is not merely software but a process that necessitates organisational change which implementing BIM involves creating 3D intelligent models and altering workflows to enhance collaboration. This interpretation moves beyond the model to consider how people and processes must evolve for BIM to be effective. Okwe et al., 2022) acknowledge BIM's potential for lifecycle management but caution that adoption is constrained by financial, technical and organisational barriers. Their research notes high software costs, licensing fees, lack of training and poor tool interoperability as major obstacles. They emphasise the need for policy support, capacity building and change management to realise BIM's benefits.

Table 2.3 illustrates how BIM's meaning has broadened over recent years. Authors variously emphasise digital representation, data integration and lifecycle orientation. Synthesising these perspectives reveals that BIM's power lies not solely in its 3D modelling capabilities but in its capacity to serve as a dynamic, collaborative information system. An integrated definition that merges comprehensive modelling, real-time data and organisational alignment offers the most promising path for enhancing Facility management. Adopting such a holistic view will help practitioners and researchers navigate the persistent challenges financial, technical and cultural while unlocking BIM's potential to improve operational efficiency, sustainability and strategic asset management.

2.3.2 BIM Implementation Chronology in Malaysia

Table 2.4 presents the chronology of BIM implementation in Malaysia, highlighting a sustained journey of digital transformation within Malaysia's construction sector. Although the Malaysian construction industry has recognized the potential of BIM for over two decades, structured and strategic adoption began to accelerate only after 2007, when the Director of Public Work Department (PWD) formally introduced the idea of BIM integration. This pivotal move signaled the government's growing awareness of BIM's potential to minimize construction costs and design discrepancies during the planning stage (Latiffi et al., 2015).

Initial Foundations and Capacity Building (2007–2012): The foundational years saw the establishment of Autodesk as the principal BIM platform for PWD projects in 2008 and the creation of the PWD BIM Technical Committee in 2010. The first significant pilot National Cancer Institute (NCI) project in Putrajaya was completed three weeks ahead of schedule, demonstrating BIM's value in expediting project delivery and resolving design issues early (Harris et al., 2014; Zainon et al., 2016). These early projects catalyzed the setup of BIM-focused units and training studios to enhance institutional capability and knowledge.

Guidelines, Standardization, and Engagement (2013–2016): April 2013 marked the inaugural PWD BIM Engagement Day, initiating an annual tradition aimed at industry wide reporting of BIM initiatives and the launch of the BIM Roadmap 2013–2016. The roadmap focused on governance, people, process, and technology. By mid 2014, the PWD BIM Guideline and Standard were released, and their enforcement began for all government projects exceeding specified values (RM10–50 million) for in-house design. This period also featured key projects such as MARA College Banting, Terengganu MBKT, and the Endocrine Complex at Putrajaya Hospital, which further cemented BIM's importance in public sector works.

Consolidation and Expansion (2017–2019): The subsequent years were characterized by an increasing number of both in-house and consultant-led BIM projects. Noteworthy were large-scale efforts like Bagan Datuk Polytechnic, Besut Polytechnic, Pasir Gudang Hospital, and Kajang Hospital, all of which leveraged BIM through Design and Build procurement. During this phase, BIM was increasingly used to facilitate design changes, enhance visualization for stakeholders, and generate accurate 3D quantity models, streamlining the estimation process. Engagement efforts deepened through PWD BIM Days, and in 2019, PWD organized a significant MoU kickoff between PWD and local universities (IPTA), strengthening academic-industry collaboration.

Digital Acceleration and National Alignment (2020–2024): In the wake of the COVID-19 pandemic, PWD accelerated its digital agenda, continuing with BIM adoption despite operational disruptions (Sepasgozar et al., 2023). The launch of the PWD Digital Construction Strategic Plan 2021–2025 set out clear goals for BIM, emphasizing standardized processes and technology-driven project delivery (Chan et al., 2023). The PWD BIM Implementation Manual 2021 and the adoption of cloud-based Common Data Environment (CDE) platforms for project collaboration represented major advancements (Othman et al., 2021). By 2022, a structured PWD BIM Competency Framework was established, outlining certification and professional development pathways for staff and stakeholders. BIM was increasingly applied to infrastructure projects beyond building construction, such as highways and utilities, and was subject to the newly launched BIM Audit Programme to ensure quality and compliance (Md Fadzil et al., 2023).

BIM Integration and Smart Asset Management (2023–2024): Recent years saw the integration of BIM with asset and facility management, in line with smart city and sustainability initiatives (Liu et al., 2024). The PWD BIM-FM Integration Guideline was published, guiding public projects toward lifecycle management using BIM and digital twin technologies. In summary, the evolution of BIM within PWD illustrates Malaysia's proactive journey from exploratory pilot projects to a digitally mature, institutionally supported, and policy-driven national standard for public sector project delivery and asset management. The continuous progression and new milestones outlined in Table 2.4 reflect PWD's commitment to digital excellence and industry leadership.

Table 2.4
BIM Implementation Chronology

Year	Description
2007	Introduction of BIM in PWD by the Director, recognizing the potential to enhance project efficiency and reduce design discrepancies (Ahmad Latiffi et al., 2013).
2008	Autodesk established as a BIM platform for PWD projects.
2010	Establishment of PWD BIM Technical Committee; First BIM Pilot Project (D&B): National Cancer Institute (NCI), Putrajaya, completed ahead of schedule (Harris et al., 2014).
2011	BIM Pilot Project Phase I (in-house): SMK Mem Raya Ipoh, Perak; Establishment of PROKOM BIM Unit.
2012	BIM Pilot Project Phase II (in-house): MACC Selangor, Health Clinic Maran Pahang; Establishment of BIM Training Studio.
2013	First PWD BIM Engagement Day; Launch of PWD BIM Roadmap 2013–2016; BIM Project RP3 RMK-10 (in-house): MARA College Banting, Selangor.
2014	Publication of PWD BIM Guideline and Standard; BIM Project (Consultant): MBKT, Terengganu; Restructuring of PWD BIM Technical Committee; PWD BIM Day
2015	BIM Work Process Manual launched; MoU between PWD and UMP; BIM Project (D&B): Endocrine Complex, Putrajaya Hospital; PWD BIM + Asset Day.
2016	BIM requirements for D&B projects enforced; BIM Projects: Parit Buntar Hospital, Kemaman Hospital, UTHM Batu Pahat, Bagan Datuk Polytechnic, Besut Polytechnic, Pasir Gudang Hospital.
2017	BIM Projects (in-house): Seri Iskandar Hospital, Kajang Hospital; BIM Project (Consultant): Istana Raja Muda Perlis; Growing use of BIM in D&B procurement.
2018	BIM Projects (in-house): Pan Borneo Highway Sarawak, Sentul Servis Apartment; PWD BIM Day 2018—BIM Mission aligned to IR 4.0.
2019	Kick-off meeting for MoU BIM between PWD and IPTA (e.g., UMP, USM, UPM, UTM, UniMAP, UTHM, UM, UKM) for academic-industry engagement; planning for BIM Day 2020.
2020	Despite the COVID-19 pandemic, PWD continued to promote BIM via online training, webinars, and the launch of the PWD Digital Construction Strategic Plan 2021–2025 to accelerate digital adoption in public projects (PWD, 2021). BIM was used for critical hospital and quarantine facility upgrades during the pandemic (Salleh et al., 2021).
2021	PWD published the PWD BIM Implementation Manual 2021, standardizing BIM execution processes for all government projects above RM20 million (PWD, 2021). Implementation of cloud-based Common Data Environment (CDE) platforms for real-time collaboration became mandatory for selected projects (Othman et al., 2022).

Year	Description
2022	Rollout of the PWD BIM Competency Framework, which set structured training and certification pathways for PWD staff and project stakeholders (PWD, 2022). BIM adoption expanded to infrastructure projects, including highways and public utilities. The PWD Digital Transformation Committee was formalized to oversee nationwide implementation.
2023	The PWD BIM Audit Programme was launched to assess BIM adoption, quality, and compliance across ongoing public projects. Findings indicated that BIM usage increased to over 50% of all new federal projects, especially for large-scale hospitals and infrastructure (Fadzil et al., 2023). PWD co-hosted the National BIM Symposium 2023, gathering industry, academia, and government to share best practices. The government revised procurement guidelines to prioritize BIM-based submissions for all public tenders above RM10 million.
2024	Full integration of BIM with asset management and Facility maintenance platforms began, aligning with smart city and sustainability initiatives (Rahmat et al., 2024; PWD, 2024). PWD published its first BIM-FM integration guideline. Pilot projects incorporated digital twin technologies for lifecycle asset management, with active collaborations involving universities and tech firms. National policy targets aimed for 75% BIM usage in all new public sector projects by end-2024. Continuous professional development (CPD) in BIM became compulsory for all PWD project managers and consultants.

2.4 Building Information Modelling (BIM) in Facilities Management (FM)

2.4.1 Growth and Development

The adoption of BIM within the FM sector in Malaysia has shown a marked upward trend over the last decade. While BIM was first introduced to drive efficiencies in design and construction, its utility for the operational phase of built assets has become increasingly evident to Malaysian stakeholders. This shift reflects broader global trends, but Malaysia's growth trajectory is shaped by local policies, pilot initiatives, and sector-specific needs.

National policy has been a decisive catalyst. The Construction Industry Transformation Programme (CITP) 2016–2020, and its successor CITP 2021–2025, specifically identify digitalization and integrated asset management as strategic priorities, with BIM at the center of these goals (CIDB, 2021) This has resulted in mandates for BIM use on selected public projects, especially those managed by the Public Works Department (PWD). PWD's Total Asset Management Plan (TAMP) stands out as a pioneering example, leveraging BIM models not only for construction but also for asset condition monitoring, planned maintenance, and facility lifecycle management (PWD, 2020).

Parallel to public initiatives, private sector interest in BIM-FM integration is growing particularly in sectors such as healthcare, higher education, and commercial property. Early adopters have reported improved coordination, more accurate asset registers, and enhanced capability for preventive maintenance (Wong et al., 2025). These benefits address long-standing information handover challenges that often limit FM effectiveness after project completion (Zadeh et al., 2016).

Despite this positive momentum, challenges persist. Integration between BIM platforms and legacy FM systems is often limited, initial costs remain a barrier for smaller organizations, and many FM practitioners are still adapting to new workflows and data requirements (Azmi et al., 2024; Michael and Bock, 2023). Nevertheless, ongoing government support, high-profile pilot projects, and increasing recognition of BIM's operational value point toward sustained growth and greater BIM maturity in Malaysia's FM sector.

2.4.2 Practice

In Malaysia, the use of BIM in FM is steadily gaining ground, particularly within government projects, higher education institutions, and large private sector developments (Abdulqader et al., 2025). BIM is not just a digital 3D modelling tool but serves as an integrated data environment that enhances the quality, accessibility, and usability of building information throughout the facility's operational lifecycle (Toochukwu, 2025).

The practice of BIM in FM typically begins during the construction phase, where project teams develop comprehensive digital models containing detailed asset and spatial information (Ashworth et al., 2023). Clients will specify Owner Information Requirements (OIR) and Asset Information Requirements (AIR) in project briefs (Ashworth, Tucker, et al., 2019). These ensure that BIM models produced during construction will support FM needs after handover, containing accurate and complete data for every system and component (Sadeghi et al., 2019; Zhu et al., 2021).

Upon building completion, the as-built BIM model is transferred to the FM team as part of the digital handover**.** This model becomes a central resource for facility managers, providing a visual and data-rich reference for all maintenance and operations activities (Alkhard, 2024a; Latiffi et al., 2015). The BIM model enables FM teams to quickly locate and assess assets, access equipment manuals and maintenance histories, and plan preventive maintenance schedules based on real-time data and asset conditions (Ashworth et al., 2023; Ehab et al., 2024)

In daily operations, BIM is used for asset and maintenance management, space planning, and condition monitoring. Facility managers can link the BIM model to CMMS or Building Management Systems (BMS), automating work orders and integrating IoT sensor data for predictive maintenance. This results in faster response times to faults, reduced downtime, and more informed decision-making (Nojedehi et al., 2022). For space management, BIM provides up-to-date digital maps of all rooms and functional spaces, supporting efficient allocation, cleaning, and refurbishment activities. In complex environments such as hospitals or university campuses, BIM helps optimize space utilization and manage reconfiguration projects with less disruption (Martino et al., 2023; Wen et al., 2020a).

BIM also facilitates compliance and reporting for audits and sustainability certifications. With all documentation digitally stored and easily retrievable, FM teams can quickly demonstrate compliance with regulatory and green building requirements (Di Gaetano et al., 2023; Kamaruzzaman et al., 2018). Despite these benefits, full BIM-FM integration remains limited in Malaysia (Azmi et al., 2024) . Challenges include the need for specialized skills, ongoing data maintenance, and interoperability with legacy FM systems (Azmi et al., 2023; Wills, 2023). Nevertheless, high-profile projects like Parcel F in Putrajaya are demonstrating the substantial value BIM brings to FM when implemented as part of a long-term information strategy (Ying, 2021). Table 2.5 summarises the practice of BIM in FM in Malaysia.

Table 2.5
Practice of BIM in Facilities Management (FM) in Malaysia

Activity	**Practice**
Data Preparation	OIR specified, BIIM model built with FM-relevant information
Digital Handover	As-built BIM model transferred to FM team at project completion
Asset Management	BIM used for asset register, warranty, maintenance scheduling
Space Management	Digital space inventory, room data, occupancy planning
Integration	Linked with CMMS, BMS for automated operations and reporting
Reporting	Digital records

2.4.3 Guidelines

In the Malaysian context, several key guidelines and frameworks have been developed to localize these international standards and address national priorities. One of the most influential is the Total Asset Management Plan (TAMP) issued by the Public Works Department (PWD). TAMP outlines the requirements for BIM deliverables in government building projects, specifying that models must contain all relevant asset data including maintenance schedules, equipment specifications, and spatial information so that FM teams can seamlessly utilize them upon project handover (Nasir et al., 2022). This has set a benchmark for information quality and transferability in public sector FM.

The Malaysian BIM Guide developed by the Construction Industry Development Board (CIDB) complements these efforts by providing detailed instructions on embedding FM needs into BIM processes from the project outset (Azmi et al., 2024; Hamid et al., 2021). The guide advocates for the early involvement of FM professionals during design and construction to ensure that OIR and AIR are clearly defined, and that BIM data structures reflect the realities of long-term building operation. This lifecycle approach aims to minimize the common problem of data loss or information gaps during the handover from construction to FM.

Sustainability focused frameworks such as MyCREST have further integrated BIM into the broader agenda of green building and carbon reduction in Malaysia. MyCREST encourages the use of BIM models for post-occupancy evaluation, energy monitoring, and reporting on sustainability performance, thus embedding information quality into environmental compliance and FM decision-making (Di Gaetano et al., 2023; Ohueri et al., 2023) . Best practice guidelines also stress the importance of continuous data maintenance and update protocols. Effective BIM for FM requires regular updates to reflect changes such as refurbishments, asset replacements, or spatial reconfigurations. This necessitates clear assignment of responsibilities and robust processes for model management after the initial project delivery (Z. Liu et al., 2024; Maphosa, 2025).

However, despite the existence of these guidelines, the implementation of BIM–FM practices in Malaysia remains inconsistent and continues to develop. The primary deficiency is that current guidance primarily outlines expected deliverables but provide limited empirical evidence and insufficient operational clarity on how organizations can reliably attain and maintain FMIQ throughout FM operations (Myeda & Pitt, 2014). In practice, FM organizations persistently report disjointed data environments, inconsistent documentation practices, inadequate governance regarding information ownership, and restricted capacity to update and validate information post-handover elements that can compromise information quality despite the existence of BIM requirements on paper (Azmi et al., 2024; Hamid et al., 2021).

Furthermore, existing Malaysian guidelines lack a broadly validated socio-technical BIM–FM framework that elucidates the interplay between human capability, organizational support, process standardization, and technology integration with BIM attributes to enhance quantifiable information quality outcomes (Azmi et al., 2023). This gap directly inspires the current project, which aims to build and experimentally evaluate a BIM–FM integrated socio-technical framework to assist Malaysian FM organizations in enhancing and maintaining FMIQ throughout the operating lifespan.

2.4.4 BIM Attributes for Facilities Management (FM)

The integration of BIM into FM is underpinned by a set of attributes that collectively enhance information quality, operational efficiency, and decision-making. After conducting an extensive literature mapping exercise (Appendix 1) to identify BIM attributes that most effectively facilitate Facility Management (FM), nine attributes emerged as the most frequently cited across recent scholarly works. These attributes Lifecycle Data Integration, Controlling and Monitoring Energy, Emergency Management, Planning and Feasibility Studies, Space Management, Digital Assets, Data Interoperability, Visualization, and Real-Time Access consistently appear in the literature as critical enablers of improved FM information quality and decision-making. Their repeated mention across multiple studies underscores their relevance and centrality in enhancing the quality, accessibility, and usability of facility-related information throughout the building lifecycle.

i. **Lifecycle Data Integration** Lifecycle data integration facilitates the continuous transfer of asset information from the design and construction phases to the operational phase (Hassanain, Zourob, et al., 2025; Toochukwu, 2025). Scholars argue that the absence of lifecycle integration results in facility managers receiving incomplete or inconsistent datasets, thereby obstructing effective decision-making (Huan et al., 2025; Mohamed & Marzouk, 2024). Recent studies indicate that BIM's structured data environment facilitates predictive maintenance and asset lifecycle cost analysis, thereby minimizing the "information drop" between project stages (Tajudin et al., 2022). This attribute is essential as its absence hinders the effective operation of other digital innovations in FM.

ii. **Controlling and Monitoring Energy** The integration of BIM with IoT and digital twins facilitates real-time tracking of energy performance (Eneyew et al., 2022; Omrany et al., 2023; Tan et al., 2022). Energy monitoring via BIM models can guide sustainability objectives outlined in the Green Technology Master Plan (2017-2030) and the Construction 4.0 Strategic Plan. The literature indicates that the predictive accuracy of BIM-based energy simulations is significantly influenced by the quality of input data. Furthermore, many Facility management organizations continue to lack the technical expertise necessary to fully utilize these tools (Gerrish et al., 2017; Saeed Banihashemi et al., 2023) . The synthesis of studies reveals significant potential. However, practical adoption remains constrained by skill and cost barriers.

iii. **Emergency Management** BIM offers significant advantages in crisis situations by facilitating the simulation of evacuation routes, enhancing fire safety planning, and enabling hazard visualization (Lotfi et al., 2021). Research indicates that the integration of Building Information Modelling (BIM) with Geographic Information Systems (GIS) and Internet of Things (IoT) sensors improves situational awareness, facilitating expedited decision-making during emergencies (Cao et al., 2023; Mushtaha et al., 2024). Yet, emergency management features remain underutilized in facility management practice, as facility teams frequently prioritize daily operations over contingency planning (Matarneh & Elghaish, 2021).

iv. **Planning and Feasibility Studies** BIM allows facility managers to participate in planning decisions prior to project execution. BIM offers data-driven insights during feasibility studies by simulating operating costs, space usage, and maintainability (Cheng et al., 2020; Saeed Banihashemi et al., 2023). Research indicates that early involvement of Facility management (FM) mitigates downstream operational risks, effectively connecting design intent with operational reality(Hassanain, Zourob, et al., 2025; Oluleye et al., 2023). This attribute emphasizes BIM's strategic role in establishing FM as a partner in organizational decision-making, rather than merely a maintenance function.

v. **Space Management** Space utilization is fundamental to Facility management, especially in commercial and institutional settings where occupancy costs significantly impact budgets (Atkin & Brooks, 2021; Wen et al., 2020). BIM facilitates the dynamic monitoring of spatial configurations, occupancy, and usage patterns, thereby enabling facility managers to enhance workplace strategies (Evjen et al., 2020; Martino et al., 2023). The COVID-19 pandemic has highlighted the necessity for flexible space management, as Building Information Modelling (BIM) enables the reconfiguration of layouts to accommodate social distancing, hybrid work, and capacity optimization (Munir et al., 2019). Consequently, the spatial intelligence of BIM converts Facility management into a catalyst for productivity and well-being.

vi. **Creating Digital Assets** Digital assets denote the development of precise and current digital representations of physical assets (Alkhard, 2024a). The capacity of BIM to function as a centralized digital repository guarantees that FM teams can access as-built information, asset specifications, and maintenance histories (Matarneh & Elghaish, 2021; Tsay et al., 2022a). Recent research connects digital asset creation to the advancement of digital twins, wherein real-time data feeds update Building Information Modelling (BIM) models to reflect the current conditions of Facility (Abdelmoti et al., 2025; Deng et al., 2021a; Evjen et al., 2020). This attribute resolves the persistent facility management issue of incomplete, outdated, or paper-based records, thereby improving information quality directly.

vii. **Data Interoperability** is essential due to the fragmentation of FM systems across CMMS, BMS, and ERP platforms (Biagini et al., 2024; May Michaeland Bock, 2023). BIM facilitates interoperability via open standards like Industry Foundation Classes (IFC), which allow for seamless data exchange among various disciplines and software (Jia et al., 2024; Patacas et al., 2020). In the absence of interoperability, BIM is at risk of devolving into yet another isolated system. Researchers emphasize that interoperability encompasses not only technical aspects but also organizational factors, necessitating agreements on data standards, responsibilities, and governance (Patacas et al., 2020).

viii. **Visualization** represents a significant contribution of BIM, with recent studies emphasizing its particular importance in Facility management (Lovell et al., 2024b; Pinti & Codinhoto, 2022). Three-dimensional (3D) and four-dimensional (4D) models enable facility managers to visualize the placement of concealed assets, model maintenance procedures, and convey intricate information to non-technical stakeholders (Biagini et al., 2024a; Deng et al., 2021a; Keles et al., 2025). Improved visualization minimizes miscommunication, enhances contractor coordination, and facilitates evidence-based decision-making (Omrany et al., 2023; Tan et al., 2022). This attribute emphasizes that information quality encompasses not only accuracy but also usability, as BIM enhances the intuitiveness and accessibility of information.

ix. **Facilitating Real-Time Data Access** integrates all other attributes, allowing facility managers to retrieve, update, and respond to live data streams. The integration of BIM with IoT, cloud, and mobile platforms facilitates ongoing visibility into asset performance, occupancy, and safety (Biagini et al., 2024a; Ehab et al., 2024; Lindholm et al., 2025). Researchers contend that real-time access transitions Facility management from static reporting to dynamic operational intelligence, facilitating predictive maintenance, adaptive comfort management, and rapid incident response (Abdelalim et al., 2025; Mannino & Dejaco, 2021). In this context, real-time access converts BIM from a static "file-based model" into a dynamic, operational system.

Table 2.6
Summary BIM Attributes in FM

Attributes	Description	References
Lifecycle Data Integration	Enables precise tracking and management of assets across their lifecycle for accurate maintenance and lifecycle planning.	(Hassanain, Zourob, et al., 2025; Toochukwu, 2025). (Huan et al., 2025; Mohamed & Marzouk, 2024). (Love et al., 2023; (Tajudin et al., 2022).

Attributes	Description	References
Controlling and Monitoring Energy	Supports real-time energy analysis and efficiency improvements towards sustainability goals.	(Eneyew et al., 2022; Omrany et al., 2023; Tan et al., 2022)(Gerrish et al., 2017; Saeed Banihashemi et al., 2023)
Emergency Management	Facilitates emergency preparedness and response using BIM-sourced data for hazard and evacuation management.	(Lotfi et al., 2021) (Cao et al., 2023; Mushtaha et al., 2024) (S. Matarneh & Elghaish, 2021).
Planning & Feasibility	Enables data-driven decision-making for facility projects via scenario analysis and cost-benefit evaluation.	(Cheng et al., 2020; Saeed Banihashemi et al., 2023). (Hassanain, Zourob, et al., 2025; Oluleye et al., 2023)
Space Management	Enhances layout optimization and occupancy tracking for efficient space utilization.	(Atkin & Brooks, 2021a; Wen et al., 2020b). (Evjen et al., 2020; Martino et al., 2023) (Munir et al., 2019b).
Digital Assets	Creates comprehensive digital records for maintenance, compliance, and long-term information management.	(Alkhard, 2024a)(Matarneh & Elghaish, 2021; Tsay et al., 2022). (Abdelmoti et al., 2025; Deng et al., 2021a; Evjen et al., 2020).
Data Interoperability	Ensures seamless exchange and integration across FM systems (e.g., CMMS, BIM, IoT).	(Biagini et al., 2024; May Michael and Bock, 2023) (Jia et al., 2024; Patacas et al., 2020)(Patacas et al., 2020).
Visualization	Offers intuitive 3D interaction with models, improving communication and decision-making.	(Lovell et al., 2024; Pinti & Codinhoto, 2022) (Biagini et al., 2024; Deng et al., 2021; Keles et al., 2025) (Omrany et al., 2023; Tan et al., 2022).
Real-Time Access	Provides live, location-independent access to updated facility information for agile decision-making.	(Biagini et al., 2024a; Ehab et al., 2024; Lindholm et al., 2025). (Abdelalim et al., 2025; Mannino & Dejaco, 2021).

2.4.5 Evolution of BIM usage in FM

Building Information Modelling (BIM) has become a pivotal instrument in the construction and Facility management (FM) sectors, fundamentally altering the processes of information creation, sharing, and utilization across the building lifecycle (Carrillo, 2024; Dahanayake & Sumanarathna, 2022a; Tajudin et al., 2022). BIM was originally developed as a digital tool to enhance design and construction processes. However, it has since evolved to become essential in the operation and maintenance of Facility, showcasing its ability to improve the efficiency and quality of facility management practices.

a) BIM in the Design Phase

The incorporation of BIM during the design phase emphasizes the development of comprehensive, data-intensive 3D models that facilitate collaboration among architects, engineers, and contractors (Yu et al., 2025). This phase utilizes BIM's ability to deliver precise visualizations, identify clashes, and simulate building performance prior to the commencement of construction (Pishdad-Bozorgi et al., 2018). Embedding Facility-related data into the design model allows BIM to promote the early integration of FM requirements, including maintenance access points, operational efficiency, and space optimization (Wong & Fan, 2013). This proactive strategy guarantees that FM considerations are incorporated at an early stage, thereby minimizing subsequent inefficiencies.

b) BIM in the Construction Phase

During construction, BIM enhances project delivery by enabling real-time tracking of progress, managing resources, and improving communication among stakeholders. It also ensures that as-built information is meticulously documented, which is critical for FM activities post-construction (Hardin & McCool, 2015). For example, the use of BIM for real-time monitoring and data collection during construction ensures that FM teams receive accurate and up-to-date information about the facility’s components, materials, and systems (Azhar, 2011).

c) Transition to Facilities Management

The transition of BIM from construction to FM marks a significant milestone in its evolution. Traditionally, FM teams relied on fragmented, paper-based documentation that was often incomplete or inconsistent, leading to inefficiencies in maintenance and operations (Patacas et al., 2015). BIM addresses these challenges by providing a centralized digital repository of information that FM teams can access for decision-making. The as-built BIM model becomes a “living document,” containing critical information such as equipment specifications, maintenance schedules, and warranty details, thereby streamlining FM processes (Edirisinghe & Woo, 2021).

d) BIM in Facilities Management

In the FM phase, BIM transforms how buildings are operated and maintained by integrating with technologies such as the Internet of Things (IoT), sensors, and real-time monitoring systems (Volk et al., 2014). These integrations allow FM professionals to monitor energy performance, track asset conditions, and automate maintenance tasks. For instance, BIM's ability to provide accurate 3D visualizations and simulations enhances space management, while its interoperability supports integration with Computer-Aided Facility Management (CAFM) systems (Bueno et al., 2018). Moreover, historical data stored within BIM models helps FM teams predict and plan for future needs, reducing operational costs and extending the lifespan of building assets.

e) BIM for Lifecycle Management

The ultimate goal of BIM is to support the entire lifecycle of a facility, from design and construction to operation and eventual decommissioning or renovation. Lifecycle BIM enables a seamless flow of information across all phases, ensuring that data generated By fostering collaboration among stakeholders and enhancing data accessibility, BIM contributes to sustainable lifecycle management practices, including energy efficiency, waste reduction, and cost optimization (Wong & Fan, 2013).

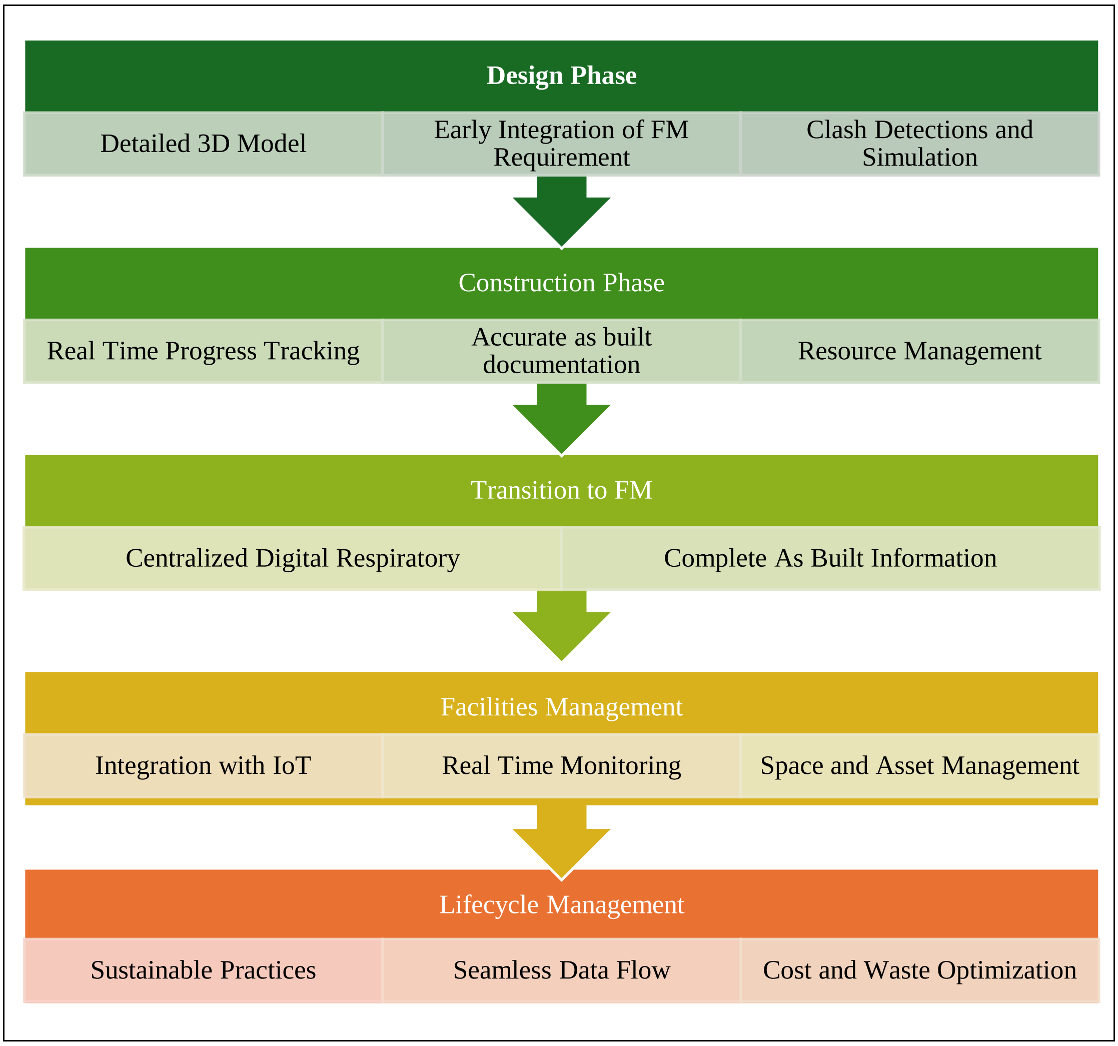

Figure 2.1 BIM for Lifecycle Management (Xu et al., 2014)

2.4.6 Software Used for BIM in FM

IT has enabled "the ability to do more and accomplish many tasks faster by providing things like building control systems, videoconferencing capabilities, computer aided facility management (CAFM), and computerised maintenance management systems (CMMS) (Carbonari et al., 2018b). Various software tools make it possible to gather, handle, and store data, improving accuracy and enabling cost and trend analysis (Carbonari et al., 2018b) (Solla et al., 2020).

BIM is the best collector for data and a great database for information management in Architecture, Engineering and Construction (AEC) as well as for operation stage which can be used for maintenance and facility management. The Malaysian government is conducting in house team to be a department which is has the responsibility to manage assets within the organization (Solla et al., 2020). Currently, ARCHIBUS is one of the FM leading software packages that are able to link with Microsoft Office, AutoCAD and BIM tools such as Revit with its ability to link to ARCHIBUS for FM based on graphical information and model geometry. BIM tools and ARCHIBUS software for facility management and space management is the main aim to evaluate the integration of BIM and facility management. ARCHIBUS was designed to integrate workplace management for real estate, infrastructure and Facility management to define the needs of multiple functions and departments in an organization (Solla et al., 2020).

ARCHIBUS Space Inventory provides an integrated Web central and mobile application in managing and viewing an organization's different types of space (such as Rooms, Division boundaries, service areas, and common areas, etc.) to ensure identification of space with great efficiency. With ARCHIBUS software, facility managers obtain a plan for greater space efficiency by locating the building, division, zones, and departments to get opportunities for the organization (Solla et al., 2020). Besides, a system name MySPATA also being used by the facility management in Malaysia. MySPATA is a system that used to assist the management in reporting, monitoring and controlling government buildings by an established system known as SKATA. It was introduced to achieve standardization coding to all government assets including healthcare Facility. The Space code system (SKATA) can be explained by the code or label used to differentiate each existing space within each area in the building according to the level, position, type, category and function of the space (Solla et al., 2020). Table 2.7 below is the summary of BIM in FM software that been utilized:

Table 2.7
Software Used for BIM in FM

No	Software	Description
1	Computerized Maintenance Management Systems (CMMS)	Facility managers utilise computer software called CMMS to keep comprehensive data about all assets in a facility. It includes modules for work order control, preventive and predictive maintenance, inventory control, etc.
2	Computer Aided Facility Management (CAFM)	Facility managers utilise CAFM software to monitor and schedule departmental events, as well as to identify potential cost-saving opportunities. With the use of this technology, facility managers may automate a number of data-intensive tasks that often lead to ongoing cost savings and better asset utilisation over the course of an asset's full lifespan.

No	Software	Description
3	Building Automation System (BAS)	BAS are computerized distributed control systems for intelligent buildings, which monitor and control certain parameters for heating, ventilation and air-conditioning (HVAC), mechanical, electrical and plumbing (MEP), fire protection and lighting systems.
4	Energy Management System (EMS)	EMS refers to a computer system which provides metering, sub-metering, and monitoring functions that allow facility and building managers to gather data and insight. This allows them to make more informed decisions about energy activities across their sites.
5	COBie	COBie is an industry foundation class (IFC) subset that may be constructed in Excel or IFC format. It is a streamlined non-geometric subset.

a) Computer-Aided Facility Management (CAFM)

CAFM systems frequently use and incorporate different building data. However, the information transfer is difficult due to the re-usability of data in CAFM (Yalcinkaya & Singh, 2014a). Meanwhile, BIM-based applications are being developed to simultaneously collect the data from various stakeholders and transfer this information to the facility manager in a cloud environment to enable the mobility of the facility manager during the FM activities because existing CAFM systems lack the capabilities and functions to collect the building information pushed from various stakeholders and different phases of the project life-cycle (Sulaiman et al., 2021). Benefits of a CAFM with an integrated BIM database and location-based services include information gathering, visualisation for space planning and forecasting, and visualising assets in the context of the space. According to (Ghosh et al., 2015a) a CAFM system will provide the following functionalities:

i. Strategic Planning for improved capital planning of new and remodel assets considering analyses of property and space,
ii. Space Inventory and Management including defining and standardizing space attributes and physical asset inventories for managing space during occupancy and move.
iii. Asset Management using bar codes or Radio Frequency Identification (RFID) tags to track all movable assets and equipment.
iv. Portfolio Management including lease management, portfolio performance and rent and contract management for multiple properties.

v. Operations including tracking energy consumption, utilities monitoring, lighting management, and maintenance management.

vi. Assessments for building condition inspections, condition reporting, security vulnerability, and risk assessments

b) Construction Operations Building Information Exchange (COBie)

COBie is an industry foundation class (IFC) subset that may be constructed in Excel or IFC format (Sakib Ahmed, 2025). It is a streamlined non-geometric subset. The COBie data contains the rooms (spaces) and zones of the facility, the equipment and its position, submittals, instructions, tests, certifications, maintenance, safety, and emergency plans, start-up and shut-down procedures, and resource information for the relevant operations (Alvarez-Romero et al., 2014). Although there is consensus that COBie is necessary for organising facility data, COBie does not specify what information must be delivered, when, or by whom (Abdirad & Dossick, 2019). It has also been considered to be difficult to use and confusing to understand (Yalcinkaya & Singh, 2014a). To filter the information receive for the FM team, the COBie specification was developed to provide a structure for the lifecycle capture and delivery of facility information needed for FM purposes (Yalcinkaya & Singh, 2014a).

c) Computerized Maintenance Management System (CMMS)

CMMS's are deployed for asset management, generation of service requests, managing work orders of different types, calculating/tracking required/used resources for planed/executed jobs, keeping employees records, and inventory of managed assets (Yalcinkaya & Singh, 2014a). BIM can help automate the transmission and updating of data. Prior labour-intensive data entry methods for transferring the characteristics to a CMMS can be avoided if the pertinent data is recorded as a part of the BIM attributes during design and construction (Ghosh et al., 2015a). BIM-CMMS has a variety of applications, including visualization of spaces and easy location of systems and components during emergencies(Ghosh et al., 2015a) and facilitating maintainability studies focusing on the desired performance at various stages of a Facility lifecycle (Becerik-Gerber et al., 2012).

d) Building Automation System (BAS)

Controlling building temperatures and lights based on occupancy as well as keeping an eye on system performance and device failures are among of the core features of BAS (Ghosh et al., 2015a). The major goal is to improve sustainability through improved system efficiency while lowering building energy and maintenance costs compared to a non-controlled building (Benard Mumo Makaa, 2015). Owners and facility managers can observe performance and track energy efficiency by comparing it to design data due to BAS integrated with BIM. Additionally, this provides an option for third-party software to control the BAS through the model (Ghosh et al., 2015a).

e) Energy Management System (EMS)

EMS allow for the monitoring of water, gas and electricity metering systems (Kumar Vishwakarma & Raj Suyambu, 2023). They may be used to remotely manage systems like lights and HVAC units at various places (Mataloto et al., 2019). The information gathered from these may subsequently be utilised to provide trend analyses and yearly consumption projections, as well as routine self-diagnostic and optimisation procedures (Ghosh et al., 2015a). Through the building's life cycle, effective energy management will be maintained by connecting the BIM data and facility life cycle data to the EMS (Zhuang et al., 2021).

2.4.7 Challenges of Building Information Modelling-Facility Management (BIM-FM) Integration

The implementation of business strategy and the management of service delivery are the two fundamental goals of facility management (Carbonari et al., 2018b). However, insufficient communication, reliance on paper and manual processes, inadequate information tools, and information "silos" have hindered facility management organisations' capacity to react swiftly and decisively to shifting business requirements (Dimitrov, 2024b). In comparison to other areas of the construction industry, the adoption of new technology to meet business demands throughout the occupation phase of buildings has historically lagged (Azmi et al., 2023; Carbonari et al., 2018b; Radzi et al., 2024).

Current studies demonstrate the benefits of BIM for the overall project lifecycle; however, adoption is still low in many countries. Four major categories of issues can be defined which are challenges encountered by the facility team or facility owners, challenges encountered by the designers and contractors and technical issues.

Table 2.8
BIM FM Challenges

BIM-FM Challenges	References
People Issues	
Facility managers hardly update information from small projects, work orders, and major renovations in as-built BIM	(Altohami et al., 2021; Marmo et al., 2019; Tsay et al., 2022)
The building owners and FM professionals are catching up on the technology but they still fear investment and commitment to digitalise their Facility.	(Marmo et al., 2019a), (Dijmarescu & Christopher, 2021; Hou et al., 2023)
Lack of collaborative working approach and scarcity of knowledge among project teams.	(Che Ibrahim et al., 2019) (Chioma et al., 2020a)(S. Matarneh & Elghaish, 2021; Tsay et al., 2022a)
The lack of skills within existing FMs is a challenge which prevents a successful BIM implementation and data transfer	(Munir, Kiviniemi, Jones, et al., 2020a), (Dijmarescu & Christopher, 2021) (Chioma et al., 2020a) (Tezel et al., 2022a)
Insufficient understanding of the requirement specifications, processes and competencies amongst stakeholders in the operations and use phase for real value to be realised	(Azmi et al., 2023; Munir, Kiviniemi, Jones, et al., 2020a)
Technological Issues	
The data transfer between BIM and other platforms (FM systems or other BIM solutions) is not a smooth process due to the interoperability problems	(Marmo et al., 2019a), (Che Ibrahim et al., 2019) (Chatsuwan et al., 2025; Otranto et al., 2025)
As-built model that is developed without early guidance is not effective for operational purposes	(Lovell et al., 2024; Marmo et al., 2019; Pinti & Codinhoto, 2022)
Lack of real cases where BIM application is demonstrated in a replicable form or context-specific information	(Chioma et al., 2020a) (Miettinen et al., 2018)(Abdelmoti et al., 2025; Chatsuwan et al., 2025)
Market readiness	(Chioma et al., 2020a) (May Michaeland Bock, 2023; Wills, 2023)
Information Issues	
Lack of data and information	(Wanigarathna et al., 2019) (Carbonari et al., 2018b) (Chioma et al., 2020a) (Motamedi et al., 2018) (Tezel et al., 2022a) (Abideen et al., 2022a)

BIM-FM Challenges	References
Data-related issues in FM induces the implementation of inefficient decisions and processes	(Demirdöğen et al., 2020)(Lovell et al., 2024c; Shehzad et al., 2022)
Asset managers rarely get the data that they need because such information is usually embedded with significant amounts of unusable parameters	(Munir, Kiviniemi, Jones, et al., 2020a)(Idowu et al., 2021, 2023)
Owners are reluctant to implement BIM	(Miettinen et al., 2018) (Tezel et al., 2022a)(Okwe et al., 2022; Tsay et al., 2022a)
Process Issues	
Lack of methods and tools to justify the contribution from built-asset maintenance expenditure to core business goals	(Wanigarathna et al., 2019)(Alkhard, 2024a; Desbalo & Woldesenbet, 2024)
Acknowledges an information gap on the BIM use, from the design and construction stages to FM and operations.	(Miettinen et al., 2018)(Azmi et al., 2023; Lovell et al., 2024)
Lack of FM professionals' engagement in early project phases when BIM is developing	(Hilal et al., 2019)(Hassanain, Zourob, et al., 2025; Pinti & Codinhoto, 2022)
Lack of FM input during design and construction process	(Carbonari et al., 2018b; S. Matarneh & Elghaish, 2021; Pinti & Codinhoto, 2022)
short-term FM contracts as another hindrance for low use of BIM	(Ashworth, Tucker, et al., 2019; Gordo-Gregorio et al., 2025; Tezel et al., 2022a)

Challenges related to people continue to represent a significant obstacle to the effective integration of BIM and FM. While early engagement of facility managers in the design phase has demonstrated benefits for organizational outcomes, FM teams are frequently not formally constituted during the initial stages of projects. Consequently, critical Facility management knowledge, especially concerning operational data requirements, is barely integrated into BIM models from the beginning (Hassanain, Zourob, et al., 2025; Jari & Abdulghafour, 2024; Liu & Issa, 2014). BIM models are often underutilized by FM teams due to a misalignment between the information provided and operational needs, and because FM professionals may lack the necessary skills to extract and integrate BIM data into FM systems. The lack of clear BIM guidelines concerning personnel, workflows, and system responsibilities during the FM phase exacerbates this issue (Abideen et al., 2022).

BIM software is significantly more complex than traditional CAD tools and requires advanced technical skills. Numerous FM organizations face challenges in retaining skilled BIM personnel, resulting in a dependence on external consultants for BIM-related tasks, which hinders the growth of in-house capabilities (Chioma et al., 2020; Munir, Kiviniemi, Jones, et al., 2020; Sabol, 2018; Tezel et al., 2022). Owners and Facility management professionals exhibit reluctance to fully engage in BIM investments, driven by uncertainties about return on investment, low digital readiness, and a lack of understanding regarding the long-term value of BIM in Facility management (Azmi et al., 2023; Munir, Kiviniemi, Jones, et al., 2020). BIM adoption at the operational stage is fragmented and inconsistent across organizations.

Technological challenges primarily arise from interoperability constraints between BIM platforms and current FM systems. In project handover, BIM data frequently necessitates manual re-entry into Computerised Maintenance Management Systems (CMMS), Computer-Aided Facility Management (CAFM), or Building Automation Systems (BAS). This process leads to duplicated efforts, heightened workload, and an increased likelihood of data errors (Chen et al., 2022; Shojaei et al., 2023).

Despite advancements in digital technologies, BIM tools and FM software are often utilized independently due to restricted system compatibility and insufficient mechanisms for seamless data exchange (Chatsuwan et al., 2025; Otranto et al., 2025; Yalcinkaya & Singh, 2014). Interoperability continues to pose significant challenges, especially when BIM models are created without initial operational guidance, resulting in as-built models that are inadequate for Facility management purposes (Lovell et al., 2024c; Pinti & Codinhoto, 2022). Furthermore, FM organizations must consider the long-term upkeep of BIM files. Numerous software vendors lack backward compatibility, compelling organizations to regularly update BIM files to newer versions for usability, thereby incurring additional costs and technical complexities (Jang & Collinge, 2020; Otranto et al., 2025; Sabol, 2018). The challenges are exacerbated by inconsistent market readiness, as organizations often lack the requisite digital infrastructure, standards, and vendor maturity to facilitate sustained BIM-enabled Facility management (Chioma et al., 2020c; May Michaeland Bock, 2023).

From an information perspective, BIM–FM integration is limited by ongoing issues related to data completeness, relevance, and usability. BIM models provided at project completion contain extensive information. However, a significant portion of this data is either irrelevant to daily Facility management operations or embedded within complex parameters that asset managers find challenging to interpret and utilize effectively (Mannino & Dejaco, 2021; Sabol, 2018). Moreover, owners often do not establish clear handover requirements, which results in the delivered information being inaccurate, unstructured, and misaligned with Facility management needs. Consequently, FM teams frequently encounter data that is incomplete, inconsistent, or poorly formatted, thereby diminishing confidence in BIM as a dependable “single source of truth” (Azmi et al., 2023; Cavka et al., 2017; Otranto et al., 2025). The limited adoption of open standards that explicitly define information requirements for FM activities intensifies these challenges (Oliveira et al., 2024; Leygonie et al., 2022; Patacas et al., 2020). As a result, facility managers allocate a significant amount of their time to find precise information, an inefficiency that is frequently predicted or mitigated during the design and construction stages.

Process related difficulties indicate critical discrepancies among design, construction, and operating workflows. The transfer of building information from project delivery teams to Facility management is frequently characterized by poor coordination, delays, and insufficient documentation, leading to fragmented and unreliable information exchange (Azmi et al., 2024; Cavka et al., 2017). Facility management professionals are rarely involved in the first phases of projects when BIM models are created, hence constraining their capacity to affect data organization, level of detail (LOD), and operational significance (Hassanain, Zourob, et al., 2025; Pinti & Codinhoto, 2022). While Level of Development (LOD) is generally established between clients and contractors, it's frequently emphasizes construction demands over long-term operating necessities, resulting in models that include unnecessary or irrelevant data for Facility management purposes (Abualdenien & Borrmann, 2022; Jang & Collinge, 2020).

The lack of standardized techniques to validate the impact of FM operations and maintenance expenditures on organizational performance hinders the strategic implementation of BIM within FM roles. The problem is exacerbated by the widespread use of short-term FM service contracts, which diminish incentives for long-term investment in BIM capabilities, data upkeep, and ongoing model updates. Consequently, BIM models although required during design and construction are often underutilized or neglected during the FM phase, where they may provide the most significant benefits (Bello & Ayegba, 2024; Chen et al., 2022).

In summary, the challenges associated with BIM–FM integration are fundamentally rooted in connected with deficiencies across people, technology, information, and process, rather than being solely due to isolated technical failures. These challenges underscore the importance of adopting a socio-technical approach that concurrently considers human capabilities, organizational practices, technological infrastructures, and information. Addressing these deficiencies establishes the basis for the current research, which aims to develop an integrated BIM–FM framework to improve information quality in Facility management.

2.4.8 Benefits of Building Information Modelling-Facilities Management (BIM-FM) Integration

BIM technology is perceived as a new platform for construction projects. Construction sectors can benefit greatly from the addition of BIM technology over the duration of a project. In which, numerous studies found that implementing BIM has significant advantages for improving efficiency and productivity. However, the number of real-world cases of BIM application for FM is quite limited therefore, there might be additional benefits not yet identified that would push the applicability of BIM even further (Carbonari et al., 2018b). The idea of using the information in the building information model to help with building and operations administration has been put up by numerous scholars, writers and even Facility managers. There are great advantages for facility management organization as Table 2.9 below:

Table 2.9
BIM FM Benefits

Benefits	**References**
Information	
Reliable database and integrated views across all facility systems	(Marmo et al., 2019a), (Wanigarathna et al., 2019), (Demirdöğen et al., 2020), (Che Ibrahim et al., 2019), (Altohami et al., 2021b; S. Matarneh & Elghaish, 2021)
Being able to make informed decisions and better manage a building, using more accurate and reliable information available about a building	(Carbonari et al., 2018b), (Demirdöğen et al., 2020)(Altohami et al., 2021b; Mannino & Dejaco, 2021)
Enable the transfer of facility information from the design and construction phases to the operational phase	(Marmo et al., 2019a), (Demirdöğen et al., 2020)(Broo & Schooling, 2023; Durdyev et al., 2022; Mannino & Dejaco, 2021)

Benefits	References
Performance	
Performance improvement, more accessible FM data allows faster analysis and correction of problems	(Marmo et al., 2019a), (Wanigarathna et al., 2019), (Demirdöğen et al., 2020) (Motamedi et al., 2018)
BIM Data for Preventative Maintenance and Retrofits	(Kensek, 2015)
Finance	
Cost reduction, data provided at the handover phase	(Marmo et al., 2019a), (Demirdöğen et al., 2020) (Motamedi et al., 2018)
Organization	
Owners can evaluate the impact of retrofit or maintenance works or associate each building object with a condition assessment over time, supporting critical analyses	(Marmo et al., 2019a), (Wanigarathna et al., 2019), (Demirdöğen et al., 2020)
BIM functionalities can support strategically driven decision making for BAM	(Wanigarathna et al., 2019)

The advantages of BIM for operational teams are a prominent subject of discourse among academic scholar. Four (4) domains have been found during an extensive literature review that revealing the benefits of integrating BIM in FM which are information, performance, finance, and organization. As well as delivering benefits which can be seen as clearly tangible, there are also many that are intangible in nature, but which may still deliver significant value to operational teams. Based on Table 2.9, information has become one of the most beneficial domains in integrating BIM in FM.

Overall, BIM able to aid facility managers team to gain data that are relevant, reliable, useful, and can add value to the operational management process. Therefore, to optimize the advantages of the BIM information database, the initial step is to ascertain the data requirements of various stakeholders throughout the building project's life cycle. It is essential to identify the requirements of FM to ensure that new technology delivers accurate information to the appropriate parties at the optimal moment. With the development of BIM, knowledge sharing between facility management and design professionals has become possible. (Liu & Issa, 2012).

2.4.9 International Application of BIM in Facilities Management

BIM-FM has increasingly been applied internationally to support the management of buildings and assets during the operation and maintenance phase. At the international level, this application is supported by ISO 19650-3, which establishes an information-management process for the operational phase of assets using BIM. The standard is applicable to different asset types and organisations and emphasises the continuous management and exchange of asset information throughout building operations.

Several international projects demonstrate how BIM has been applied in FM. In Australia, the Sydney Opera House was used as an early BIM-FM case study to examine the application of digital building models in managing a large and complex operational asset. The initiative demonstrated the potential of BIM to support accurate geometric representation, asset documentation, information sharing, and long-term facility management activities (Ballesty, 2006). This example indicates that BIM-FM can be valuable not only for new construction but also for complex and existing landmark facilities.

In the United Kingdom, BIM-FM was examined at Northumbria University's city campus, which consists of multiple non-residential buildings. BIM was investigated as a means of improving the accessibility, visualisation, and management of facility information across the campus. The case also highlighted that successful BIM-FM implementation depends on clear information requirements, organisational readiness, interoperable technology, and collaboration between project and FM stakeholders (Kassem et al., 2015). This demonstrates that international BIM-FM practice involves both technical integration and organisational preparation

Studies from the United States have similarly reported BIM-FM applications in university, healthcare, public, and institutional facilities. In these contexts, building models and structured asset data have been connected to FM databases to support asset identification, maintenance planning, space management, and information retrieval. These applications demonstrate that BIM-FM is not limited to three-dimensional visualisation; rather, it enables facility managers to access lifecycle asset information and link physical building components with operational records (Becerik-Gerber et al., 2012).

Across these international applications, several common BIM-FM functions can be identified, including lifecycle data integration, digital asset information, three-dimensional visualisation, system interoperability, real-time information access, space management, emergency support, and energy monitoring. However, international experience also shows that the benefits of BIM-FM are not achieved through software alone. Effective implementation requires competent personnel, organisational support, reliable technological infrastructure, standardised information processes, and clearly defined asset information requirements (Kassem et al., 2015; Tsay et al., 2022). Therefore, international BIM-FM practice supports the socio-technical position adopted in this research, in which BIM Attributes operate together with people, organisation, technology, and process to improve facility management information quality.

2.5 Information Quality in Facilities Management

2.5.1 Definition and Conceptualization of Information Quality

Information Quality (IQ) is a complex and multifaceted concept that has been variously defined across scholarly literature. Despite extensive research, there remains no universally agreed-upon definition, reflecting differing emphases across studies. Information quality generally refers to the fitness of information for use within specific contexts, encompassing dimensions such as accuracy, completeness, timeliness, and relevancy (Abd Aziz et al., 2024). Effective management and assessment of information quality are critical as it directly impacts organizational decision-making and operational efficiency (Moshood et al., 2025; Moshood, Rotimi, et al., 2024). However, despite numerous definitions, scholars often highlight the contextual dependence of information quality, arguing that definitions and dimensions vary significantly according to organizational settings and specific usage contexts (Eppler, 2006; Madnick et al., 2009).

Table 2.10 synthesizes key definitions of information quality from previous studies, including both general information systems research and asset-related contexts. Even though these definitions come from a wider body of literature on information management, there is general agreement that information quality pertains to the information's usefulness for decision-making, operational effectiveness, and performance improvement.

Table 2.10
Definitions of Information Quality

Author(s) & Year	Definition	Key Aspects
(Akter et al., 2017)	Information quality is defined as the completeness, accuracy, format and currency of information produced by the information system.	completeness, accuracy, format and currency
(Essiet, 2016)	Information quality refers to the extent to which information is accurate, complete, consistent, timely, relevant, and accessible, ensuring effective decision-making throughout the facility management lifecycle.	accurate, complete, consistent, timely, relevant, and accessible
(Zadeh et al., 2017a)	The process of evaluating whether information delivered for facility management meets the quality expectations of end-users, by assessing multiple dimensions of quality that influence decision-making and operational performance	accessibility, completeness, conciseness, consistency, relevance, timeliness
(Paggi et al., 2021)	Information quality is the degree to which asset-related information is fit for purpose and supports effective decision-making throughout the asset lifecycle.	accuracy, completeness, consistency, timeliness, accessibility and relevance
(Chang et al., 2022)	Information quality" refers to how well asset information meets business, system, and technical requirements for effective asset management	accuracy, completeness, consistency, timeliness,, relevance.
(Leygonie et al., 2022)	The degree to which it is fit for facility-management use meaning it is complete, accurate, consistent, compliant with owner's IR, understandable, and relevant,	completeness, accuracy, consistency, clarity, compliance, relevancy
(Oluleye et al., 2023)	Information quality refers to the degree to which building information in the BIM/FM system is accurate, timely, complete, consistent, and fit for purpose, thereby enabling efficient decision-making and operations in facility management	accuracy, completeness, timeliness, consistency, relevance
(Mannino & Dejaco, 2021)	Information quality is where the degree to which digitized facility data are accurate, timely, complete, consistent, and relevant for FM	completeness, accuracy, format and currency
(Tsay et al., 2023)	IQ defined completeness, intelligibility reflecting real FM compliance issues	intelligibility, accuracy, consistency, completeness, compliance

To synthesize these definitions, a thematic analysis was performed, as summarized in Table 2.11. The analysis identifies a series of recurring and interconnected themes, encompassing accuracy, completeness, timeliness, consistency, relevance, accessibility, format or clarity, compliance, clarity, and suitability for purpose. These themes represent the multifaceted nature of information quality and emphasize the operational criteria that information has to fulfill to effectively facilitate FM decision-making.

Table 2.11
Identifying Key Themes from Thematic Analysis

Theme	Description	Relevant Definitions (Author, Year)
Accuracy	Information must correctly represent the real-world facility condition or asset data.	Akter et al. (2017); Paggi et al.; Chang et al. (2022); Oluleye et al. (2023); Mannino et al. (2021); El-Diraby & Osman (2020)
Completeness	Information must be full, with no missing or partial data that affects decision-making.	Akter et al. (2017); Essiet (2016); Zadeh et al. (2017a); Chang et al. (2022); Leygonie et al. (2022); Oluleye et al. (2023)
Timeliness	Information should be current and available when needed for effective facility decisions.	Essiet (2016); Paggi et al.; Chang et al. (2022); Mannino et al. (2021); Oluleye et al. (2023)
Consistency	Information should be logically coherent and uniform across systems and time periods.	Essiet (2016); Zadeh et al. (2017a); Paggi et al.; Chang et al. (2022); Leygonie et al. (2022); El-Diraby & Osman (2020)
Relevance	Information should be applicable and helpful in the FM decision-making context.	Essiet (2016); Zadeh et al. (2017a); Paggi et al.; Chang et al. (2022); Mannino et al. (2021)
Accessibility	Users should be able to access the information easily and efficiently.	Essiet (2016); Zadeh et al. (2017a); Paggi et al.
Format/Clarity	Information should be presented in a readable, clear, and standardized format.	Akter et al. (2017); Leygonie et al. (2022); El-Diraby & Osman (2020)
Compliance	Information should meet regulatory, contractual, or owner-defined requirements.	Leygonie et al. (2022); El-Diraby & Osman (2020)
Fit for Purpose	Information must support decision-making and be aligned with its intended use or lifecycle phase.	Paggi et al.; Oluleye et al. (2023); Leygonie et al. (2022)
Intelligibility	Information should be understandable by users with varied backgrounds or roles.	El-Diraby & Osman (2020); Leygonie et al. (2022)

Numerous FM related research, including those by Essiet (2016), Paggi et al. (2021), Chang et al. (2022), and Oluleye et al. (2023), outline information quality through an extensive array of variables encompassing correctness, completeness, consistency, timeliness, relevance, and accessibility. These definitions are significant in emphasizing the varied informational needs throughout the FM lifetime. Nonetheless, their comprehensive scope indicates a descriptive focus that is mainly appropriate for qualitative evaluation or operational discourse rather than empirical modeling.

Similarly, Zadeh et al. (2017) and Tsay et al. (2023) conceptualize information quality from an evaluative approach, highlighting user expectations, comprehensibility, and compliance to FM standards. Although these definitions offer valuable insights into user-centric and regulatory considerations in FM, they encompass aspects that are highly context-specific and may differ considerably across organizations, positions, and regulatory frameworks. This variability poses difficulties for standardized measurement and the operationalization of constructs in quantitative research.

Other definitions, including those proposed by Leygonie et al. (2022) and Mannino and Dejaco (2021), explicitly incorporate considerations of reliability, clarity, and digital data. These perspectives are especially pertinent in BIM-enabled environments. However, they are closely associated with particular implementation contexts, such as owner information requirements or digitized FM platforms. Consequently, their direct adoption may restrict the general application of findings across FM organizations operating within hybrid BIM and non-BIM settings, as is frequently observed in the Malaysian context.

On the other hand, the definition stated by Akter et al. (2017), which defines information quality through completeness, accuracy, format, and currency, provides a straightforward and theoretically robust framework that incorporates the fundamental dimensions consistently recognized in the FM-specific definitions presented in Table 2.11. The thematic analysis demonstrates that the dimensions identified by Akter et al. (2017), encompass the most prevalent themes which are accuracy, completeness, timeliness and format or clarity. These dimensions denote the essential attributes necessary for information to be dependable, applicable, and actionable, irrespective of the particular FM function or system context.

Although Akter et al. (2017) does not originate from the facility management literature, its definition is firmly anchored in information systems and data quality theory, from which the concept of information quality originated. As recent facility management increasingly depends on information systems, digital platforms, and BIM-enabled data environments, the utilization of a foundational information quality framework from the information systems domain is both theoretically sound and methodologically essential. Notably, the adoption of Akter et al. (2017) definition does not preclude FM-specific considerations. Instead, it offers a robust theoretical foundation upon which FM-related information practices can be contextualized and analyzed.

Moreover, the clarity of Akter et al. (2017) concept reinforces its suitability for empirical research. The limited yet thorough collection of characteristics enables the operationalization of information quality as a reflective construct, hence allowing rigorous measurement and hypothesis testing through structural equation modelling. This is especially significant for the current research, which aims to investigate how socio-technical factors affect information quality outcomes rather than to comprehensively enumerate all potential information qualities within FM practice.

This research adopts Akter et al. (2017) not as a definition particular to FM, but as a theoretically sound, measurement-ready framework that consistently captures the fundamental characteristics of information quality evident in FM literature. This research contextualizes the definition within facility management, linking foundational information systems theory with FM practice, thereby facilitating a systematic analysis of information quality as the principal result of socio-technical interactions in both BIM-enabled and traditional FM settings.

2.5.2 Importance of Information Quality in Facilities Management

The importance of information quality in facility management is regularly highlighted in FM and asset management literature, especially in research that articulates information quality in practical terms. In contrast to general information systems, FM depends on continuous, precise, and actionable information to facilitate decision-making across the building lifecycle (Mannino & Dejaco, 2021). FM activities rely heavily on asset-related, spatial, and operational data. Thus, inadequacies in information quality result in inefficiencies, risks, and reduced efficiency.

Numerous studies clearly indicate that high-quality information is essential for effective asset and maintenance management. Paggi et al., (2021) contend that information quality is essential for ensuring that asset-related information is suitable for various lifecycle stages, since facility managers rely on dependable data to plan maintenance activities, optimize asset performance, and manage lifecycle costs. Mannino and Dejaco (2021) assert that precise, prompt, and uniform digitized facility data are crucial for efficient FM operations, especially in contexts where decision-making relies heavily on data. These investigations collectively indicate that information quality is not a supplementary factor but a fundamental enabler of FM functionality.

The literature further indicates that inadequate information quality has demonstrable adverse effects on FM performance. Essiet (2016) and Zadeh et al. (2017) indicate that incomplete, inconsistent, or inaccessible information affects the capacity of FM personnel to make informed decisions, resulting in delayed maintenance approaches and suboptimal allocation of resources. In these situations, facility managers are compelled to depend on manual inspections, their personal expertise, or supplementary records to offset unreliable system data. This not only elevates the operational burden but also introduces supplementary risks related to human error and data loss.

From a compliance and governance view, the quality of information is equally significant. Leygonie et al. (2022) emphasize that FM information must satisfy owner-specified information criteria and regulatory standards to facilitate statutory compliance, safety audits, and contractual duties. Insufficient information quality, especially regarding completeness and consistency, can jeopardize regulatory reporting and subject FM organizations to legal and reputational issues. Tsay et al. (2023) emphasize that the intelligibility of information and compliance related aspects are crucial for assuring that FM information is both technically accurate and comprehensible for practitioners with varying responsibilities and experience.

Recent Facility management literature emphasizes the significance of information quality in facilitating digital Facility management projects, particularly BIM-enabled asset management. Oluleye et al. (2023) contend that the efficacy of BIM-FM systems is significantly influenced by the quality of the information contained within them, asserting that erroneous or insufficient building data constrains the practical utility of BIM in the operational phase. Chang et al. (2022) assert that asset information must satisfy business, system, and technical criteria to provide effective asset management, underscoring information quality directly impacts the efficacy of digital FM systems.

These studies collectively demonstrate that information quality affects FM outcomes in three essential dimensions: operational effectiveness, compliance and risk management, and digital system performance. High-quality information facilitates proactive maintenance, informed decision-making, and strategic planning, while poor information quality leads to fragmented workflows, system distrust, and underutilization of digital resources. Thus, information quality must be considered a primary performance outcome in FM rather than a subordinate technological characteristic

Table 2.12
Importance of Information Quality in Facilities Management

Author(s)	**Key Focus of Research**	**Importance**
Essiet (2016)	FM information systems	High-quality information enables effective decision-making and reduces reliance on informal or manual practices
Zadeh et al. (2017)	Evaluation of FM information delivery	Information quality affects user satisfaction and operational performance
Paggi et al. (2021)	Asset lifecycle information	Fit-for-purpose information supports decision-making across lifecycle stages
Mannino & Dejaco (2021)	Digitised FM data	Accurate and timely information is essential for data-driven FM decisions
Chang et al. (2022)	Asset information requirements	Information quality must meet business and technical needs for effective asset management
Leygonie et al. (2022)	Owner information requirements	High-quality information is critical for compliance and governance
Tsay et al. (2023)	FM information intelligibility	Information must be understandable and compliant to be usable by FM practitioners
Oluleye et al. (2023)	BIM–FM integration	BIM/FM effectiveness depends on accurate and complete information

2.5.3 Role of BIM in Information Quality in FM

The role of Building Information Modelling (BIM) in facility management has progressively been cantered on its capacity to improve the quality of information rather than solely digitizing building data. In Facility management contexts, where operational decisions rely significantly on precise, comprehensive, and actionable asset data, BIM offers a structured and integrated platform that effectively resolves longstanding issues of information fragmentation. Recent studies consistently contend that the value of BIM in facility management resides in enhancing the accuracy, accessibility, and consistency of information throughout the entire facility lifecycle.

BIM improves the quality of information through the implementation of object-oriented and standardized data structures, which enhance accuracy and consistency relative to conventional document-centric systems. Mannino and Dejaco (2021) demonstrate that BIM-based FM environments facilitate more dependable access to digitized facility data, thereby minimizing ambiguity and data redundancy. Similarly, Chang et al. (2022) demonstrate that BIM facilitates asset information to more effectively satisfy both business and technical requirements, thereby enhancing the accuracy and comprehensiveness of data utilized in Facility management decision-making.

Another essential contribution of BIM is its capacity to facilitate the seamless transfer of lifecycle information, especially during the transition from construction to operation. Paggi et al. (2021) emphasize that BIM enables the systematic transmission of asset information, minimizing data loss during handover and enhancing the long-term integrity of data. This is particularly important in FM, where inadequate handover information has been recognized as a primary cause of poor information quality and operational inefficiencies.

BIM further enhances the usability and comprehensibility of FM information through the integration of structured data with visual representations. Tsay et al. (2023) contend that BIM improves the lucidity of information and user comprehension, thereby fostering greater trust in FM information systems and decreasing dependence on informal knowledge or manual verification. Furthermore, BIM facilitates enhanced information accuracy by allowing more efficient updates and sharing of asset data across operational processes (Oluleye et al., 2023).

Despite these advantages, the literature states that BIM does not inevitably ensure high information quality. Durdyev et al. (2022) indicate that BIM-enabled projects frequently provide FM teams with incomplete or misaligned information, related to insufficient FM engagement, ambiguous information requirements, and deficient data governance. Leygonie et al. (2022) additionally highlight that BIM enhances information quality solely when it is consistent with the owner's information requirements and facility management-specific data standards. These findings emphasize that the influence of BIM on information quality depends on organizational processes and governance rather than solely on technology.

Overall, recent Facility Management literature affirms the notion that Building Information Modeling (BIM) improves information quality by increasing accuracy, completeness, consistency, timeliness, and usability of facility data. However, these advantages are achieved solely through the effective integration of BIM with FM processes, organizational frameworks, and user techniques. Accordingly, BIM should be regarded as a socio-technical agent, with its enhancement of information quality arising from its interaction with individuals, organizational structures, and information management procedures. This perspective offers a clear justification for investigating BIM attributes as a moderating factor in the relationship between socio-technical determinants and information quality outcomes in facility management.

2.6 Determinants Predictors of Facilities Management Information Quality

Previous FM studies describe information quality problems without clearly explaining the factors that cause them. Identifying determinant predictors provides a systematic way to understand why information quality varies across FM organisations and enables the development of testable relationships between influencing factors and information quality outcomes. Therefore, below focuses on identifying the key determinant predictors of facility management information quality. Understanding these determinants provides the theoretical foundation for examining how information quality can be improved and supports the development of the research framework and hypotheses presented in this research.

Based on the thorough review of prior literature (mapping see Appendix 2), frequency analysis (Table 2.13) and a rational consideration of the present research's context, a total of eight (8) hypotheses have been developed. The determinants for these hypotheses' formulation were selected on the basis of their importance, appropriateness, and recommendations by prior research. These hypotheses are mainly driven by the belief that information quality can be improved by persistently optimizing strategic resources and capabilities of an organization (Gorla et al., 2010; Svetlana, 2025; Zohry & Al-Dhubaibi, 2024).

Table 2.13
Frequency Analysis on Information Quality used in Previous Studies with Information Quality

Independent Variables	Definition	Frequency
People	Person refers to the characteristics or conditions of a single or group of practitioners performing their related tasks (Salahuddin et al., 2020)	23%
Organization	Organisational condition of the work system in which the practitioners perform their tasks (Salahuddin et al., 2020).	33%
Technology	Technology used by practitioners to support their services (Salahuddin et al., 2020).	90%
Process	Process refers to the activities that support the accomplishment of work goals (Kashif Ali and Abdul Waheed 2024)	43%

Based on the frequency analysis above, people, organization, technology and process were selected as the independent variables in the research framework. Information Quality (IQ) does not solely emerge from technological capabilities but rather results from the intricate interplay of several critical factors. Previous research strongly underscores four primary determinants of People, Organization, Technology, and Process as key predictors of information quality within Facility Management (FM). The selection of these determinants is justified through careful analysis, synthesis, and evaluation of the existing body of literature.

a) People

People are central to any information system, serving as primary users, contributors, and evaluators of information. Literature consistently highlights human competencies, such as user knowledge, attitudes, skills, and training, as essential determinants of information quality (Abd Aziz et al., 2024; Matimbwa & Kamala, 2024). Several empirical studies suggest that human-related factors are pivotal in shaping perceptions and practical outcomes of information quality. (Al-Okaily et al., 2025; Lutfi, 2022; Salahuddin et al., 2020) underline that effective use of information systems significantly depends on user expertise and understanding. Likewise, Viitanen et al. (2011) found that adequate training and clear communication among users directly enhance the accuracy, completeness, and usability of facility management data. Without competent and adequately trained personnel, FM systems risk poor adoption, inaccurate data entry, misinterpretation, and underutilization of critical information resources. Hence, considering people as a determinant is essential to achieve high information quality standards.

b) Organizational

Organizational structures and resources collectively determine the environment within which FM information systems function. These organizational components substantially influence data governance, decision-making processes, and overall system efficiency (Adepoju, 2023; Fischer & Herrmann, 2011a; Simamora & Carisma Marbun, 2025). DeLone and McLean (2003) emphasized that strong organizational support and strategic alignment directly enhance information system effectiveness and, consequently, information quality. Baxter and Sommerville (2011) further supported this notion, illustrating that robust organizational frameworks, characterized by clear resources, training and teamwork significantly improve the consistency, compliance, and relevance of FM information. Moreover, organizational culture that fosters continuous improvement and information transparency is consistently linked to higher information quality standard (Che et al., 2023; Eppler, 2006; Fukami, 2024). A supportive organizational environment is imperative for the successful implementation and ongoing operation of FM information systems. Organizational commitment ensures robust governance practices, aligning information processes with strategic goals, thereby directly enhancing information quality.

c) Technological

The technological infrastructure including hardware, software, systems integration, and interfaces plays a critical role in facilitating accurate, timely, and relevant information within FM contexts (Akter et al., 2017; S. Lee et al., 2022). Previous research has consistently identified technological capabilities as fundamental to maintaining high information quality standards. Akter et al. (2017) and Mannino et al. (2021) provided empirical evidence demonstrating how advanced and appropriately integrated technologies minimize information errors, enhance data consistency, and improve accessibility and timeliness. Additionally, Adepoju, (2023) argued that robust technological infrastructure facilitates seamless data exchange and reduces inefficiencies, enhancing information clarity and accuracy. Inadequate or misaligned technological infrastructure significantly compromises the quality of FM information, negatively impacting operational and strategic decision-making. Therefore, integrating robust and appropriate technology solutions is a prerequisite for achieving optimal information quality in FM.

d) Process

Processes, comprising workflows, tasks, standard operating procedures, and systematic methodologies, are vital in governing how information is collected, managed, and utilized within FM systems (Zadeh et al., 2017; Leygonie et al., 2022). Literature highlights the critical role of well-defined and streamlined processes in achieving high information quality. Zadeh et al. (2017) illustrated how structured and standardized processes ensure consistency, accessibility, and completeness of FM information. Leygonie et al. (2022) similarly emphasized that clearly articulated and compliant processes significantly enhance the relevance and accuracy of facility-related data. The establishment of standardized processes reduces ambiguity and inconsistencies, thus maintaining information integrity and usability across organizational contexts (Leygonie et al., 2022). Clear, structured, and optimized processes are indispensable for aligning technological capabilities and human actions effectively. Robust processes ensure consistency and minimize errors, significantly enhancing overall FM information quality.

In conclusion, the selection of People, Organization, Technology, and Process as determinants of FM information quality is robustly supported through analytical evaluation, synthesis of empirical findings, and compelling arguments derived from established literature. These factors collectively underpin the comprehensive socio-technical framework necessary for achieving and sustaining high standards of information quality in facility management.

Table 2.14
Frequency Analysis on Moderators used in Previous Studies with Facilities Management Information Quality

Moderators	Definition	Frequency
Building Information Modelling (BIM)	Building Information Modelling (BIM) is a digital methodology that facilitates the creation, management, and interchange of structured and reliable data throughout the entire life cycle of a asset, thereby promoting collaborative decision-making among project stakeholders.(Chatsuwan et al., 2025; Fang et al., 2022; Mushtaha et al., 2024)	7.6%
User Satisfaction	Satisfaction reflects user perception of FM systems' ability to meet expectations, which moderates IQ's influence on outcomes (Abd Aziz et al., 2024a; Chen Chunlei et al., 2023)	16.7%
Perceive ease of use	Defined as the degree to which users believe using FM-related systems is free from effort, moderating IQ's effect on system use (F. D. Davis et al., 1989; Ng Ching Woon, 2022; Tsay et al., 2023)	12.1%
Management Support	Management support indicates the degree to which the upper management offers commitment, resources, strategic guidance, and motivation for system implementation, thus enhancing the correlation between technological projects and organizational performance (Abbas & Kumari, 2021; Jayeola et al., 2022; Qiao et al., 2024).	25.8%
Culture	Organizational culture is the collection of shared values, norms, and beliefs that influence the behaviors of an organization, thereby affecting the efficacy of management practices or technologies in achieving enhanced performance outcomes (Christopher & Edwinah, 2022; Mingaleva et al., 2022; Zhang et al., 2023).	9.1%
Work Environment	Work environment is the physical, psychological, and social environment in which employees perform their tasks, which modifies the relationship between system implementation, organizational practices, and employee outcomes (Dulloh et al., 2024; Hikmah Perkasa et al., 2023; Rabuana & Yanuar, 2023).	10.6%
Policy	Policy denotes the formal regulations, governance mechanisms, and institutional frameworks that direct organizational practices, thereby influencing the impact of technological adoption and management initiatives on operational outcomes (Onifade et al., 2024)	10.6%

Table 2.14 presents the frequency analysis of moderating variables identified in 66 empirical research (Appendix 3). The investigation involved a systematic evaluation of published journal publications concerning Facility Management, BIM implementation, and digital information systems, along with the categorization of the moderating variables utilized in their research models. Each research was categorized according to the moderator, and the overall frequency of each group was calculated. The results demonstrate that management support is the most studied moderator (17 research), followed by user satisfaction (11 studies) and perceived ease of use (8 studies). The work environment and policy are each referenced in seven studies, whilst organizational culture is noted in six studies. Conversely, BIM is featured in merely 5 studies, making it the least studied moderating variable. The findings indicate that

previous studies have mostly focused on organizational and user-related dependent factors, while technological skills like BIM have been infrequently regarded as moderating mechanisms

The dominance of moderators such as management support and user satisfaction reflects a strong inclination in existing literature toward human-centric and cognitive constructs, which primarily explain how users perceive, accept, or respond to information systems. While these moderators are essential for understanding post-adoption behaviour and managerial influence, they operate largely at the individual or organizational perception level (Davis et al., 1989; Chen Chunlei et al., 2023). In contrast, BIM serves as a technological and structural moderator, influencing the organization, integration, visualization, and exchange of information throughout the entire facility lifecycle. Therefore, the conceptual gap is underscored by the low frequency of BIM as a moderator, as studies acknowledge information quality outcomes without adequately examining the digital infrastructure that fundamentally shapes those outcomes (Alvanchi & Seyrfar, 2020; Oluleye et al., 2023).

Moreover, the underrepresentation of BIM as a moderator is especially significant due to increasing strategic value in policy and practice. In the Malaysian context, national agendas such as the 13th Malaysia Plan (RMK-13) and National Construction Policy 2030 initiatives explicitly emphasize digitalisation and BIM adoption for asset and Facility management (Abu Bakar & Kamaruzzaman, 2023; Azmi et al., 2024). Despite this, empirical FM information quality studies have not yet fully incorporated BIM into their analytical models, particularly as a variable that influences the strength of relationships between socio-technical factors and information quality outcomes. Furthermore, this discrepancy between academic theory and policy direction helps to demonstrate the necessity of establishing BIM as a critical moderator.

In contrast to narrower constructs such as user satisfaction, which reflects subjective evaluations after system use, or perceived usefulness, which captures expected performance gains, BIM fundamentally alters how information is created, validated, shared, and reused throughout the FM lifecycle. By enabling integrated data environments, BIM influences not only outcomes but also the processes and interactions leading to those outcomes (Oluleye et al., 2023; Toochukwu, 2025). Consequently, although BIM is infrequently included in previous moderation analyses, its exclusion signifies a notable theoretical limitation rather than an absence of relevance.

In summary, the frequency analysis demonstrates that BIM is the least examined moderator in previous FM information quality studies, despite its comprehensive capability to bridge people, organization, techonology and process dimensions. This underutilisation presents a clear research gap and justifies the inclusion of BIM as a moderating variable in the present research. This research positions BIM as a moderator, addressing gaps in the existing literature, aligning with national digitalization agendas, and offering a comprehensive socio-technical explanation of the formation and enhancement of facility management information quality.

2.7 Socio-Technical Perspective of Information Quality in FM

2.7.1 Theoretical Underpinning

A theory is a set of interrelated constructs (concepts), definitions and propositions that present a systematic view of phenomena by specifying relations among variables, with the purpose of explaining and predicting the phenomena" (Kerlinger, 1988). The research framework and hypotheses proposed in this research are grounded in Social Technical System theory originally developed by Trist and Bamforth (1951). STS serves as a fundamental theoretical model that underpins discussions on information quality (IQ). Specifically, this theory offers a theoretical rationale for understanding the relationships among the independent, moderator and dependent variables within the research.

2.7.1.1 Theory Mapping

This research performed a theory mapping to analyze the theories applied to information quality research from 2015 to 2025. The objective of this mapping was to identify, categorize, and analyze the theoretical perspectives that are frequently used to explain information quality in previous studies. The literature review was mainly carried out by using the Scopus database, pertaining to its extensive coverage of peer-reviewed journals. Relevant keywords consisting of *"information quality," "Building Information Modelling (BIM)," "Facility Management," "information management," and "theoretical framework"* were employed in various combinations. The search was confined to peer-reviewed articles published in the English language.

Articles were initially screened through their titles and abstracts, followed by a comprehensive review of the full texts of the selected studies. The identified theories were subsequently classified based on their primary focus, encompassing people-related, organizational, technological, and process-oriented aspects of information quality (Appendix 4). Following this mapping, a frequency analysis was performed to determine the most frequently cited theories in information quality research during the specified period. The findings of this analysis are displayed in Table 2.15, which emphasizes the five most commonly utilized theories from 2015 to 2025. This analysis offers a comprehensive overview of prevailing and emerging theoretical trends in information quality research and guides the ensuing selection of a suitable theoretical framework for this research.

Table 2.15 and Figure 2.2 indicate the Socio-Technical Systems (STS) theory as one of the less frequently utilized frameworks in information quality research, accounting for a smaller percentage compared to more dominant theories such as DeLone and McLean’s 2003 IS Success Model (ISM). However, its unique relevance to the facility management (FM) context justifies its selection for this research. Despite its lower prevalence, the STS theory provides a holistic and integrative framework that simultaneously examines the interplay between social (people and organizational structures) and technical (technology and process) elements within an organization. This holistic perspective is crucial in the FM sector, where successful information quality management depends significantly on effectively integrating technological systems with human and organizational factors.

Compared to other prevalent theories such as Task-Technology Fit (TTF) Theory or DeLone and McLean’s IS Success Model, STS emphasizes the alignment between social and technical components, making it particularly suitable for examining complex FM information systems. The theory highlights that optimizing technical aspects alone, without equal consideration of social elements, may result in suboptimal outcomes. Therefore, it underscores the importance of comprehensive integration, reflecting precisely the conditions and challenges faced by FM organizations attempting to achieve improved information quality.

Moreover, based on the analysis in Appendix 4 it that illustrates the applicability of STS theory in various sectors from 2015 to 2025, demonstrating its capability to address integrated system challenges across diverse fields including information, organizational studies, healthcare and manufacturing. This cross-disciplinary relevance underscores STS theory’s flexibility and robustness in analyzing complex socio-technical interactions, further validating its suitability for addressing FM information quality issues. This evidence enhances the appropriateness of STS within the FM context, where information quality is fundamentally socio-technical as it is generated and maintained by individuals, regulated by organizational rules and resources, facilitated by technologies, and upheld through processes and ongoing updating practices. Hence, despite its comparatively lower frequency of application, the Socio-Technical Systems theory offers a particularly valuable lens for exploring the intricate dynamics involved in FM information, aligning closely with the objectives and practical concerns of this research.

Table 2.15
Frequency Analysis on Theories Related to Information Quality

No	Theoretical underpinnings	Gist of the theory	Field/Discipline	Sources	Frequency (%)
1.	DeLone and McLean's 2003 IS Success Model (ISM)	A multidimensional model assessing IS success through six interrelated dimensions: system quality, information quality, service quality, use, user satisfaction, and net benefits.	Information Systems, Management, Health Informatics, Library Science, Engineering, Public Administration	(Akter et al., 2017; Çelik & Ayaz, 2022; Delone & Mclean, 2003; Petter et al., 2008; Y.-S. Wang & Liao, n.d.)	26
2.	Task-Technology Fit (TTF) Theory	Proposes that technology is more likely to have a positive impact on performance when its capabilities align well with the tasks it supports.	Information Systems, Management, Healthcare, FM, E-Government, Education, Operations	(Bozorgkhou, 2015; Khaleel & Hilal, 2023; H. Wang et al., 2020; Zhou et al., 2010)	16
3.	Knowledge Management Theory	Focuses on the processes of capturing, distributing, and effectively using knowledge within organizations to enhance decision-making and performance	Knowledge Management, Organizational Studies, Construction Management, Engineering, Healthcare, Library Science, FM	(Alavi & Leidner, 2001; Edwards, 2019; Ferreira et al., 2020; Nonaka, 2009; Tzortzaki & Mihiotis, 2014)	21
4.	System Theory	An interdisciplinary framework that studies systems as cohesive groups of interrelated components, emphasizing the whole system's behavior over individual parts.	Systems Science, Engineering, Organizational Theory, Management, FM, Cybernetics, Environmental Studies, Project Management	(G. Chen & Kanfer, 2006; Hong et al., 2003; Lai & Huili Lin, 2017; Thimm, 2022)	14
5.	Resource Based View	Suggests that valuable, rare, inimitable, and non-substitutable organizational resources (including information quality and IS capabilities) create sustained competitive advantage.	Strategic Management, Information Systems, Education	(A. M. Cruz & Haugan, 2019; Kero & Bogale, 2023; Lubis, 2022)	17

No	Theoretical underpinnings	Gist of the theory	Field/Discipline	Sources	Frequency (%)
6.	Socio-Technical System Theory	Emphasizes the interrelatedness of social and technical aspects of organizations, advocating for joint optimization to improve system performance and employee satisfaction	Organizational Studies, Information Systems, Engineering,Health Informatics, Project Management, Education, Human Factors	(Bauer & Herder, 2009b; K. Davis, 2014; Fischer & Herrmann, 2011a; Malatji et al., 2019; Trist & Bamforth, 1951)	9
7.	TAM (Technology Acceptance Model) /UTAUT (Unified Theory of Acceptance and Use of Technology)	Explains user adoption of technology through perceived usefulness, perceived ease of use, performance expectancy, and behavioral intention.	Technology Adoption, IS, Healthcare	(T. Oliveira et al., 2014; Safeena et al., 2013)	10

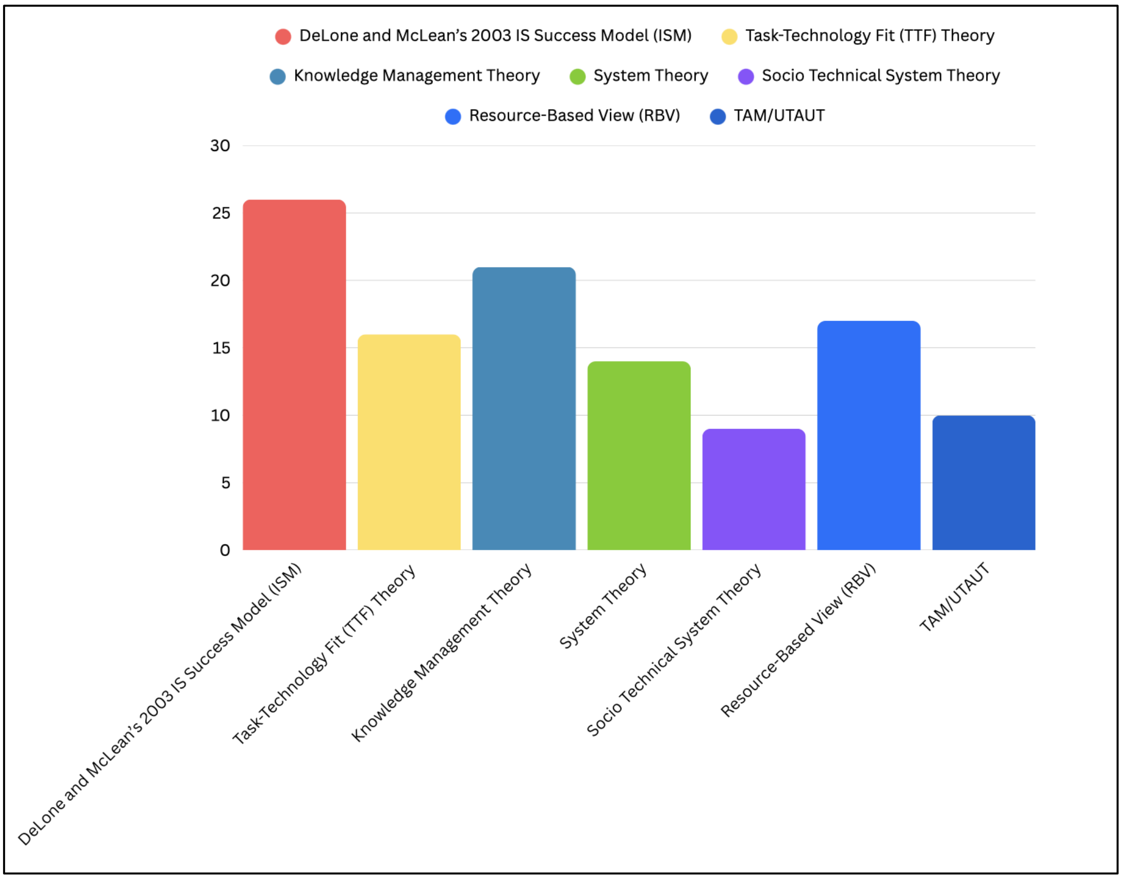

Figure 2.2 Theories Related to Information Quality, 2015 – 2025

Source: Author

As a conclusion, Table 2.16 consolidates the key justifications for selecting STS as the theoretical foundation of the research, ensuring a clear, structured, and academically rigorous argument.

Table 2.16
Overall Justification for Selection Socio-Technical System View

Justification Criteria	Justification Based on Table 2.15, Figure 2.2, and Literature Review
Empirical Dominance (Table 2.1)	STS theory is less frequently utilized, highlighting an opportunity to explore and expand empirical validation within FM information quality research (Azmi & Ismail, 2025)
Broad Application Across Disciplines	STS is applied across diverse sectors such as healthcare, manufacturing and information management, reflecting its broad applicability in complex organizational environments (Lyytinen & Newman, 2008; Sony & Naik, 2020; Thomas, 2024)
Holistic Integration of Social and Technical Components	Unlike more narrowly focused theories, STS uniquely integrates social (people and organizational structures) and technical (technology and process), essential for comprehensive understanding information systems (Bostrom et al., 2009; Ciriello et al., 2024; Luna-Reyes et al., 2005)

Justification Criteria	Justification Based on Table 2.15, Figure 2.2, and Literature Review
Alignment with Research Objectives	This research investigates both social and technical influences on FM information quality and their interaction through BIM integration, aligning closely with STS's socio-technical alignment principles.
Long-Term Perspective on System Integration	STS promotes sustainable system improvements through balanced optimization of technical systems and social processes, crucial for long-term effectiveness of FM information systems (Azmi & Ismail, 2025b; Karanasios, 2025; Thomas, 2024)
Strategic Advantage through Integrated Systems	Organizations effectively applying STS principles are better positioned to enhance information quality, operational efficiency, and decision-making capabilities, leading to strategic advantages (Moshood et al., 2024b; Ping-Ju Wu et al., 2015)
Comprehensive Theoretical Foundation	STS theory provides a robust and credible theoretical basis, capable of addressing the multifaceted nature of FM and BIM integration challenges in the context of information quality management (Bostrom et al., 2009; Thomas, 2024)

2.7.1.2 Socio-Technical System Theory

The Socio-Technical Systems (STS) theory originated in the 1950s through the work of researchers at the Tavistock Institute of Human Relations in London, UK. Initially developed to address the human and organizational issues emerging from technological changes in coal mining, STS highlighted the relationship between social and technical systems within an organization (Trist & Bamforth, 1951). Trist and Bamforth’s seminal research on coal miners demonstrated how optimizing both social and technical elements led to enhanced productivity, safety, and employee satisfaction, laying the foundation for a broader application across various industries and contexts (Pasmore, 1988a).

STS theory emphasizes specific characteristics that distinguish it from other organizational theories. Primarily, STS posits that organizations are composed of two interrelated components which are the social system, encompassing people, relationships, skills, and organizational structure and the technical system, comprising technology and processes (Eason, 2014). Furthermore, STS underscores the need for flexibility and adaptability, enabling organizations to respond effectively to changes in their operational environments and technology advancements (Carayon & Salwei, 2021). Under the lens of Socio-Technical Systems (STS) theory, this research views the research variables social (people and organizational) and technical (technology and process) as inherently interconnected components critical to achieving superior FM information quality.

The social dimension encompasses organizational practices and human factors. Meanwhile, the technical dimension focuses on technological infrastructure, system quality, and clearly defined FM processes. From an STS perspective, optimizing FM information quality requires not merely enhancing individual technical or social factors independently but achieving a balanced integration of both elements. Additionally, the moderating role of BIM Attributes (BA) is seen as pivotal, functioning as the integrative mechanism that enhances the synchronization between these socio-technical elements, thereby significantly influencing FM information outcomes at the organizational level.

Table 2.17
View of Research Variables under the Lense of STS

Variable	Explanation based on STS Context	Past Studies
Information Quality	Information Quality (IQ) is considered an outcome that emerges from the optimal alignment and interaction between social and technical subsystems within an organization. IQ in this context is not merely a product of technology or data management alone. Rather, it reflects how well the social aspects (people and organizational) interact with technical aspects (technology and processes) to effectively produce, manage, and deliver information.	(Bosch-Sijtsema et al., 2019; Salahuddin et al., 2020; Trist & Bamforth, 1951)
Social (People)	STS emphasizes the role of individuals, their skills, as critical elements influencing system effectiveness and information quality. People influence how technology is adopted, perceived, and utilized.	Mumford (2006); Fischer and Herrmann (2011); Salahuddin et al. (2019); Baxter and Sommerville (2011);Thomas, 2024)
Social (Organizational)	Organizational factors under STS theory include organizational culture, resources, teamwork and training, all affecting information dissemination, organizational learning, and the adoption of new technologies such as BIM.	Salahuddin et al. (2019); Fischer and Herrmann (2011); Baxter and Sommerville (2011); Trist and Bamforth (1951)
Technical (Technology)	STS posits that the technical subsystem, which comprises software, hardware, system interfaces, and technical infrastructure, significantly impacts information quality. Technology must align with human capabilities and organizational contexts.	Mumford (2006); Baxter and Sommerville (2011); Fischer and Herrmann (2011); Salahuddin et al. (2019)
Technical (Process)	Processes in STS involve workflow designs, task allocations, and process integration within technological frameworks. Processes determine how effectively technologies facilitate information exchange and integration.	Fischer and Herrmann (2011); Salahuddin et al. (2019); Mumford (2006); Baxter and Sommerville (2011)

This provides sufficient flexibility to the researcher to select and test the most important resources and capabilities that are highly relevant to the current context of research. As such, STS allows the inclusion of new moderating variables as well as their corresponding propositions, concurrent with the evolution of literature without a need to integrate additional theories in the research model.

2.8 Research Gap

Facility Management Information Quality (FMIQ) has been an emerging topic of interest within organizational and technology-oriented research fields. The integration of Building Information Modelling (BIM) with Facility Management (FM) has significantly shifted industry practices, yet specific determinants influencing FMIQ, particularly from social and technical perspectives, remain underexplored. Despite numerous studies examining general information quality across different organizational contexts, research specifically focusing on FM information quality, especially at the organizational level within Facility Management organizations, is limited.

Firstly, existing studies primarily examine information quality from generic organizational perspectives or broader IT contexts, often neglecting the specific social factors like people and organizational structures that uniquely influence FMIQ in FM organizations. While general IT quality and user satisfaction are well-covered, research explicitly connecting organizational support, employee training, and teamwork to FMIQ is relatively sparse. This gap highlights the need for empirical evidence demonstrating how social dimensions distinctly impact the quality of information delivered within facility management practices.

Secondly, although considerable research addresses the role of technical aspects such as system quality, information systems integration, and technological infrastructure in general information management contexts, their specific application to facility management remains underrepresented. Many studies overlook how particular technological tools and processes within FM contexts directly enhance or impede information quality. Consequently, it remains unclear precisely which technological attributes are most beneficial for enhancing FMIQ, necessitating further empirical exploration tailored explicitly to FM settings.

Thirdly, while moderation effects are commonly examined in broader organizational and IT research, the moderating role of BIM attributes specifically within the relationship between social and technical factors and FMIQ in FM organizations has been rarely investigated. Although BIM's potential benefits for FM have been highlighted in literature, few studies explicitly test how BIM attributes moderate social and technical dimensions' impact on FMIQ. Clarifying this moderation effect is crucial for developing targeted strategies to leverage BIM effectively in improving FM information quality.

Additionally, the literature extensively discusses technological advancements and their benefits in information management but inadequately examines how BIM specifically moderates the relationship between technical elements (technology and processes) and FMIQ. The precise impact of BIM's technological capabilities in enhancing or possibly weakening the association between FM-specific processes, technology adoption, and FMIQ is not well documented. This oversight limits the understanding of BIM's comprehensive role in optimizing FM information practices and suggests a significant area for targeted research.

Lastly, existing studies often examine BIM and FM integration broadly, highlighting its general benefits without delving into detailed, measurable outcomes specifically related to information quality. There remains a notable paucity of empirical studies that systematically assess how and to what extent integrating BIM with FM specifically improves information quality metrics such as accuracy, completeness, format, and currency. Bridging this gap would enable practitioners to better assess, predict, and leverage BIM-FM integration for enhanced organizational outcomes. Addressing these identified gaps is essential to provide a comprehensive understanding and practical guidance for effectively enhancing FMIQ through BIM integration in Facility Management organizations. Table 2.18 and Figure 2.3 depicts the gaps discussed in the form of the research framework.

Limited Research on Facility Management Information Quality (FMIQ): Despite growing interest in Facility Management (FM), comprehensive studies specifically focusing on FMIQ at the firm level within FM organizations remain limited, highlighting a significant gap given its critical impact on operational effectiveness.

Limited Empirical Evidence on Social Determinants of FMIQ: Although extensive research addresses organizational and human factors in broader information quality contexts, empirical evidence specifically examining the impact of social determinants such as teamwork, training, and organizational support within FM organizations is scarce.

Inadequate Examination of Technical Determinants within FMIQ: Studies exploring technical dimensions (e.g., system quality, processes) within the FM-specific context are limited, thereby creating ambiguity regarding which technological attributes directly influence FMIQ and how effectively these tools integrate into FM practices.

Underexplored Moderating Role of BIM Attributes (People and Organization): The moderating influence of Building Information Modeling (BIM) attributes on the relationship between social factors (organizational support, people management) and FMIQ within FM organizations remains underexplored, despite BIM's significant potential to enhance organizational effectiveness.

Limited Investigation into BIM Moderation on Technology and Process: Although BIM’s technological potential is well-recognized, its moderating effect specifically on the technical relationship between FM processes, technological tools, and FMIQ is inadequately studied, leaving critical insights underdeveloped in literature.

Gap in Empirical Assessment of BIM-FM Integration Outcomes: There is a notable scarcity of empirical studies assessing the tangible outcomes and measurable benefits of integrating BIM with FM, particularly regarding detailed metrics of information quality such as accuracy, completeness, currency, and format within FM organizations.

Figure 2.3 Summary Thematic Gaps in Literature

Source: Author

Table 2.18
Gap Analysis: Factors Affecting Information Quality in Facilities Management in Malaysia

Theme	Variables	Prior Research Review	Application to FM in Malaysia	Present Research Gaps	Research Question
Social (Organization)	Independent Variable	Organizational support significantly impacts information quality and performance in general management studies. Effective organizational structures, adequate resources, and clear policies enhance overall information management effectiveness (Delone & Mclean, 2003; Fu et al., 2022; Sepúlveda-Rivillas et al., 2022)	FM organizations require clearly defined organizational structures and resources to effectively manage and improve IQ (Anuar et al., 2024; Myeda et al., 2023).However, resource constraints are common in Malaysian FM contexts (Azmi et al., 2024; Syed Shabahar et al., 2024)	Limited empirical evidence specifically on how organizational resources uniquely influence FMIQ within Malaysian FM organizations.	RQ1: What is the impact of social (people and organizational) and technical (technology and process) on FM information quality?
Social (People)	Independent Variable	Employee knowledge, significantly influence information quality. Proper training and effective teamwork enhance accuracy, completeness, and currency of organizational information (Abd Aziz et al., 2024b; Moshood et al., 2025; Salahuddin et al., 2020)	Effective management of employee knowledge, training, and teamwork within FM organizations in Malaysia can significantly enhance FMIQ (Azmi et al., 2024; Faridah Abdul Rahim et al., 2025).However, specific studies addressing these factors within the FM sector remain limited.	Scarce research focusing explicitly on how people-related factors such as teamwork and training specifically influence FMIQ in Malaysian FM organizations.	

Theme	Variables	Prior Research Review	Application to FM in Malaysia	Present Research Gaps	Research Question
Technical (Technology)	Independent Variable	Technological tools and systems quality significantly enhance information management processes. Effective technological systems lead to improved information accuracy, timeliness, and format (Hasan & Akter, 2022; Sunarjo et al., 2024; Zadeh et al., 2017b)	Technological adoption in FM in Malaysia is essential to enhance information management. However, the specific impacts of technological tools and systems within Malaysian FM organizations have not been extensively studied.	Limited studies explicitly addressing the relationship between technology-specific factors and FMIQ within FM contexts in Malaysia.	
Technical (Process)	Independent Variable	Well-defined and structured processes significantly impact the quality of information management. Processes that are clearly documented and standardized contribute positively to information completeness and accuracy (Cavka et al., 2017c; Ebbers et al., 2022; Sharma Vadigicherla, 2025)	Structured and standardized processes can significantly benefit FM organizations in Malaysia by improving information quality. Yet, the explicit relationship between process management and FMIQ in FM contexts remains inadequately explored.	Insufficient empirical research specifically addressing the direct influence of process-related factors on FMIQ within Malaysian FM organizations.	

Theme	Variables	Prior Research Review	Application to FM in Malaysia	Present Research Gaps	Research Question
BIM Attributes (Moderator)	Moderator Variable	BIM attributes, including collaborative platforms, real-time updates, and detailed asset management capabilities, significantly moderate relationships between organizational and technological factors in broader contexts, enhancing overall information quality (J. Chang et al., 2024; E. , & F. M. T. E. , & F. M. Toulimat, 2024)	Integration of BIM attributes in FM organizations in Malaysia potentially moderates and enhances FMIQ by improving collaboration and data management practices. However, studies specifically exploring BIM attributes' moderation effects in Malaysian FM contexts remain sparse.	Limited empirical studies explicitly examining the moderating role of BIM attributes between both social (organization and people) and technical (technology and process) factors in Malaysian FM contexts, specifically regarding FMIQ.	RQ2: What is the moderation effect of BIM Attributes on the relationship between social (people and organizational) and FM information quality? RQ3: What is the moderation effect of BIM Attributes on the relationship between technical (technology and process) and FM information quality?
Facility Management Information Quality (FMIQ)	Dependent Variable	Information quality includes accuracy, completeness, format, and currency, essential for effective decision-making and organizational performance (Khong et al., 2023; Moshood et al., 2024c)	FMIQ directly influences decision-making efficiency, operational performance, and strategic planning in FM organizations.	Limited focused empirical studies examining the specific dimensions of FMIQ (accuracy, completeness, format, and currency) within FM organizations, especially at a firm-level analysis.	Dependent Variable

2.9 Framework and Conceptual Overview

Drawing from a critical review of the literature, the variables of this research are conceptualized through the integration of core theories and contemporary research recommendations. This research adopts the Socio-Technical Systems (STS) theory as the theoretical framework, aligning it with additional constructs and relationships identified as significant in the field of BIM-enabled facility management (FM) information quality. This approach marks a significant advancement over prior research, which often focused on isolated aspects such as technology adoption or technical processes, rather than a holistic, interdependent view.

The research model proposed in this research is primarily grounded in the Socio-Technical Systems (STS) theory, which emphasizes the interdependence of social (people, organization) and technical (technology, process) elements within complex work environments (Trist & Bamforth, 1951). In addition to STS, the conceptualization is informed by digital transformation literature, especially regarding the integration of Building Information Modelling (BIM) in FM (Azmi & Ismail, 2025 ; Yu et al., 2024; Karanasios, 2025).

Unlike previous studies that have largely addressed BIM either from a technological or process perspective, this research's model explores the simultaneous, dynamic interactions between people, organization, technology, and process, and how these are amplified by BIM attributes to enhance FM information quality. This holistic integration allows for an investigation into the mechanisms that underpin effective information management throughout the asset lifecycle, which remains underexplored in the Malaysian context.

This research contributes to the field in several novel ways. First, it expands the examination of information quality in FM by considering not only the direct impacts of social and technical factors but also the moderating role of BIM attributes such as visualization and real-time collaboration on these relationships. While earlier research often isolated the effects of either people or technology, this model tests their combined effects and potential synergies when supported by advanced BIM tools.

Second, the framework introduces social and technical factors as explicit constructs, addressing calls in the literature for greater recognition of process alignment, organizational, and knowledge-sharing in the success of BIM-FM integration (Oluleye et al., 2023; Pavón et al., 2021). In this way, the framework goes beyond the dominant focus on technical solutions by capturing the broader socio-organizational context. Third, by integrating FM information quality as a central outcome variable, the research offers a more comprehensive understanding of how socio-technical and BIM-related factors collectively drive the accuracy, reliability, and usability of information delivered to facility managers and decision-makers. This focus addresses a key gap, as information quality is often discussed in general terms but rarely operationalized with reference to both technological and social antecedents in a BIM-FM context. The proposed research model, illustrated in Figure 2.4, comprises the following key constructs:

i. People (PEO): refers to the characteristics or conditions of a single or group of practitioners performing their related tasks.
ii. Organization (ORG): Organisational condition of the work system in which the practitioners perform their tasks
iii. Technology (TEC): Technology used by practitioners to support their services
iv. Process (PRO): Process refers to the activities that support the accomplishment of work goals
v. BIM Attributes (BA) BIM Attributes refer to application areas of Facility management BIM could be implemented and beneficial
vi. Information Quality (IQ): Information quality is defined as the completeness, accuracy, format and currency of information produced by the information system

The model hypothesizes that both social (people, organization) and technical (technology, process) factors exert significant positive effects on information quality in FM. BIM attributes is posited as a moderator, strengthening these relationships, such that higher levels of BIM integration lead to even greater improvements in information quality. This aligns with recent findings that highlight the value of BIM in bridging gaps between people, organization, process, and technology for more effective FM information quality (Durdyev et al., 2022; Tsay et al., 2023)

The relationships among these constructs will be empirically tested using data from G7 facility management organizations in Malaysia, including both BIM users and non-users. The framework’s comprehensive design allows for the exploration of direct, indirect, and moderating effects, thus providing robust evidence on how to optimize FM information quality through an integrated socio-technical and BIM-enabled approach. In summary, the proposed framework for this research integrates the strengths of STS theory with emerging insights from digital transformation and FM literature. By explicitly modelling the roles of people, organization, technology, process, and BIM attributes, the research aims to advance both theoretical understanding and practical guidance for enhancing information quality in facility management. The detailed constructs and hypothesized relationships are further elaborated in the following subsections, with Figure 2.4 presenting the overall conceptual framework guiding this research.

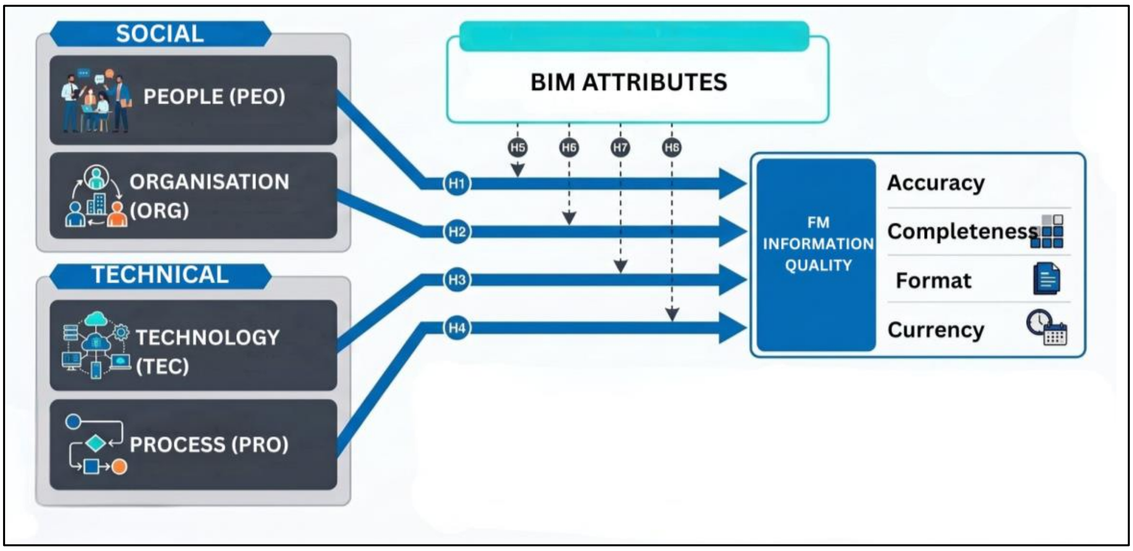

Figure 2.4 Research Conceptual Framework

2.10 Hypothesis Development

The research conceptual framework model is depicted in Figure 2.4. The research design outlines the research's hypotheses for determining the empirical relationship between PEO, ORG, TEC and PRO. Additionally, this research demonstrates that BA act as moderator between the independent variables (PEO, ORG, TEC and PRO) and the dependent variable (IQ).

2.10.1 People (PEO) and Facilities Management Information Quality

In today's information driven environment, organizations seeking to improve performance and decision-making capabilities have increasingly recognized the importance of information quality (IQ) as a critical asset (Batini et al., 2009; Ismail et al., 2021; Khong et al., 2023; Moshood et al., 2025). The human dimension skills, knowledge, involvement of people has been repeatedly shown to influence the effectiveness and reliability of information system (Abbu et al., 2022; Rezaei et al., 2021; Shakir, 2024). Recent scholarship in both information systems and facility management supports the argument that a robust investment in human capital not only enhances information quality but also underpins operational excellence, innovation, and sustainable competitive advantage (Alam et al., 2024; Camisón-Haba et al., 2024; Khemraj et al., 2023).

Watts et al., (2009) define information quality as a contextually dependent construct, influenced by users' cognitive and experiential attributes. The research indicates that the perceived quality of information is not exclusively dependent on objective data attributes like accuracy or completeness. Rather, it is influenced by users' proficiency, comprehension, and task-specific interpretations. The findings highlight that human cognitive processes are central to the evaluation of information quality dimensions, specifically relevance, believability, utility, and value. As a result, information quality is realized through the interplay of an information system and its users, highlighting the critical role of knowledgeable and engaged employees in the effective management of information quality.

Eppler, (2006) takes a complementary approach by investigating how human competence and interpretative skills affect organizational information quality. This work shows that interpretation errors, data misuse, and communication breakdowns often originate from deficits in user skill and understanding. The author contends that organizations must prioritize user training and develop clear guidelines for information interpretation, arguing that high information quality is ultimately dependent on practitoner abilities to comprehend, process, and apply information correctly within their work context.

Meanwhile. Srivastava et al., (2020) focus on the role of user training and communication in the facility management sector. By analyzing the effects of structured training programs and clarity in role expectations, their research demonstrates a direct positive impact on the accuracy, completeness, and trustworthiness of FM information. The analysis of their findings indicates that when facility personnel are adequately trained and fully understand their duties, the accuracy and dependability of data within FM systems improve greatly. The authors firmly claim that organizations should allocate resources in ongoing training and establish transparent communication protocols in order to maintain high standards of information quality.

Salahuddin et al., (2020) address the issue from a socio-technical perspective, analyzing how organizational factors and human elements collectively influence the safe and efficient utilization of information within FM environments. Their empirical findings emphasize that a properly managed work system, distinguished by supportive leadership, effective communication, and a safety-focused culture, minimizes risks and enhances the quality of information. The assertion is that both social and organizational dimensions must be optimized in conjunction with technical aspects to fully realize the potential of FM information systems.

DeLone & McLean (2003), highlight the mediating roles of user satisfaction and system utilization in influencing information and system quality outcomes. Building upon ten years of empirical validation, their revised Information Systems Success Model illustrates that high-quality systems and information encourage greater user satisfaction, thereby promoting more effective system utilization and organizational advantages. The model highlights that service quality, including adequate user support and system responsiveness, is essential in sustaining satisfaction and reliable information outcomes. Their research underscores the importance of adopting human-centered system design approaches, claiming that effective information quality initiatives must persistently incorporate user feedback and experiences throughout the entire system lifecycle.

Prior studies indicate that employee involvement plays a critical role in determining the quality of facility management information. Research within Facility management environments indicates that increased staff engagement in data generation, validation, and utilization processes correlates with more comprehensive, precise, and dependable facility data (Marmo et al., 2019b; Pärn et al., 2017). From an information quality perspective, engaging users throughout the information lifecycle enhances contextual understanding and reduces data inconsistencies (R. Nelson et al., 2005) .These findings collectively indicate that employee engagement is not solely operational but functions as a strategic instrument for enhancing the quality of FM information and overall facility management performance.

From the past studies presented in Table 2.19 below, the majority indicate a positive relationship between people and information quality, supporting the hypothesis that people plays a crucial role in enhancing various aspects of information quality. As a result, based on the literature reviewed above, the current research proposes the following hypothesis:

H1: People have a positive impact on information quality in facility management

Table 2.19
Past Studies on People and Information Quality

Research	Author(s)	Hypothesis	Independent Variable (People)	Dependent Variable (Information Quality)	Key Findings	Conclusion
1	Watts et al. (2009)	Information quality is influenced by users' cognitive and experiential characteristics rather than solely by objective data attributes	User cognition, experience, proficiency, task understanding	Perceived information quality (relevance, believability, utility, value)	Information quality is context-dependent and shaped by users' interpretations, comprehension, and experience	Information quality emerges from the interaction between information systems and knowledgeable users, highlighting the importance of cognitively competent and engaged employees
2.	(Salahuddin et al., 2019)	Social and organizational factors jointly influence safe and effective information use	Leadership support, communication, safety culture, organizational conditions	Information quality and safe information use	Supportive leadership and effective communication reduce risks and enhance information quality	Optimizing social and organizational dimensions alongside technical systems is necessary to fully realize information system potential
3.	Srivastava et al. (2020)	User training and role clarity positively influence the accuracy and reliability of FM information	User training, role clarity, communication	Accuracy, completeness, trustworthiness of FM information	Structured training and clear role expectations improve data accuracy and dependability in FM systems	Continuous training and transparent communication protocols are essential for sustaining high FM information quality
4	Eppler, M. J. (2006).	Human competence and interpretative skills significantly affect organizational information quality	User competence, interpretative skills, communication capability	Organizational information quality	Interpretation errors and data misuse often stem from inadequate user understanding and skills	High information quality depends on user training, clear interpretation guidelines, and practitioners' ability to correctly process and apply information

Research	Author(s)	Hypothesis	Independent Variable (People)	Dependent Variable (Information Quality)	Key Findings	Conclusion
5.	(DeLone & McLean, 2003)	User satisfaction and system use mediate the relationship between system characteristics and information quality outcomes	User satisfaction, system use, user support (service quality)	Information quality and system success outcomes	High system, information, and service quality increase user satisfaction and effective system use	Human-centred system design and continuous user feedback are critical for sustaining reliable information quality
6.	Marmo et al. (2019); Pärn et al. (2017)	Employee involvement across the information lifecycle improves FM information quality	Employee involvement, participation in data creation, validation, and use	Completeness, accuracy, reliability of FM information	Greater staff engagement leads to more comprehensive and dependable facility data	Employee involvement is a strategic lever for improving FM information quality and overall FM performance

2.10.2 Organisation (ORG) and Information Quality

Organizational determinants such as training, teamwork and structured resources are increasingly recognized as vital contributors to information quality within facility management and information systems (Atkin & Brooks, 2021a; Kejžar et al., 2023; Oluleye et al., 2023). A growing body of research supports the view that organizational environments which prioritize capacity building, collaboration, and structured policy frameworks achieve consistently higher standards of data reliability, accuracy, and usability (Adepoju, 2023; Alkhard, 2024; Santos et al., 2024). The following synthesis of key studies highlights the centrality of these factors in fostering high information quality outcomes.

Nelson (2005) empirically examine the determinants of information quality and illustrate that organizational factors are essential in influencing the production of high-quality information. Their research indicates that user competence, collaborative efforts, and organizational support mechanisms such as training and coordination among users are substantially impact the accuracy, comprehensiveness, and utility of information generated by information systems. The findings suggest that when organizations cultivate collaborative work environments and allocate resources to enhance user capabilities, individuals are more capable of comprehending, verifying, and utilizing information effectively, resulting in enhanced information quality. This evidence underscores the importance of organizational practices, especially collaboration and training, as vital factors in achieving dependable and significant information quality results.

Expanding this perspective, Salahuddin et al. (2019) apply a socio-technical lens to demonstrate how supportive organizational and effective teamwork contribute to both the safe use and high quality of information. Their research finds that organizations which foster teamwork, and a training culture empower employees to collaborate effectively, reduce data entry errors, and improve the overall trustworthiness of information. The research strongly argues that organizational environments characterized by trust, open communication, and shared responsibility are crucial to reducing risk and ensuring the completeness and accuracy of information.

Jahanger et al., (2021) research the quality of information within organizational information systems and establish that organizational capabilities, such as staff training, cross-functional collaboration, and managerial support, exert a substantial positive impact on information quality results. Their empirical research indicates that organizations investing in the development of employee competencies and promoting collaborative work practices attain superior levels of data accuracy, completeness, and reliability. The research emphasizes that information quality is not solely a technical concern but is significantly influenced by organizational structures that facilitate users in generating, validating, and utilizing information efficiently. The authors assert that training and collaboration should be regarded as strategic organizational assets for maintaining high information quality and enhancing overall system performance.

Similarly, Fischer and Herrmann (2011) focus on the role of teamwork and organizational structure in facilitating effective data management and communication. Their research demonstrates that team-based management not only promotes more consistent and transparent information sharing but also leads to higher standards of data integrity and usability.

Meanwhile, Boadu et al., (2025) present empirical evidence indicating that organizational factors significantly influence information quality via information governance practices. Their research indicates that insufficient organizational investment in training, inadequate leadership commitment, and limited collaborative data quality practices substantially impair data accuracy, consistency, and dependability. Conversely, healthcare organizations that establish routine training, systematic supervision, and collaborative data validation processes are better equipped to attain superior information quality results. These findings strengthen the assertion that organizational capabilities such as particularly training, coordination, and management support are vital drivers of information quality.

Further, Hussien Gomaa, (2025) underscores the importance of organizational capabilities in the attainment of high-quality asset information in asset management standards. The research emphasizes the necessity of structured training programs, cross-functional collaboration, and clearly defined organizational processes to guarantee the accuracy, consistency, and reliability of asset data. Through the promotion of continuous improvement, standardized protocols, and competency development, the proposed roadmap illustrates how organizational practices directly influence the quality of information utilized in asset and facility management decision-making. This serves to substantiate the argument that information quality in asset-intensive environments is significantly enhanced by organizational investment in collaboration and training.

From the past studies presented in Table 2.20 below, the majority indicate a positive relationship between organization and information quality, supporting the hypothesis that organization plays a crucial role in enhancing various aspects of information quality. As a result, based on the literature reviewed above, the current research proposes the following hypothesis:

H2: Organisations have a positive impact on information quality in facility management

Table 2.20
Past Studies on Organization and Information Quality

Research	Author(s)	Hypothesis	Independent Variable (Organization)	Dependent Variable (Information Quality)	Key Findings	Conclusion
1	Nelson et al. (2005)	Organizational and user-related factors significantly influence information quality outcomes	User competence, collaboration, training, organizational support	Accuracy, completeness, utility of information	Collaborative environments and investment in user capability development significantly enhance users' ability to verify and utilize information	Organizational practices, particularly training and collaboration, are critical enablers of high-quality information
2.	Salahuddin et al. (2019)	Organizational and teamwork factors positively influence safe information use and information quality	Teamwork, training culture, organizational support, communication	Accuracy, completeness, trustworthiness of information	Supportive organizational environments reduce data entry errors and improve information reliability	Team-based and supportive organizational contexts are essential for reducing risk and achieving high information quality
3.	Jahanger et al. (2021)	Organizational capabilities have a significant positive impact on information quality	Staff training, cross-functional collaboration, managerial support	Accuracy, completeness, reliability of information	Organizations investing in employee competencies and collaboration achieve superior information quality	Training and collaboration function as strategic organizational assets for sustaining high information quality
4	Fischer & Herrmann (2011)	Teamwork and organizational structure facilitate effective data management and communication	Team-based management, organizational structure, communication	Data integrity, consistency, usability	Team-based organizational arrangements promote transparent information sharing and higher data integrity	Effective teamwork and organizational structuring are crucial for achieving usable and reliable information

Research	Author(s)	Hypothesis	Independent Variable (Organization)	Dependent Variable (Information Quality)	Key Findings	Conclusion
5.	Okyere Boadu et al. (2025)	Organizational governance practices significantly influence information quality outcomes	Training, leadership commitment, supervision, collaborative validation	Accuracy, consistency, dependability of information	Insufficient training and weak leadership impair data quality, while collaborative validation improves it	Organizational capabilities, especially training and coordination, are vital drivers of information quality
6.	Hussien Gomaa, (2025)	Organizational capabilities positively influence asset information quality	Structured training, cross-functional collaboration, standardized processes	Accuracy, consistency, reliability of asset information	Continuous improvement, standardized protocols, and competency development enhance asset data quality	Organizational investment in training and collaboration significantly improves information quality in asset-intensive environments

2.10.3 Technology and Information Quality

Technological advancements continue to reshape the landscape of facility management, with information quality emerging as a direct beneficiary of robust and integrated technology systems. Research increasingly supports the argument that the effective implementation of technology including system quality, analytics, digitalization, integration, and user-centered design not only enhances the accuracy, timeliness, and relevance of information but also underpins organizational efficiency and strategic decision-making (Hussien Gomaa, 2025; Petter et al., 2008). The following review of key studies demonstrates how different facets of technology influence and elevate information quality within organizations and facility management contexts.

Abd Aziz et al., (2024) offer a thorough analysis of the literature on information system success, emphasizing the critical role of technology in the development of information quality outcomes. Their review, which is based on empirical evidence and established information system success models, demonstrates that information systems that are distinguished by high reliability, usability, and accessibility consistently generate more accurate, timely, and usable information. The results underscore the importance of a well-designed and robust technological infrastructure as a fundamental component of attaining superior information quality. The authors also contend that it is imperative to maintain the quality of information and accommodate the changing requirements of organizations through ongoing investment in system enhancement.

Meanwhile, Adamides & Karacapilidis, (2020) information and communication technologies improve the integrity of information by facilitating the aggregation, transformation, and interpretation of data within organizational processes. The research emphasizes that technologies that are distinguished by their high usability, integration, and analytical capability facilitate sense-making, collaboration, and informed decision-making, thereby enhancing the accuracy, consistency, and utility of information. The authors also claim that the reduction of information fragmentation and the preservation of information's reliability and significance in organizational contexts are based upon the deployment of integrated and adaptable ICT infrastructures.

Meanwhile, Dewett & Jones, (2001) underscore that the efficacy of information systems is dependent upon their compatibility with operational workflows and organizational requirements. It clarifies that technologies that are intended to improve existing processes enhance the accuracy, timeliness, relevance, and usability of information, whereas systems that are not well-aligned frequently produce fragmented and unreliable data. The authors further contend that organizational requirements should inform system design and selection decisions, emphasizing that technology and organizational compatibility are essential for the realization of high-quality information and effective decision-making.

Addressing the facility management context specifically, Mannino & Dejaco, (2021) illustrates that the quality of information in facility management is substantially enhanced by the implementation of advanced digital technologies. The authors demonstrate that the accuracy, timeliness, and relevance of FM information are improved by digitalization, particularly through the integration of BIM and IoT, which facilitates real-time data collection, automated updates, and centralized information management. By reducing data inconsistencies, manual errors, and information fragmentation, these technological capabilities render facility data more actionable and reliable for operational decision-making.. The research also contends that digital and automation technologies are indispensable rather than optional, as high-quality FM information and operational excellence are becoming more reliant on robust, integrated technological infrastructures.

Further, Lee (2004) extended this logic by analyzing the impact of technology enabled data assessment tools. Their results demonstrated that automated technology driven assessments are more accurate and comprehensive than manual evaluations leading to greater trust in information assets and improved organizational data management practices.

Finally, Yu et al. (2013) examined the role of enhance technology greatly enhance the accessibility, completeness, and integrity of FM information. Their empirical findings argue that integrating technology systems across the FM domain is a key driver of improved IQ and operational effectiveness.

From the past studies presented in Table 2.21 below, the majority indicate a positive relationship between technology and information quality, supporting the hypothesis that technology plays a crucial role in enhancing various aspects of information quality. As a result, based on the literature reviewed above, the current research proposes the following hypothesis:

H3: Technology have a positive impact on information quality in facility management

Table 2.21
Past Studies on Technology and Information Quality

Research	Author(s)	Hypothesis	Independent Variable (Technology)	Dependent Variable (Information Quality)	Key Findings	Conclusion
1	Abd Aziz et al. (2024)	System quality characteristics significantly influence information quality outcomes	System reliability, usability, accessibility, technological robustness	Accuracy, timeliness, usability of information	Systems with high reliability and usability consistently produce more accurate and timely information	Robust and well-designed technological infrastructure is a foundational requirement for achieving high information quality
2.	Adamides & Karacapilidis (2020)	ICT capabilities positively influence information integrity and usability	ICT integration, usability, analytical capability, interoperability	Accuracy, consistency, utility, integrity of information	Integrated and adaptable ICT reduces information fragmentation and improves sense-making and collaboration	Advanced and integrated ICT infrastructures are essential for sustaining reliable and meaningful information
3.	Dewett & Jones (2001)	Technology–organization fit positively affects information quality	Workflow compatibility, process-supporting technologies	Accuracy, timeliness, relevance, usability of information	Technologies aligned with organizational workflows improve information quality, while misaligned systems cause fragmentation	Technology should be selected and designed based on organizational needs to achieve high-quality information
4.	Mannino & Dejaco (2021)	Advanced digital technologies significantly enhance FM information quality	BIM, IoT, digital automation, integrated FM systems	Accuracy, timeliness, relevance, reliability of FM information	Digitalization enables real-time data capture, reduces errors, and improves information consistency	Digital and automation technologies are essential enablers of high-quality FM information and operational excellence

Research	Author(s)	Hypothesis	Independent Variable (Technology)	Dependent Variable (Information Quality)	Key Findings	Conclusion
5.	Lee (2004)	Technology-enabled assessments improve information accuracy and completeness	Automated data assessment tools, decision-support technologies	Accuracy, completeness, trustworthiness of information	Automated assessments outperform manual methods in accuracy and coverage	Technology-driven data assessment enhances trust in information assets and improves data management practices
.6.	(Yu et al., 2013)	Enhance technology improve FM information quality.	Integrated CAFM/IS Technology	FM Information Quality	CAFM systems improved FM data accessibility, completeness, and integrity.	System integration is a key technological driver for IQ in FM.

2.10.4 Process and Information Quality

The processes by which information is created, managed, and assessed are fundamental drivers of information quality in both facility management and broader organizational contexts. Increasingly, research has recognized that the structure, clarity, and routine assessment of these processes are central to achieving accurate, complete, and timely information (Batini & Scannapieco, 2019; Wang & Strong, 2020; López et al., 2021). The following synthesis reviews key empirical works that illustrate how process-related factors directly and indirectly impact information quality.

Klungseth & Tonsberg (2023) underscores the significance of information processes that are well-defined and standardized in order to facilitate the implementation of effective facility management practices. The authors demonstrate that standardized FM processes and digitalized standards enhance information flow, reduce ambiguity, and foster shared understanding among FM stakeholders through expert interviews. The results of the research indicate that structured information management processes are essential for the achievement of consistent, reliable, and usable information in FM operations. The research bolsters the argument that organizations should invest in the development and refinement of standardized protocols to facilitate high-quality information environments by emphasizing the role of process standardization.

Leygonie et al. (2022) further advance this discourse by focusing on the role of process clarity and compliance. Through a detailed analysis of FM projects, they reveal that clearly documented and compliant processes substantially reduce information errors while improving both compliance and reliability. Their work synthesizes the practical impact of clear process documentation, making a compelling case for organizations to prioritize transparent, well-documented procedures to enhance data reliability and quality in FM settings.

Chen et al. (2014) highlight the significance of routine data quality assessment processes, emphasizing the necessity of systematic and continuous evaluation for the early detection and correction of information errors. Their review indicates that organizations that conduct consistent data quality assessments are more likely to achieve long-term enhancements in data completeness, accuracy, and timeliness. The authors contend that ongoing assessment should be integrated into organizational processes as a continuous quality improvement mechanism, rather than being regarded as a one-time exercise.

Crossette-Thambiah et al., (2024) underscore the significance of governance mechanisms and process controls in assuring that information is accurate, complete, consistent, and expeditious throughout organizations. The research emphasizes the importance of structured process management, standardization, and continuous oversight in order to maintain high levels of information quality over time. This is achieved through the development and justification of an information quality framework that is based on expert insights.

Ashwin Ramesh (2016) investigates the correlation between process management and the fundamental information quality dimensions, specifically accuracy and timeliness, in the context of information handover enabled by BIM and FM. The research underscores the importance of well-defined process planning and control mechanisms in order to reduce errors, omissions, and inconsistencies in information delivery. The paper contends that effective process management should be regarded as a strategic organizational function to maintain and support high levels of information quality.

Lastly, Talamo & Bonanomi (2015) underscore the significance of conducting data and information production processes in a systematic manner during the maintenance of buildings. The authors emphasize that organizations are more likely to maintain consistent, reliable, and usable information when information workflows are explicitly documented, monitored, and supported by appropriate knowledge management tools. The book asserts that well-managed data production processes are essential for attaining and maintaining high levels of information quality in FM. Consequently, effective information workflows necessitate consistent documentation and monitoring.

From the past studies presented in Table 2.22 below, the majority indicate a positive relationship between process and information quality, supporting the hypothesis that process plays a crucial role in enhancing various aspects of information quality. As a result, based on the literature reviewed above, the current research proposes the following hypothesis:

H4: Process have a positive impact on information quality in facility management

Table 2.22
Past Studies on Process and Information Quality

Research	Author(s)	Hypothesis	Independent Variable (Process)	Dependent Variable (Information Quality)	Key Findings	Conclusion
1	Klungseth & Tonsberg, (2023)	Well-defined information processes improve FM information quality.	Process standardization and digitalized FM standards	Information flow and consistency	Standardized and well-defined FM processes improve information flow, reduce ambiguity, and support consistent information use, based on expert insights.	Structured information processes provide a foundational condition for reliable information management in FM
2.	(Leygonie et al., 2022)	Clarity and compliance in FM processes enhance data reliability.	Process Clarity & Compliance	Information Quality	Clear, documented processes reduced errors and improved data compliance and reliability.	Clear process documentation is critical to IQ in FM.
3.	Chen et al., (2014)	Processes positively influence IQ.	Routine and systematic data quality assessment processes	Data accuracy, completeness, and timeliness	Regular and continuous data quality assessments enable early detection and correction of data errors, supporting sustained improvements in information quality across information systems.	Data quality assessment should be embedded as an ongoing organizational process rather than treated as a one-off activity, serving as a continuous quality improvement

Research	Author(s)	Hypothesis	Independent Variable (Process)	Dependent Variable (Information Quality)	Key Findings	Conclusion
4	Crossette-Thambiah et al., (2024)	Process controls enhance IQ.	Process controls, governance mechanisms, and standardized information management processes	Information accuracy, completeness, consistency, and timeliness	The research highlights that clearly defined process controls, governance structures, and standardized procedures are essential for maintaining accurate, complete, and timely information.	Governance and structured process management are foundational supports for sustained high information quality.
5.	Ashwin Ramesh, (2016)	Effective process management improves information accuracy and timeliness.	Process planning, process control, and quality management procedures	Information accuracy, timeliness, and completeness	The research highlights that well-defined process planning and control mechanisms are essential for minimizing errors, omissions, and inconsistencies in information handover and FM operations	Process management should be treated as a strategic organizational function to support and sustain high information quality.
6.	Talamo & Bonanomi, (2015)	Processes improve IQ in organizations.	Data and information production processes, documentation, monitoring.	Information reliability, consistency, completeness, and usability	Emphasizes that systematically documented and monitored information production processes reduce inconsistency and ambiguity, supporting more reliable and usable FM information.	Well-managed data production processes are indispensable for achieving and sustaining high information quality in FM. Regular documentation and monitoring should be embedded within information workflows to support effective maintenance decision-making.

2.10.5 The Moderator Effect of BA-PEO-IQ

As digital transformation accelerates in the built environment, Building Information Modeling (BIM) has emerged as a critical technological enabler for improving information quality (IQ) in facility management and construction. Recent literature has moved beyond simply viewing BIM as a tool for information storage and visualization; it is increasingly recognized for its roles of shaping and strengthening the relationship between people factors, such as knowledge and the quality of information outcomes. This moderating effect means that the positive impact of people-centric practices on information quality is amplified when supported by BIM platforms and processes.

Pishdad-Bozorgi et al. (2018) explore the interplay between team integration and information exchange quality, demonstrating that BIM moderates this relationship by making information sharing more seamless and reliable. The research highlights that BIM’s standardized data structures and common data environments allow integrated teams to work more cohesively, resulting in higher quality exchanges of information. The argument is that BIM doesn’t just support integration; it makes the integration process more effective in producing consistent and accurate information.

Alvanchi & Seyrfar (2020) extend this logic to team communication, finding that BIM-based communication platforms amplify the positive effect of team interactions on facility information quality. By using BIM’s collaborative features, FM teams can clarify roles, streamline information requests, and resolve issues rapidly. Their research supports the synthesis that BIM’s real-time data exchange and visualization capabilities foster better communication, directly improving the completeness and reliability of facility information.

Oluleye et al. (2023) focus on staff participation and its effects on FM data quality, finding that BIM strengthens the link between people’s active engagement and the accuracy and completeness of data. The research demonstrates that when staff can interact with BIM-enabled systems, their participation leads to better data capture and validation, reducing errors and omissions. This provides strong evidence that BIM amplifies the impact of human engagement on information quality.

El-Diraby and Osman (2020) examine the effect of knowledge sharing, finding that BIM platforms facilitate higher consistency in shared information compared to non-BIM environments. Their analysis shows that the structured nature of BIM supports the recording, retrieval, and transfer of knowledge, which in turn leads to fewer discrepancies and better data consistency. Thus, BIM is positioned as a moderator that turns informal knowledge exchange into consistently high-quality information.

Leygonie et al. (2022) analyze the moderating effect of BIM on compliance culture within FM teams. They find that BIM-enabled teams who adhere to compliance protocols achieve much higher information reliability than non-BIM teams, as BIM helps automate process checks and ensures documentation aligns with industry standards. This supports the synthesis that BIM not only supports organizational culture but also amplifies its positive effects on information quality.

Mannino et al. (2021) look at staff coordination, discovering that BIM enhances the effectiveness of coordination on digital FM data quality. The digital workflow and automated audit trails in BIM platforms make it easier for teams to align their efforts and reduce data entry mistakes, leading to consistently better information outcomes. Their findings confirm that BIM is a crucial moderator for turning coordination into tangible information quality improvements.

From the past studies presented in Table 2.23 below, the majority indicate a positive moderating effect of BA between the relationship of people and information quality, supporting the hypothesis that BIM moderates the relationship and can enhancing various aspects of information quality. As a result, based on the literature reviewed above, the current research proposes the following hypothesis:

H5: BA positively moderate the relationship between people and information quality in facility management

Table 2.23
Past Studies on BIM between People and Information Quality

Research	Author(s)	Independent Variable (People)	Dependent Variable (Information Quality)	Key Findings	Conclusion
1.	(Pishdad-Bozorgi et al., 2018)	Team Integration	Information Quality	BIM implementation increases the effectiveness of team integration on info exchange quality.	BIM is a significant moderator for social-technical integration outcomes.
2.	(Alvanchi & Seyrfar, 2020)	Team Communication	Facility Information Quality	BIM platforms facilitate better team communication, boosting info quality.	BIM improves the link between people-focused factors and FM information quality.
3.	(Oluleye et al., 2023)	Staff Participation	FM Data Quality	Staff engagement had a greater positive impact on IQ when BIM was present.	BIM amplifies the effect of people engagement on FM data quality.
4.	(El-Diraby & Osman, 2020)	People Knowledge Sharing	Information Consistency	Knowledge sharing among users led to higher consistency only with BIM platforms.	BIM enhances the outcome of social knowledge processes on info quality.
5.	(Leygonie et al., 2022)	FM Team	Information Reliability	BIM-enabled FM teams had a stronger compliance-IQ relationship than non-BIM teams.	BIM acts as a catalyst for organizational compliance in FM info quality.
6.	(Mannino et al., 2021)	Staff Coordination	Digital FM Data Quality	Staff coordination improved data quality more in BIM-based digital FM.	BIM amplifies people-process–IQ links in digital FM.

2.10.6 The Moderator Effect of BA-ORG-IQ

The moderating role of Building Information Modelling (BIM) between organizational factors and information quality (IQ) has gained increasing attention as organizations seek to digitalize their information environments. BIM not only provides technical tools for information management, but it also acts as a catalyst, enhancing how organizational structures, policies, cultures, and resources affect the quality, reliability, and accessibility of facility management (FM) data. Recent research demonstrates that the presence of BIM amplifies or transforms the effects of key organizational variables, resulting in superior information outcomes across the asset lifecycle.

Tsay et al. (2023) emphasizes the importance of organizational factors in the development of information-related outcomes in BIM environments. BIM is viewed as an enabling mechanism whose efficacy is contingent upon the governance structures and organizational readiness. This implies that organizational factors are the primary driving force behind improvements in information quality.

Erciyas, (2024) analyzes the function of BIM in facilitating the delivery of facility management information and emphasizes that the primary challenges in FM related to information quality are organizational and process related. The research underscores the fact that BIM can only provide high-quality FM information when organizational responsibilities, workflows, and information requirements are explicitly defined. The thesis conceptualizes BIM as an enabling mechanism whose efficacy is contingent upon organizational alignment and process maturity.

Munir, Kiviniemi, Stephen W Jones, & Finnegan, (2020) demonstrate that the successful realization of BIM business value in asset management is contingent upon the implementation of effective asset information management strategies. The research underscores that information quality challenges are predominantly organizational related, resulting from weak information control mechanisms, unclear data requirements, and inadequate governance. BIM is conceived as a platform that facilitates information integration and reporting. However, its capacity to enhance information outcomes is contingent upon organizational readiness and structured processes.

Alkhard, (2024) demonstrates that the primary causes of information quality challenges in facility and asset management are deficiencies in data governance, metadata management, and process standardization, rather than limitations in digital technologies. The research identifies recurring issues, such as incomplete, inaccurate, redundant, and untimely information, that undermine effective asset management, using real-world Facility data. Further substantiate the notion that digital platforms are effective as enablers of information quality only when they are built upon robust organizational and process foundations.

From the past studies presented in Table 2.24 below, the majority indicate a positive moderating effect of BA between the relationship of organization and information quality, supporting the hypothesis that BIM moderates the relationship and can enhancing various aspects of information quality. As a result, based on the literature reviewed above, the current research proposes the following hypothesis:

H6: BA positively moderate the relationship between organizational and information quality in facility management

Table 2.24
Past Studies on BIM between Organizational and Information Quality

Research	Author(s)	Independent Variable (Organizational)	Dependent Variable (Information Quality)	Key Findings	Conclusion
1.	(Tsay et al., 2023)	Organizational factors	FM Quality	Information-related outcomes	The research finds that organizational factors strongly influence information outcomes in BIM-enabled environments. BIM supports information integration and standardization, but its effectiveness depends on organizational readiness and governance
2.	(Erciyas, 2024)	Organizational responsibilities, FM information requirements, information handover processes, workflow definition	FM Data Quality	FM information usability, completeness, consistency, and accessibility	The research finds that FM information quality issues are largely driven by organizational and process deficiencies, such as unclear responsibilities and poorly defined FM information requirements. BIM supports FM information delivery only when aligned with organizational workflows and process governance.
3.	(Munir, Kiviniemi, Jones, et al., 2020b)	Asset Information Management (AIM) strategy, governance structures	Information Consistency	Information accuracy, completeness, timeliness, and reliability	The research finds that information quality and business value in asset management are primarily driven by effective AIM strategies and organizational processes. BIM supports information integration and reporting but does not generate value independently. Its effectiveness depends on organizational readiness.
4.	(Alkhard, 2024b)	Data governance, standardized data	FM Quality	Information accuracy, completeness, timeliness, consistency, and reliability	The research finds that incomplete information are primarily caused by weak data governance, poor metadata standards, and lack of process control rather than limitations of BIM or digital tools.

2.10.7 The Moderator Effect of BA-TEC-IQ

As digital transformation reshapes the built environment, the synergy between technological advancements and Building Information Modelling (BIM) has become crucial in elevating information quality (IQ) within facility management. BIM does not merely function as a technological repository, but rather as a dynamic moderator amplifying and shaping the relationship between other technological factors and the quality, accuracy, and reliability of information. The studies below reveal how the adoption of BIM transforms the outcomes of technological investments, turning standard digital upgrades into powerful drivers of information quality improvement.

Biagini et al. (2024) underscores the fact that BIM functions as a central reference model within a broader digital ecosystem, thereby enabling the exchange of structured data between design, construction, and facility management systems. Organizations can enhance the continuity and consistency of asset data and reduce information fragmentation by integrating BIM with complementary digital platforms. Nevertheless, the paper portrays these enhancements as the result of technical and process integration, rather than as organizational or behavioural effects.

Abd Jamil & Mohamad Syazli Fathi. (2020) investigates the interoperability of systems in BIM-enabled environments and emphasizes the necessity of effective interoperability mechanisms to ensure the reliable exchange of information when multiple digital systems interact. The authors contend that BIM can assist in the mitigation of information inconsistencies and disputes when it is accompanied by standardized data exchange protocols and explicit contractual agreements.

Alnajjar et al. (2025) demonstrate that the integration of automation and emerging technologies within BIM-enabled environments significantly enhances their impact, despite the fact that they increase process efficiency and accuracy. BIM serves as a central platform that enables real-time validation, coordinated operations, and lifecycle-wide data integration, thereby enhancing the contribution of automation to information quality.

Chung et al. (2021) underscores the significance of system usability in digital and BIM environments, illustrating that user-friendly interfaces improve user performance, efficiency, and consistency of system use. The research's results indicate that usability is a critical prerequisite for effective information handling. This suggests that the mere presence of BIM does not guarantee enhanced information quality unless digital systems are adequately usable to facilitate users' information entry, sharing, and retrieval activities.

From the past studies presented in Table 2.25 below, the majority indicate a positive moderating effect of BA between the relationship of technology and information quality, supporting the hypothesis that BIM moderates the relationship and can enhancing various aspects of information quality. As a result, based on the literature reviewed above, the current research proposes the following hypothesis:

H7: BA positively moderate the relationship between technology and information quality in facility management

Table 2.25
Past Studies on BIM between Technology and Information Quality

Research	Author(s)	Independent Variable (Technology)	Dependent Variable (Information Quality)	Key Findings	Conclusion
1.	(Biagini et al., 2024b)	Integrated digital platforms, lifecycle information integration, interoperability processes	FM Information Reliability	Information consistency, continuity, availability, and usability across the asset lifecycle	The research highlights that integrating BIM with other digital platforms enables better harmonization of asset data across lifecycle phases.
2.	(Abd Jamil & Mohamad Syazli Fathi., 2020)	System interoperability, data exchange standards, legal and contractual governance mechanisms	Improvement FM Information	Information reliability, consistency, and clarity	The paper highlights that poor interoperability among digital systems leads to inconsistent and unreliable information, often resulting in disputes. BIM can support more reliable information exchange when combined with standardized data formats, clear exchange protocols, and well-defined contractual responsibilities.
3.	(Alnajjar et al., 2025)	Automation and emerging technologies (AI, IoT, Digital Twins, Robotics) integrated through BIM	Accuracy, reliability, timeliness, and consistency of project information	Automation improves efficiency and accuracy, but its effectiveness is significantly enhanced when embedded within BIM-enabled workflows that support real-time data validation, coordination, and lifecycle integration	BIM acts as a central integration platform that amplifies the benefits of automation, functioning as a force multiplier that enhances information reliability and process-driven information quality
4.	(Chung et al., 2021)	System usability, interface design, user interaction quality	FM Information Reliability	Information quality discussed indirectly through user interaction effectiveness	The research finds that user-friendly digital systems improve user performance, efficiency, and consistency of system use. In BIM-related environments, poor usability increases cognitive load and hinders effective interaction, while good usability supports smoother information entry, navigation, and retrieval.

2.10.8 The Moderator Effect of BA-PRO-IQ

The intersection of process management and digital technologies in facility management is now widely acknowledged as pivotal to achieving high information quality (IQ). Building Information Modelling (BIM), as a digital enabler, has advanced beyond simple data visualization as it is increasingly identified as a moderator that strengthens or transforms the positive effect of process-related improvements such as standardization, documentation, workflow integration, and compliance—on the quality, completeness, and reliability of information. The following review synthesizes five key studies that explore this dynamic.

Toochukwu (2025) emphasizes that the implementation of BIM facilitates the development of more standardized and coordinated workflows by allowing stakeholders to collaborate within a shared digital environment throughout the project's lifecycle. Through the centralization of project information within a shared model, BIM enables the coordinated interchange of information, real-time updates, and consistent data collection from planning and construction to operation and maintenance. This integrated approach reduces errors and supports more reliable and continuous information management across the asset lifecycle by minimizing information fragmentation, duplication, and miscommunication.

Leygonie (2020) emphasizes that the enhancement of FM information quality necessitates the establishment of well-defined quality improvement procedures, which are facilitated by structured BIM environments. The research emphasizes that BIM enables organizations to implement systematic verification and review processes by facilitating traceability, consistency, and documentation. Nevertheless, the continued significance of human oversight in BIM-enabled FM is underscored by the fact that information reliability improvements are accomplished through procedural compliance and governance mechanisms, rather than automated validation.

Matarneh et al. (2019) emphasizes the importance of well-defined documentation and standardized information exchange requirements in order to achieve consistent Facility information, which is accomplished through information completeness and clarity. It also illustrates that BIM facilitates these outcomes by offering a structured environment for the management and transmission of documented information, particularly when documentation processes are in accordance with FM information requirements.

Nicał & Wodyński (2016) elucidates that BIM can facilitate the enhancement of facility management practices by facilitating the continuous and standardized flow of information throughout the asset lifecycle. Nevertheless, these advantages are only realized when BIM is integrated into well-defined FM processes and is bolstered by organizational readiness. BIM adoption alone is insufficient to address information quality challenges in FM without such alignment.

Wetzel et al., (2016) emphasizes that information quality challenges in facility management are primarily logistical in nature, arising from poorly defined information flows, late or incomplete data delivery, and misalignment between information production and FM needs. The research argues that BIM can support information logistics by providing a structured environment for storing and accessing building information. However, its effectiveness depends on clearly defined processes, early specification of FM information requirements, and coordinated organizational responsibilities. This reinforces the view that BIM alone is insufficient to ensure high-quality FM information without strong process and organizational foundations.

From the past studies presented in Table 2.26 below, the majority indicate a positive moderating effect of BA between the relationship of process and information quality, supporting the hypothesis that BIM moderates the relationship and can enhancing various aspects of information quality. As a result, based on the literature reviewed above, the current research proposes the following hypothesis:

H7: BA positively moderate the relationship between process and information quality in facility management

Table 2.26
Past Studies on Moderator BIM between Process and Information Quality

Research	Author(s)	Independent Variable (Technology)	Dependent Variable (Information Quality)	Key Findings	Conclusion
1.	(Toochukwu, 2025)	Standardized and integrated workflows across planning, execution, and lifecycle management	Information Consistency	Information consistency, continuity, accuracy, and reduction of duplication and errors (conceptual)	The research indicates that embedding workflows within a shared BIM environment supports harmonized data collection and real-time information updates across the asset lifecycle.
2.	(Leygonie, 2020)	Quality improvement procedures	Information Accuracy	FM information reliability, consistency, and completeness	The research finds that FM information quality improves when clearly defined procedures, checklists, and review processes are implemented. BIM supports these procedures by providing structured information storage, traceability, and documentation.
3.	(S. Matarneh et al., 2019)	Process documentation, information exchange requirements, completeness and clarity of FM documentation	Information Consistency	Information consistency, completeness, and reliability in FM	The research highlights that incomplete and unclear documentation is a major source of inconsistency in FM information. Clearly defined documentation processes and standardized information requirements are essential for achieving consistent Facility information. BIM supports these processes by providing a structured environment for managing and transferring documented information when aligned with FM needs.
4.	(Nicał & Wodyński, 2016)	BIM-enabled FM processes, lifecycle information logistics, standardized information exchange	Information Consistency	Information continuity, consistency, accessibility, and reliability in FM	The research shows that FM inefficiencies are largely due to fragmented information flow across the asset lifecycle. BIM-enabled FM processes can optimize FM practices by sustaining structured information flow and supporting standardized documentation and interoperability.

Research	Author(s)	Independent Variable (Technology)	Dependent Variable (Information Quality)	Key Findings	Conclusion
5.	(Wetzel et al., 2016)	Information flow, organizational coordination	FM Information Reliability	Information timeliness, completeness, relevance, and consistency in FM	The research finds that FM information quality problems stem mainly from poor information logistics, such as late delivery, incomplete data, and misalignment between information production and FM needs. BIM can support structured information management, but only when FM information requirements and processes are clearly defined and coordinated across the lifecycle.

2.11 Chapter Summary

This chapter had discusses the extent literature related to all the key constructs of the research. It reveals the theoretical foundation for the research model and hypotheses formulation of the research. The research model stands on STS and has a total of eight hypotheses to represent the phenomenon of interest. The next chapter will discuss the methodology involved for the empirical examination of the proposed hypotheses.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the methodology used in accomplishing the present research. It delineates the overall architecture of the research including the research paradigm, research design and process, scope, population, and sampling determination. In addition, the chapter also elaborates the data collection procedure, survey instruments and operationalization of the key constructs as well as pretesting procedures. Finally, the chapter ends with a detailed explanation of the statistical analysis involved in the research.

3.2 Research Paradigm

Research paradigm comprises of “the abstract beliefs and principles that shape how researcher sees the world and how she or he interprets and acts within that world” (Kivunja & Kuyini, 2017). In other words, it sets the foundation that directs researcher’s thinking on what need to be accomplished, which methods to use, as well as how data will be analyzed and interpreted to contribute to the knowledge (Kivunja & Kuyini, 2017; Leavy, 2022). Positivism, constructionism, critical realism, and pragmatism are dominant research paradigms which are mostly influenced by academic researchers (Fuyane, 2021). The paradigm establishes the research's intentions. Mackenzie & Knipe, (2006), stated “Without nominating a paradigm as the first step, there is no basis for subsequent choices regarding methodology, methods, literature or research design.” (Mackenzie & Knipe, 2006) has described few types of research paradigms as listed in Figure 3.1.

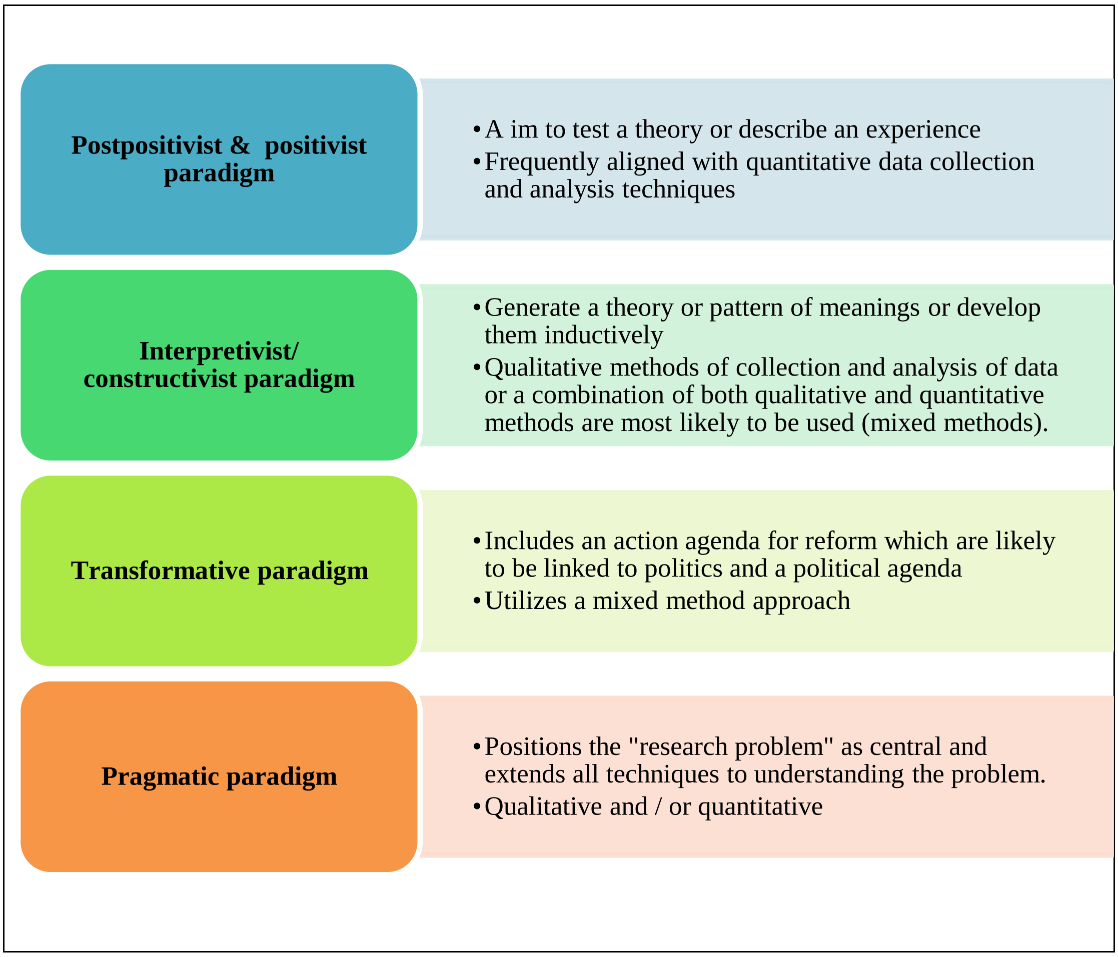

Figure 3.1 Four Common Paradigms

Source: (Mackenzie & Knipe, 2006)

Four elements that form a research paradigm are ontology, epistemology, methodology and axiology (Khatri, 2020). Ontology refers to “a philosophical belief system about the nature of the social world (e.g., whether it is patterned and predictable or constantly re-created by human)” (Leavy, 2022). Next, epistemology explains what is acceptable as knowledge; how it forms and how it is obtained and conveyed to others (Cooksey, 2019; Guba, 1989; Kivunja & Kuyini, 2017; Leavy, 2022). Both ontology and epistemology guide the researcher’s perspective on the approach to be used to acquire the knowledge.

The methodology of positivism is aimed at explaining relationships. Positivists attempt to identify causes that influence outcomes (Creswell, 2009). Their objective is to formulate laws, thus forming a framework for prediction and generalisation. A deductive approach is being carried out. Correlation and experimentation are used to reduce complex interactions with their constituent components. Proof of verification is sought through direct experience and observation, including empirical testing, random sample samples, controlled variables (independent, dependent, and moderator), and control groups (Scotland, 2012). The scientific paradigm seeks predictions and generalisations; thereby, methods often generate quantitative information.

In general, the positivist paradigm fits the intended objective of the research's to employ the quantitative method. The research process involves identifying the population, examining the sample of the population, and conducting statistical analysis of the variables. This research paradigm has been widely used in renowned scholars in social sciences as it allows researchers to test theory and hypotheses based on the basis of objective measures to support the results.

3.3 Research Design

Research design provides the basic structure and direction to carry out the research. Bougie, & Sekaran, (2016) defined research design as a "blueprint or plan for the collection, measurement and analysis of data created to answer the research empirical questions". An appropriate selection of research design is essential as it allows the researcher to obtain the relevant information required for the attainment of research objectives in an efficient way (Hair & Alamer, 2022).

The method followed in this research is a quantitative research, which focuses on collecting data at one point in time and is focused on deductive reasoning. The deductive investigation is an investigation that begins with a general theory to explain specific cases. Quantitative research methodologies can be employed to address inquiries regarding the relationships between variables under investigation. Quantitative researchers aim to generate explanations and predictions that can be applied to other locations and individuals. The primary objective is to establish, validate, or establish relationships, as well as to formulate generalisations that make a theoretical contribution (Filho & Kovaleva, 2015). Hence the current research has followed a quantitative approach.

The present research employed a survey design to investigate the relationships between constructs of the research. In addition, the method was also selected based on the consideration of the resources' requirements such as time, cost, and access to the data. According to Malhotra et al., (2015), a survey method facilitates fast responses, saves cost and provides good control over the respondents. It allows the researcher to collect quantitative data for various types of research questions about people, events and situations. These qualities fit the current research's intention of providing a rigorous result through an efficient use of resources. Ibrahim, (2025) stated that surveys are the most popular and widely used research design in the social sciences because it allows for collecting data in a shorter amount of time. The research embraced the online survey method using structured questionnaires. Moreover, this method will enable the researcher to reach a wider geographical area in Malaysia.

As the survey was conducted cross-sectionally, data were collected and measured only once in this research. The cross-sectional strategy was found to be sufficient to answer the research questions. This is because this research did not focus on analyzing the trend of the relationships nor comparing a phenomenon before and after a specific intervention. Besides, this correlational field of research establishes relationships among independent, moderator, and dependent variables. Hence, the research examines the relationships between each construct of people (PEO), organizational (ORG), technology (TEC), process (PRO), BIM attributes (BA) and information quality (IQ) among facility management organization in Malaysia who are registered under CIDB.

3.4 Time Horizon

According to Saunders (2012) there are two types of time horizons namely, cross-sectional, and longitudinal research. A *cross-sectional research* is a research of a particular phenomenon at a particular time. On the other hand, *longitudinal research* is defined as research of a particular phenomenon over an extended period of time. Based on the aim and objectives of this research, the cross-sectional time horizon is the most appropriate.

3.5 Unit of Analysis

Unit of analysis is defined as "the level at which information is analyzed and conclusion were drawn" (Uma Sekaran & Roger Bougie, 2016). In this research, the unit of analysis is at organizational level. The respondents are the facility managers or employees who generally involve in facility management information system. The primary focus of this research is to examine how social (people and organizational) and technical (technology and process) influence information quality within the context of FM. Given that the integration of BIM and FM typically occurs at the organizational level, it is crucial to focus on the facility management organization as the unit of analysis, rather than individual employees.

This approach aligns directly with the research objectives and questions, such as "Does social (people and organizational) and technical (technology and process) factors have an impact on FM information quality?" and "How does BIM and FM integration improve FMIQ?" By centring the unit of analysis at the organizational level, the research aims to capture how institutional practices, strategies, structures, and technology collectively affect the quality of information in FM. Data will be collected from FM organizations registered under the CIDB.

This firm-level focus is justified because decisions on information management are typically made at the organizational not individual level. Moreover, many of the moderating factors under research such as BIM are implemented through organizational policies and cross-functional teams rather than by individuals alone. By emphasizing the organization as the unit of analysis, this research provides a holistic understanding of how both social and technical subsystems contribute to or hinder effective information quality in FM. The organizational level data will enable identification of best practices, gaps, and strategic interventions that can be generalized across the FM sector in Malaysia.

3.6 Research Process

The research process of this study was conducted in three main phases: Phase 1: Information Gathering, Phase 2: Main Data Collection, and Phase 3: Framework Development and Validation. These phases were developed to ensure that the study was conducted systematically, beginning with the identification of the research problem and ending with the validation of the proposed integrated BIM-FM framework.

a) Phase 1: Information Gathering

Phase 1: Information Gathering focused on establishing the foundation of the study. This phase involved a comprehensive review of literature related to Facility

Management, Information Quality, BIM-FM integration, Socio-Technical Systems theory, and the main constructs of the study, namely People, Organisation, Technology, Process, BIM Attributes, and Facility Management Information Quality. In addition to the literature review, a research need analysis was conducted to obtain preliminary industry insights and to confirm the relevance of the research problem in actual FM practice. The research need analysis was collected through expert interviews with selected industry practitioners who had experience in Facility Management, asset management, BIM, or built environment operations. The experts were asked to provide their views on current FM information management practices, information quality issues, BIM-FM readiness, workforce capability, organisational support, and the need for an integrated framework. The interview data were then analysed thematically by identifying recurring issues, patterns, and key themes from the expert responses. These themes were compared with the findings from the literature review to strengthen the problem statement and justify the need for the study. The information gathered from the literature review and Research Need Analysis was used to refine the research problem, aim, objectives, research questions, scope, and preliminary conceptual framework.

b) Phase 2: Main Data Collection

Phase 2: Main Data Collection involved the development of the research instrument and the collection of quantitative data. A structured questionnaire was designed based on the constructs identified from the literature review and conceptual framework. The questionnaire items were adapted from previous studies and modified to suit the BIM-FM and FM Information Quality context. Before the main survey was conducted, the instrument underwent pre-testing and a pilot study to assess item clarity, relevance, and reliability. The main data collection was then carried out using a questionnaire survey among G7 facility management organisations in Malaysia. After the data were collected, data preparation and screening were conducted to check for blank responses, missing values, straight-lining responses, outliers, and other data quality issues. The cleaned data were then analysed using SPSS and SmartPLS through Partial Least Squares Structural Equation Modelling.

c) Phase 3: Framework Development and Validation

Phase 3: Framework Development and Validation focused on developing and validating the integrated BIM-FM framework. The framework was developed based on the literature review, theoretical foundation, Research Need Analysis, and quantitative research procedures. Expert validation was then conducted to assess the clarity, relevance, usefulness, and practical applicability of the framework. Feedback from the experts was reviewed and used to refine the framework before finalisation. This phase ensured that the proposed framework was not only theoretically and methodologically grounded, but also suitable for practical application in the Facility Management industry.

In conclusion, the three-phase research process provided a systematic pathway for conducting the study. Phase 1 established the research foundation, Phase 2 focused on instrument development, data collection, data screening, and statistical analysis, while Phase 3 focused on framework development and expert validation. This process ensured that the development of the integrated BIM-FM framework for Facility Management Information Quality was conducted in a structured, rigorous, and methodologically sound manner.

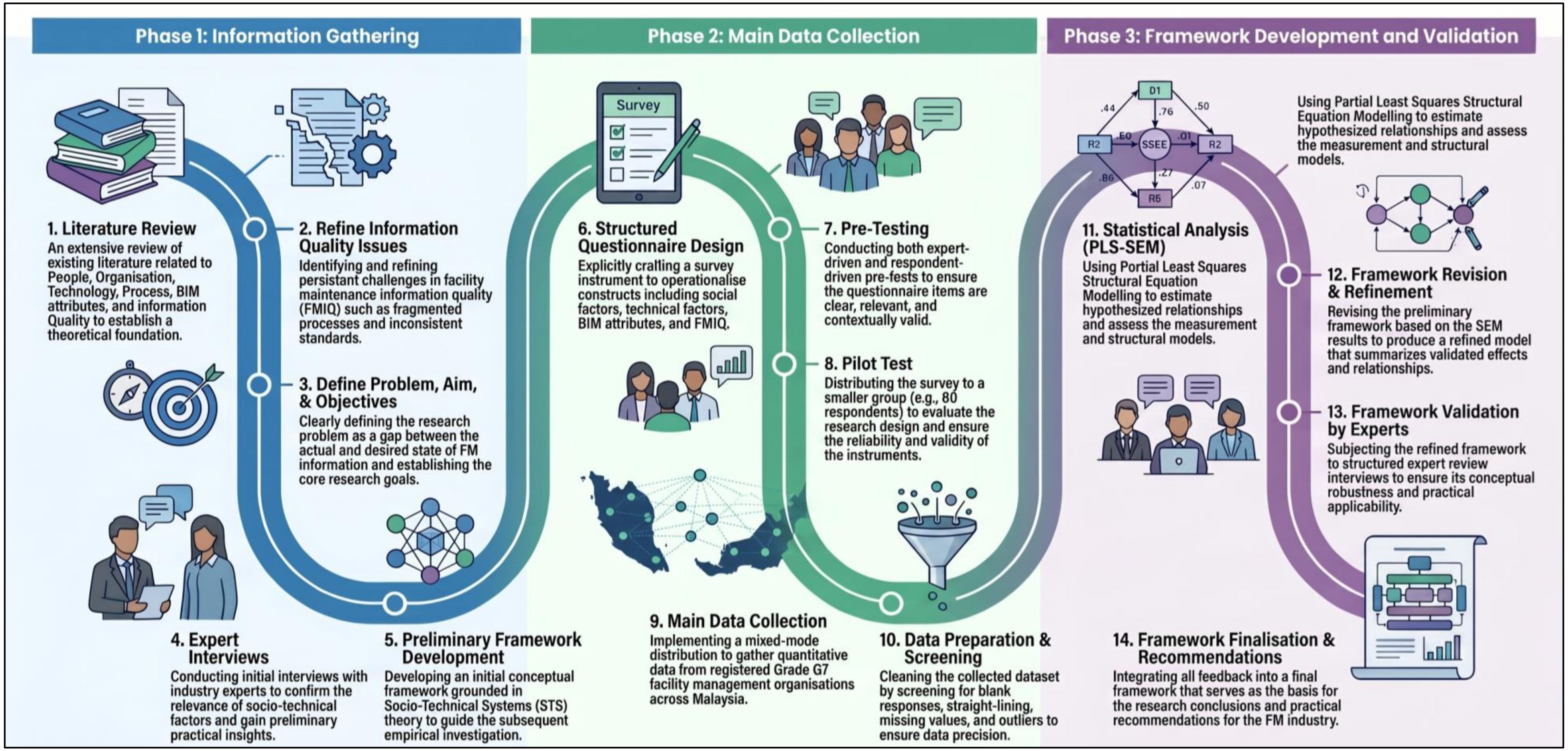

Figure 3.2 Research Process Flow

3.7 Research Framework

The literature has been reviewed extensively based on the constructs of people, organization, technology, process, BIM attributes, and information quality to develop the proposed research framework. This framework is grounded in the Socio-Technical Systems (STS) Theory, which emphasizes the social and technical subsystems within an organization (Trist & Bamforth, 1951; Bostrom & Heinen, 1977). By integrating both social components (people and organizational structures) and technical elements (technology and process), the framework aims to assess how these domains collectively influence Facility Management Information Quality (FMIQ). The structure of this framework is informed by prior empirical studies and is graphically presented in Figures 3.3 to 3.6. Through a systematic literature review, key constructs were identified and linked to information quality outcomes in the context of Facility Management (FM), especially where BIM is integrated as a moderating technological intervention.

STS theory posits that organizational performance outcomes are maximized when social and technical systems are aligned (Klassen et al., 2012; Pasmore, 1988). In this research, FMIQ serves as the dependent variable, representing the completeness, accuracy, format, and currency of information required for effective FM decisions (J. Chang & Parlikad, 2024; Heaton et al., 2019). Social components such as people (knowledge) and organizational support (training, teamwork, resources) are hypothesized to directly influence FMIQ, consistent with findings by Ghosh et al., (2015) and Salahuddin et al. (2019). On the technical side, the quality of FM technologies and process standardization are also seen as critical predictors of FMIQ (Zhao et al., 2022; Ghosh & Arif, 2018). BIM attributes are introduced as a moderating variable due to their potential to enhance collaboration, visualization, and information flow within FM systems (Motawa & Almarshad, 2013; Succar, 2009). The integration of these constructs under the STS lens allows for a holistic understanding of how the interaction between social and technical systems influences the quality of FM information quality.

3.7.1 The First Order

Millan & Esteban, (2004) conducted a first-order factor model of CFA. In this particular CFA model, this research explicitly defines a single level of factors (referred to as the first order) that show correlation. However, this technique implies that the correlated factors are distinct constructs. But what if the researcher works with a multi-dimensional concept like TEC, ORG and IQ. First, researcher need to find out if the dimensions are related. Second, researcher need a way to show how the dimensions and the construct are structurally related.

This research use higher-order constructs (HOC) to model a construct on more concrete subdimensions known as lower-order components (LOC). There are several benefits to using HOC. For instance, HOCs help reduce the number of path model relationships, leading to model parsimony. It can summarise the independent constructs in an HOC instead of detailing interactions between various dependent and independent constructs in a path model. This renders the relationships between the (then) LOCs and the dependent constructs in the model redundant (Sarstedt et al., 2019). The second-order model has two distinct features: firstly, the second-order factor is considered the exogenous construct, whereas the first-order factors are considered endogenous; secondly, there are no indicators for the second-order factor.

This research measures the constructs for TEC, ORG and IQ using the second-order factor. Salahuddin et al. (2019) have developed the ORG framework using a second-order approach. They first analyse the differences between the first and second-order measurement models before investigating the conceptual and theoretical aspects of the second-order constructs. ORG is a latent variable with a set of measurement variables that includes training (4 items), teamwork (5 items), and organisational resources (4 items). Due to the fact that ORG is comprised of three constructs, it is regarded as complex, according to (Sarstedt et al., 2019). Therefore, it is appropriate to utilise the second-order approach for this research, as shown in Figure 3.3.

Salahuddin et al., (2020) established the TEC framework by employing a second-order approach. TEC is a latent variable comprising several measurement variables, including system quality (8 items) and service quality (5 items). TEC is considered complicated since it consists of two constructs, as stated by Sarstedt et al. (2019). Hence, it is suitable to employ the second-order approach for this as depicted in Figure 3.4.

Akter et al., (2017) established the IQ framework by employing a second-order approach. IQ is a latent variable comprising several measurement variables, including completeness (3 items), accuracy (3 items), format (3 item) and currency (3 item). IQ is considered complicated since it consists of three constructs, as stated by Sarstedt et al. (2019). Hence, it is suitable to employ the second-order approach for this investigation, as depicted in Figure 3.5

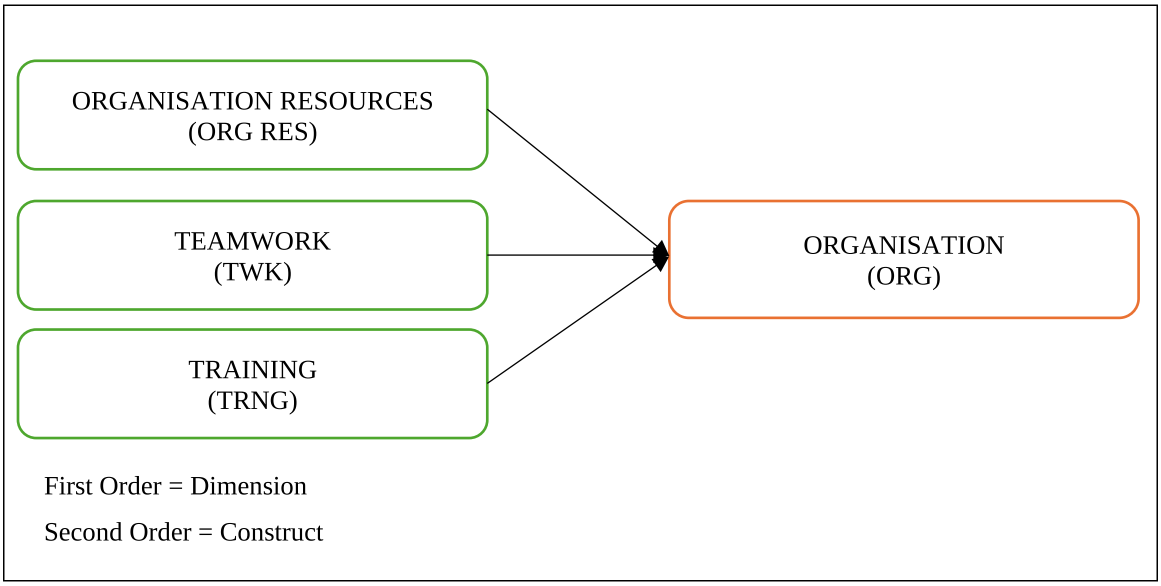

Figure 3.3 First-Order Model Research Framework – Organization

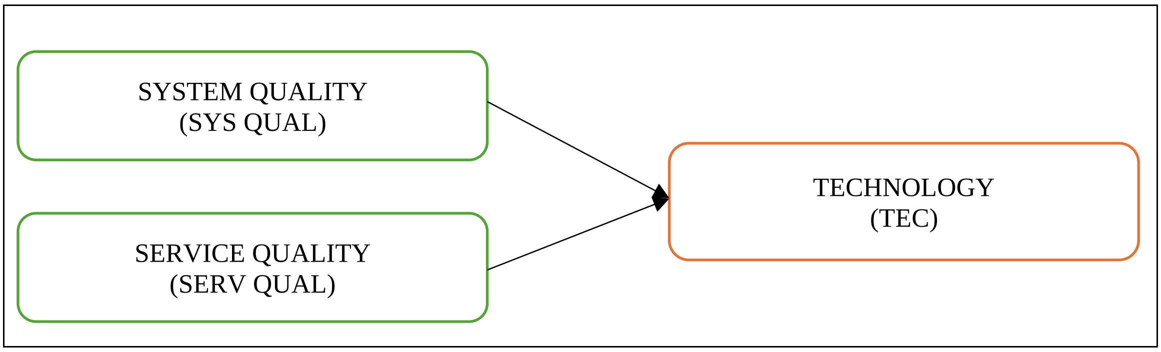

Figure 3.4 First-Order Model Research Framework – Technology

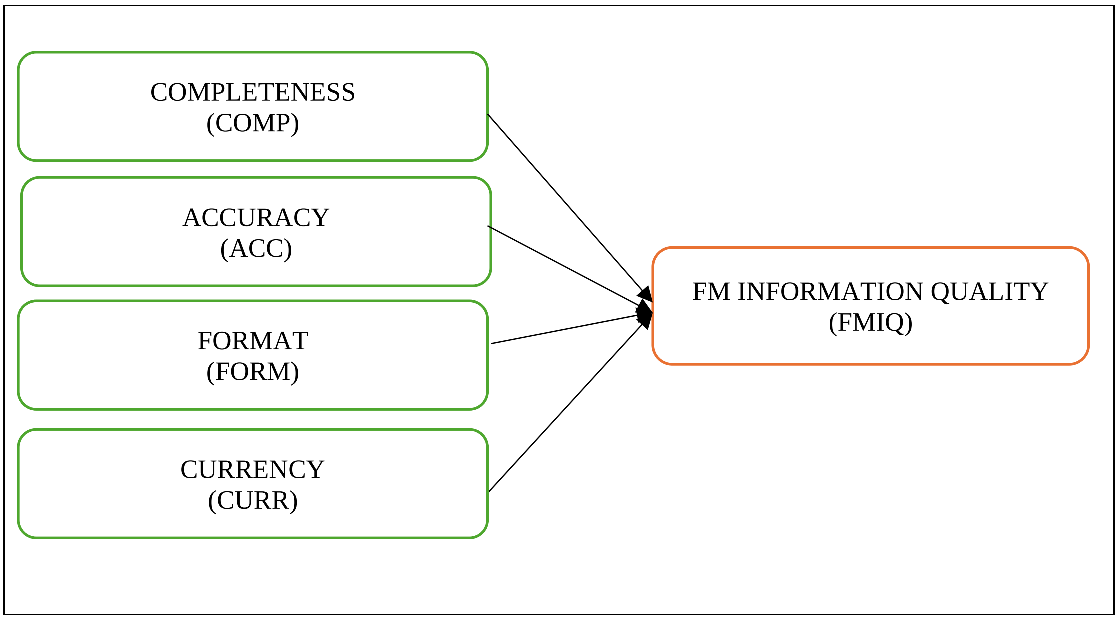

Figure 3.5 First-Order Model Research Framework – Information Quality

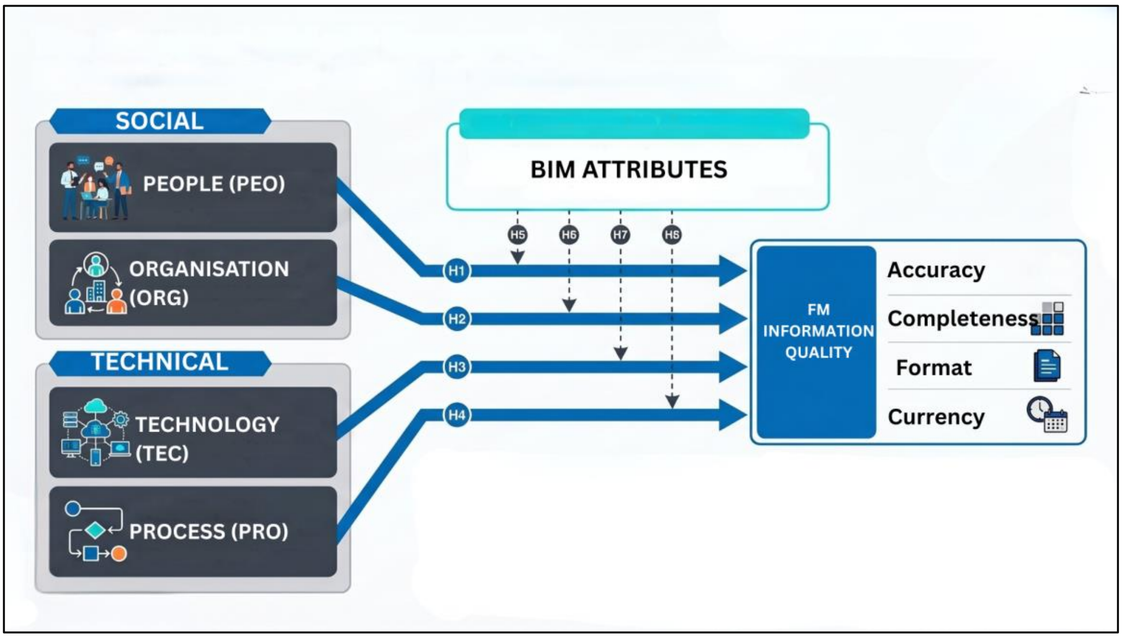

Figure 3.6 Research Framework

Source: Author

Based on Figure 3.6, the research framework consists of several variables: (i) dependent variable – IQ, (ii) independent variables – PEO, ORG, TEC and PRO (ii) moderator variable –BA. The discussion of each variable is available in the following subsections:

3.7.2 Dependent Variable: Information Quality

FMIQ is the dependent variable in this research. FMIQ refers to the degree to which information used in facility management processes is accurate, complete, currently, and appropriately formatted to support effective decision-making (Zadeh et al., 2017). In this research, FMIQ is influenced by social (people and organization) and technical (technology and process) factors. These predictors are derived from the STS theory which posits that optimal organizational performance is achieved when both social and technical subsystems are jointly optimized (Trist & Bamforth, 1951; Clegg, 2000). The delivery of high-quality facility information is essential in ensuring that maintenance, asset management, and strategic planning processes are efficient and reliable.

According to STS theory, organizational performance is a result of the interaction between social elements and technological. When social systems provide sufficient support, and technical systems are effectively implemented, the quality of FM information improves significantly (Ghosh et al., 2015; Heaton et al., 2019). This reflects the dual optimization emphasized by STS. Furthermore, BIM serves to enhance these interactions by enabling real-time data integration, improving coordination, and visualizing facility assets which further strengthening the quality of information produced and shared throughout the facility lifecycle (Altwassi et al., 2024; Chatsuwan et al., 2025). Therefore, FMIQ in this framework is the core outcome influenced by the balance and synergy between social and technical elements within FM organizations.

3.7.3 Independent Variable: People

The first pertinent independent variable in this research is People. People refers to the characteristics or conditions of a single or group of practitioners performing their related tasks (Salahuddin et al., 2020). These elements are essential in shaping the effectiveness of information quality. Knowledge among FM staff directly contribute to higher information quality by reducing errors, improving communication, and enhancing decision-making (Moshood et al., 2024a; Oluleye et al., 2023). Employees who are empowered with clear responsibilities, communication channels, and collaboration tools are more capable of managing and delivering reliable facility-related information (Atkin & Brooks, 2021; Santos et al., 2024).Therefore, the human factor plays a pivotal role in ensuring the accuracy, completeness, and timeliness of information within FM systems.

3.7.4 Independent Variable: Organizational

The second key independent variable in this research is organizational. Organizational factors represent the conditions of the work system within which practitioners perform their tasks (Salahuddin et al., 2019). Drawing on the socio-technical systems perspective, these organizational conditions influence how effectively technology is used and how people interact with information systems. A supportive organizational environment fosters teamwork and training departments, which in turn contributes to higher information quality. Prior studies have emphasized that when organizations provide structured workflows, clear communication protocols, and a commitment to continuous learning, employees are more likely to engage meaningfully with FM systems, ensuring that data is complete, accurate, and timely (Pishdad-Bozorgi et al., 2018a; Wills, 2023) .Thus, the organizational setting acts as a foundational enabler that shapes both the behavior of practitioners and the performance of technical systems, ultimately influencing the effectiveness of FM information quality.

3.7.5 Independent Variable: Technology

The third key independent variable in this research is technology. Technology refers system used by practitioners to support their services (Salahuddin et al., 2019). Within the socio-technical systems (STS) theory, technology is not viewed in isolation, but as a critical enabler that must align with social systems to optimize performance outcomes (Li, 2020; Thomas, 2024). In FM contexts, technology a pivotal role in enhancing information accuracy, accessibility, and timeliness (Lee et al., 2021; Sulaiman et al., 2021). When effectively implemented, these technologies streamline workflows, automate data capture, and provide real-time insights that improve operational decisions and strategic planning. However, technology alone is insufficient its effectiveness depends on usability, interoperability, and how well it is integrated into existing organizational and process structures (Akter et al., 2017; Cachata et al., 2024). As such, technology serves as a dynamic component of the FM work system, influencing the quality of information by enabling efficient data handling, system connectivity, and user interaction.

3.7.6 Independent Variable: Process

The fourth key independent variable in this research is process. Process refers to the activities that support the accomplishment of work goals (Ali & Waheed, 2024). From a socio-technical systems (STS) perspective, processes form the structured link between the social (people and organization) and technical (technology and process) elements, ensuring alignment, coordination, and consistency across FM functions (Azmi & Ismail, 2025b; Fischer & Herrmann, 2011b; Thomas, 2024). Efficient and well-defined processes reduce ambiguity, minimize redundancies, and ensure that data is collected and utilized systematically contributing to improved information quality (Leygonie et al., 2022; Zadeh et al., 2017). Conversely, fragmented or poorly documented processes can lead to information silos, errors, and delays that degrade decision-making and asset performance. As such, this research considers process a vital predictor of FM information quality, as it governs how consistently and effectively information flows through the work system.

3.7.7 Moderator Variable: BIM Attributes

The moderating variable in this research is BIM attributes which refer to application areas of BIM that could be implemented and beneficial (Becerik-Gerber et al., 2012). Under the socio-technical systems (STS) lens, BIM attributes are not merely technological tools but act as moderators that bridge the technical and social subsystems, enhancing information quality (Fischer & Herrmann, 2011; Sackey, 2014). BIM enables real-time access to accurate and structured facility data, streamlines maintenance workflows, and ensures that asset information remains consistent throughout the building lifecycle. Empirical studies have shown that BIM's functionalities such as clash detection, 3D visualization, and automated data updates improve the efficiency and reliability of FM processes (Leygonie, 2020b; Oluleye et al., 2023). By serving as a moderator, BIM attributes influence the strength and direction of the relationship between people, organization, technology, and process on information quality, potentially amplifying the positive effects of these predictors in both BIM and non-BIM organizational settings.

3.8 Scope of Research

The research setting for this research refers to the context and location in which data were collected. Given the increasing emphasis on digital transformation within the built environment, Malaysia has shown growing interest in integrating technologies such as Building Information Modelling (BIM) into Facility Management (FM) practices. This research focuses specifically on FM organizations across Malaysia, which include both BIM users and non-BIM users, in order to evaluate how socio-technical elements influence Facility Management Information Quality (FMIQ).

The research targets FM organizations operating in all sectors in Malaysia. As digitalization becomes a national agenda under initiatives such as the 13th Malaysia Plan (RMK-13) and Industrial Revolution 4.0 (IR4.0), Malaysian FM organizations are at different stages of BIM adoption. Therefore, collecting data from a diverse sample enables the research to capture varying practices and levels of maturity in FM information quality.

This research was conducted at all states in Malaysia. The data collection period spanned approximately four months, from January to June 2025. Respondents were selected based on their roles in FM-related departments, such as facility managers, asset managers, engineers, and maintenance supervisors. The selection criteria ensured that respondents were familiar with FM operations, systems, and challenges related to information management. Data were collected through a mixed-mode approach. The online distribution involved inviting registered Grade G7 companies to participate by using their official organizational email addresses. Each organization was requested to nominate a representative to complete the questionnaire through a provided Google Form link. Furthermore, offline data collection occurred through direct engagement at online meetings, professional briefings, workshops, and site visits, where printed questionnaires or access to the online survey were made available on-site. This integrated strategy improved response rates and promoted inclusivity across various geographical areas and degrees of digital readiness.

3.9 Population & Sampling

3.9.1 Population

Following the prior section that explained the rationale of conducting this research in Malaysia, particularly in the Malaysian facility management sector, this section elaborates more on the population and sampling choice of the present research. A population refers to the elements such as people, events or objects sharing a common set of characteristics that a researcher aims to investigate (Hair & Alamer, 2022; Uma Sekaran & Roger Bougie, 2016). The population of the present research is the G7 facility management organization from all sectors in Malaysia as listed in CIDB.

3.9.2 Sampling Design

Sampling involves finding the right sample or respondents for research (Sekaran & Bougie, 2016; Sekaran, 2003). Two commonly used sampling methods are non-probability and probability (Sekaran & Bougie, 2016; Sekaran, 2003). Due to the exist of a sampling frame of facility management organization in Malaysia, probability sampling was used in this research. This type of sampling denotes that the members of the target population having an identical known, nonzero opportunity or probability of being picked as sample items. It indicates that every member has a possibility to be selected (Sekaran & Bougie, 2010). Probability sampling can be further divided into simple random sampling, stratified sampling, cluster sampling, systematic sampling and multistage sampling.

3.9.3 Sampling Technique

This research employs a two-stage probability sampling technique, namely stratified sampling followed by simple random sampling, to ensure representation across different regions of Malaysia and to enhance the generalizability of the results. As outlined in Section 3.9.2, the use of probability sampling is justified due to the existence of a defined sampling frame, which includes 333 Facility Management (FM) contractors registered under the G7 grading across Malaysia. This research specifically focuses on G7-grade FM organizations, as they represent the highest classification of contractors authorized to undertake large-scale projects without financial limitations. These organizations are more likely to have structured FM systems and exhibit potential or existing adoption of Building Information Modelling (BIM). The research includes both BIM users and non-BIM users to understand their perspectives on whether the presence of BIM attributes can help improve Facility Management Information Quality (FMIQ), regardless of current adoption status. This targeted focus ensures that the research captures insights from experienced organizations that play a major role in national facility management operations. This systematic approach reduces sampling bias and supports the collection of reliable, representative data (Etikan, 2017).

In the first stage, the population of FM organizations was stratified based on geographical regions, with the organizations grouped according to the official regional classifications in Malaysia. These included the Central Region (comprising Selangor, Wilayah Persekutuan Kuala Lumpur, and Putrajaya), Northern Region (including Perak, Penang, Kedah, and Perlis), Southern Region (covering Johor, Negeri Sembilan, and Melaka), East Coast Region (consisting of Kelantan, Terengganu, and Pahang), and East Malaysia (including Sabah and Sarawak) (Appendix 5). Stratification according to state and region helps ensure that regional differences in FM practices, infrastructure development, and levels of BIM adoption are adequately represented in the research (Author & Ilkhamov, 2002; Klassen et al., 2012).

In the second stage, within each state (stratum), simple random sampling is carried out to select the participating organizations. This technique ensures that every FM organization within each state has an equal chance of being included in the research. Simple random sampling is widely regarded as one of the most effective methods to eliminate selection bias and ensure fairness in participant selection (Taherdoost, 2016). A random number generator will be used to facilitate the selection process from a comprehensive list of FM organizations, which will be obtained from CIDB. This approach is supported by previous research that emphasizes the effectiveness of stratified random sampling in achieving more precise estimates, particularly when the population contains identifiable subgroups (Singh & Masuku, 2014).

3.9.4 Sample Size

The minimum sample size required for this research was determined through power analysis using the G*Power software (Faul & Lang, 2009) ,which is commonly used in social science studies (e.g., (Hopf, 2024.; Memon et al., 2022; Memon et al., 2014). As recommended for social science and business research, the present research used F-test and A-priori power analysis to compute the required sample size in G*Power where the effect size, alpha value, and power were set at 0.15, 0.05 and 0.80, respectively (Hair, Matthews, et al., 2017)

The number of predictors was set as 3 based on the maximum arrows pointing to a construct in the research model. Consequently, G*Power indicated a total of 77 as the minimum required sample size for the current research. However, the questionnaires were distributed to all the 300 FM organization (CIDB List) to obtain the maximum response rate.

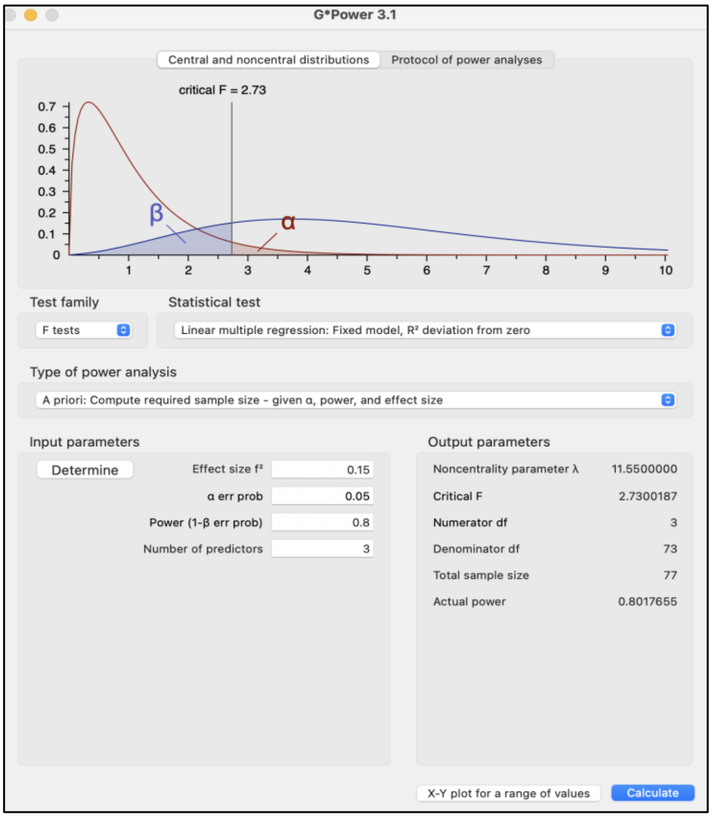

Figure 3.7 Sample Size by G Power

3.10 Measurement of Variables and Instrumentation

The measurement instruments for this study were adapted from established literature to ensure content validity, theoretical alignment, and suitability for empirical testing within the BIM-FM and Facility Management Information Quality context. The majority of the socio-technical constructs, specifically People, Organisation, and

Technology, were adapted from Salahuddin et al. (2020) because their study provides a clear operationalisation of human, organisational, and technological dimensions that is consistent with the Socio-Technical Systems (STS) perspective. Although Salahuddin et al. (2020) was conducted in an information systems context, the constructs are relevant to this study because FM information management also depends on user capability, organisational support, and technology readiness. To complete the technical subsystem of the STS framework, the Process construct was adapted from Ali and Waheed (2025), as it reflects the importance of standardised activities, workflows, coordination, and procedures in supporting organisational information management.

The moderating variable, BIM Attributes, was adapted from Becerik-Gerber et al. (2012) because the study identifies key BIM application areas in FM, which are relevant to BIM capabilities such as visualisation, lifecycle information, asset data, interoperability, and information integration. Finally, the dependent variable, Facility Management Information Quality, was adapted from Akter et al. (2017) because it provides established and measurement-ready information quality dimensions, namely accuracy, completeness, format, and currency, which are suitable for assessing whether FM information is correct, sufficient, usable, and up to date. Therefore, the adaptation of these instruments is justified because the selected constructs are theoretically grounded, contextually relevant, and aligned with the objectives of this study.

Hence, research variables, questionnaires, and sources of adapted instruments are described in the following section. Composite reliability or Cronbach's alphas were this research's most commonly used reliability measures. Several research have used these metrics extensively (Colquitt, 2001b; Latif, 2012; Na-nan et al., 2019; Schaufeli et al., 2006; Wilmar B Schaufeli et al., 2006), as shown below.

3.10.1 People (PEO)

People refers to the characteristics or conditions of a single or group of practitioners performing their related tasks (Salahuddin et al., 2020). A five-point Likert scale ranging from (1) strongly disagree to (5) strongly agree used to quantify PEO. A three-item instrument adapted from Salahuddin et al., (2020) was used to assess this variable. The precise details of construct measurement are shown in Table 3.1

Table 3.1
Precise Details of Construct Measurement (People)

Measurement Details	Items proposed for this research (Adopted)	Author
Type of Construct: Reflective Unit of Analysis: Organization Reliability: 0.89 (CR) Journal: Behaviour & Information Technology Journal	PEO1. Employees in our organization clearly understand all the functions provided in the FM Information System. PEO2. Employees in our organization effectively utilize all available functions in the FM Information System to carry out their assigned work tasks. PEO3. Employees in our organization possess sufficient knowledge to appropriately use our FM Information System, ensuring high-quality information.	(Salahuddin et al., 2020).

3.10.2 Organisation (ORG)

Organisational condition of the work system in which the practitioners perform their tasks (Salahuddin et al., 2020). Three dimensions were used to assess ORG in this research.

i. **Teamworks (TWK):** Teamwork encompasses the degree of collaboration among practitioners in pursuit of common objectives concerning information management.
ii. **Training (TRNG):** Training encompasses the degree to which organizations offer practitioners sufficient and ongoing education concerning information systems and procedures.
iii. **Organisation resources (ORG RES):** Organisational resources refer to the extent to which sufficient human, technical, and time-related resources are available to support FM information management activities

A five-point Likert scale ranging from (1) strongly disagree to (5) strongly agree used to quantify. A thirteen-item instrument adapted from Salahuddin et al., (2020) was used to assess this variable. The precise details of construct measurement are shown in Table 3.2

Table 3.2
Precise Details of Construct Measurement (Organisation)

Measurement Details	**Dimensions**	**Items proposed for this research (Adopted)**	**Author**
Type of Construct: Reflective Unit of Analysis: Organization Reliability: 0.89 (CR) Journal: Behaviour & Information Technology Journal	Teamwork	ORG1. The organization facilitates effective communication regarding FM information management queries. ORG2. Clear instructions and guidelines for managing FM information are provided by our organization. ORG3. Departments within our organization coordinate effectively concerning FM information systems. ORG4. There is strong inter-departmental collaboration regarding FM information handling within our organization.	(Salahuddin et al., 2020).
	Training	ORG5. Our organization provides adequate training on utilizing FM information systems. ORG6. Regular and scheduled training sessions are provided by our organization to update knowledge on digital FM systems. ORG7. Our organization conducts specific training whenever new FM procedures or system improvements are introduced. ORG8. Training provided by our organization effectively equips with necessary skills to manage FM information systems. ORG9. Our organization ensures staff are trained to handle situations involving information system downtime or malfunction.	
	Organisation resources	ORG10. Our FM department has sufficient staff to manage operations and maintain information systems effectively. ORG11. Our FM organisation is equipped with adequate and functional digital devices (e.g., desktops, laptops, tablets) to support FM information management	

Measurement Details	Dimensions	Items proposed for this research (Adopted)	Author
		ORG12. The digital equipment in our organisation (e.g., computers, tablets) have sufficient speed and performance to support information management	
		ORG13. Our FM staff have sufficient time and resources to complete facility management information tasks safely and effectively	

3.10.3 Technology (TEC)

Technology used by practitioners to support their services (Salahuddin et al., 2020). Two dimensions were used to assess TEC in this research:

i. **System quality (SYS QUAL):** System quality refers to the desirable characteristics of information systems that influence users' ability to perform their tasks effectively.
ii. **Service Quality (SER QUAL):** Service quality represents the degree of technical and organizational support offered to users of information systems.

Given the multi-faceted nature of the 'technology' construct in this research, there are no single validated scale adequately addressed all dimensions in the BIM-FM context. A five-point Likert scale ranging from (1) strongly disagree to (5) strongly agree used to quantify TEC. A thirteen-instrument adapted from Salahuddin et al., (2020)was used to assess this variable. The precise details of construct measurement are shown in Table 3.3

Table 3.3
The Precise Details of Construct Measurement (Technology)

Measurement Details	Dimensions	Items proposed for this research (Adopted)	Author
Type of Construct: Reflective Unit of Analysis: Organization Reliability: 0.89 (CR) Journal: Behaviour & Information Technology Journal	System Quality	TEC1. The FM information system of my organization is easy to use TEC2. The FM information system of my organization displays information in a manner easy to read. TEC3. Routine tasks can be performed in a straightforward manner using the FM information system. TEC4. The FM information system of my organization is well designed to allows me to enter comprehensive information TEC 5. The FM information system of my organization uses terms that are clear and easy to understand TEC 6. The FM information system of my organization uses consistent words, terminology, and sequences of action TEC 7. The FM information system of my organization fit my actual work practice and workflow TEC 8. The FM information system of my organization provides adequate functions to support my work.	(Salahuddin et al., 2020).
	Service Quality	TEC9. Technical supports are always willing to help resolving FM system issues. TEC10. Adequate technical support is available for resolving FM information system issues promptly. TEC11. Technical support have the knowledge to resolve FM information system issues. TEC12. Technical supports in my organization perform continuous updates and maintenance of the FM information system TEC13. Technical supports in my organization perform continuous maintenance of hardware related to the FM information system	

3.10.4 Process (PRO)

Process refers to the activities that support the accomplishment of work goals (Ali & Waheed, 2025). A five-point Likert scale ranging from (1) strongly disagree to (5) strongly agree used to quantify PEO. A five-item instrument adapted from (Ali & Waheed, (2025) was used to assess this variable. The precise details of construct measurement are shown in Table 3.4.

Table 3.4
The Precise Details of Construct Measurement (Process)

Measurement Details	**Items proposed for this research (Adopted)**	**Author**
Type of Construct: Reflective Unit of Analysis: Organization Reliability: .825 (CR) Journal: TQM Journal	PRO1. Our FM organization has standardized operational processes that are clearly understood by staff and relevant stakeholders. PRO2. Most FM processes in our organization are automated or systematized to minimize the risk of human error. PRO3. Our FM organization utilizes the latest technology and tools to perform maintenance and operations more effectively. PRO4. The FM systems used in our organization allow us to monitor and track FM information. PRO5. Our FM organization regularly reviews and improves its operational processes to maintain information quality.	(Ali & Waheed, 2025).

3.10.5 BIM Attributes (BA)

BIM Attributes (BA) refer to application areas of Facility management BIM could be implemented and beneficial (Becerik-Gerber et al., 2012). A five-point Likert scale ranging from (1) strongly disagree to (5) strongly agree used to quantify BA. A five-point Likert scale ranging from (1) strongly disagree to (5) strongly agree used to quantify BA. The precise details of construct measurement are shown in Table 3.5.

Table 3.5
The Precise Details of Construct Measurement (BIM Attributes)

Measurement Details		**Items proposed for this research (Adopted)**	**Author**
BIM Attributes Journal of Construction Engineering and Management	Data Interoperability	BA1. The ability to integrate and exchange information seamlessly across different platforms and software environments can improve FM information quality	(Becerik-Gerber et al., 2012).
	Facilitating real time data access	BA2. Accurate and timely information from a system would enhance FM information quality	
	Visualization	BA3. A system with clear visuals of FM data would help in enhance FM information quality.	
	Lifecycle Data Integration	BA4. Precise identification, tracking, and management of building assets throughout the entire lifecycle can improve FM information quality	
	Creating digital assets	BA5. Efficiently creating, updating, and managing electronic documents or databases related to assets can improve FM information quality	
	Space Management	BA6. Visualize space and host space attributes for immediate access to facilitate identifying underutilized spaces, forecast space requirements, simplify space analysis, manage the move process, and compare actual with planned space utilization can enhance FM information quality	
	Planning and Feasibility Studies	BA7. Assist in planning, designing, analyzing, and simulating remodel, renovation, or demolition work can enhance FM information quality	
	Emergency Management	BA8. Improving preparation, response, and recovery during emergencies such as fire, natural disasters, or security issues can improve FM information quality	
	Controlling and Monitoring Energy	BA9. Better tracking and managing of energy consumption for cost savings and sustainability can improve FM information quality.	

3.10.6 Information Quality (IQ)

Information quality is defined as the completeness, accuracy, format and currency of information produced by the information system. Completeness indicates the extent to which the user perceives that information system provide all the necessary information; accuracy focuses on the perceived correctness of information; format refers to the perception of how well the information is presented; and, finally, currency refers to the extent which the information is up to date (Akter et al., 2017). Four dimensions were used to assess IQ in this research:

i. **Accuracy (ACC):** focuses on the perceived correctness of information
ii. **Completeness (COM):** Completeness indicates the extent to which the user perceives that information system provide all the necessary information.
iii. **Format (FOR):** format refers to the perception of how well the information is presented
iv. **Currency (CURR):** currency refers to the extent which the information is up to date

A five-point Likert scale ranging from (1) strongly disagree to (5) strongly agree used to quantify IQ. The precise details of construct measurement are shown in Table 3.6.

Table 3.6
The Precise Details of Construct Measurement (Information Quality)

Measurement Details	Dimensions	Items proposed for this research (Adopted)	Author
Information Quality	Completeness	IQ1. Our organization provide complete set of FM information for recent events	(Akter et al., 2017).
		IQ2. FM information I receive contain all comprehensive information about recent events.	
		IQ3. I received all FM information I need about the recent events.	
	Accuracy	IQ4. I receive correct FM information	
		IQ5. The FM information I receive was error free	
		IQ6. The FM information provided was accurate	

Measurement Details	Dimensions	Items proposed for this research (Adopted)	Author
	Format	IQ7. The FM information provided was well formatted	
		IQ8. The FM information was well laid out	
		IQ9. The FM information are clearly presented on the screen.	
	Currency	IQ10. I received the most recent FM information	
		IQ11. My system produce the most current FM information	
		IQ12. The FM information from my system was always up to date	

3.11 Structure of Questionnaire

All elements were merged to produce a questionnaire after establishing the operationalized items for each construct. The front page of the survey included a cover page and a cover letter detailing the research's goals and ethical considerations. The relevance and purpose of the research were discussed in order to emphasise the importance of maintaining strict confidentiality and to clarify how the data will be used. This is usually followed by the remaining research model questions (Refer to Appendix 6).

To avoid confusion, each construct's operational description was added to provide a clear and simple definition of what the construct is about. Every survey form was printed on A4 paper, with a coloured paper cover meant to entice respondents to increase response rates. The items were printed in black and white on white paper and typed in Times New Roman font size 12 with Times New Roman typeface. The research attempted to avoid utilising small and colourful fonts, which could make the objects more difficult to read. After testing during the pre-testing stage, each respondent took roughly 10-15 minutes to complete the questionnaires.

Table 3.7
Survey Form Structure

PARTS	Section 1
Cover Letter	√
PART A	Respondents' Demographic • 7 questions
PART B	People (PEO) • 3 questions Organization. (ORG) • 13 questions
PART C	Technology • 13 questions Process • 5 questions
PART D	BIM Attributes • 9 questions
PART E	Information Quality • 12 Questions

Table 3.7 outlines the comprehensive conceptual framework of the research, specifying each construct along with its associated measurement items. The constructs were operationalized according to established literature and tailored to the context of BIM-enabled facility management in Malaysia. This framework underpins the measurement and structural model analysis conducted through PLS-SEM.

3.12 Back-to-Back Translation

A translation that is as close to the original language in structure and format as possible while also taking into account the contextual cues associated with the translation's use (Chen & Boore, 2009; Cruz et al., 2000). Back-to-back translation of all the items was conducted in this research. Table 3.8 shows the stages in back-to-back translation for this research.

Table 3.8
Back to Back Translation Stages

Stages	Translation	Translator	Date
Stage 1	Items were translated from English to Bahasa Melayu.	Translator 1	30 December 2024
Stage 2	Translated items in Bahasa Melayu were translated back to English.	Translator 2	3 January 2025
Stage 3	Items in English and Bahasa Melayu were reviewed.	Author	16 January 2025

3.13 Pre-Testing

Pre-testing ensures the questions are relevant and clear before the research research is undertaken (Sekaran & Bougie, 2016). It helps avoid item deletion and poor data quality during measurement model evaluation (Memon et al., 2017). Assess the survey question and instrument's potential to obtain data on research objectives before collecting main data. Pre-testing lowers ambiguity and biases (Sekaran, 2003). All of these issues point to the need for pre-testing. The instrument has been previously validated to evaluate PEO, ORG, TEC, PRO, BA and FMIQ. However, the contents must be re-validated (Sekaran, 2006), mainly when instruments have been used in different settings, contexts, sets of respondents and characteristics from the original studies (Hair, Black, Babin, & Anderson, 2010).

3.13.1 Expert Driven Pretesting

An expert driven pretesting typically includes subject matter experts and survey professionals experienced in survey design, data collection, coding, and data (Czaja, 1998; Hashim et al., 2022). The term "content validity" refers to the degree to which components of an assessment instrument are truly relevant and accurately depict the concept designed for a specific evaluation aim (Cook & Beckman, 2006; Yusoff, 2019). Due to the crucial nature of content validity in assuring overall validity, it should be performed systematically based on evidence, and best practices (Yusoff, 2019). It is vital to recognise the critical nature of ensuring the content validity of an evaluation tool, such as a questionnaire, especially for research purposes. According to (Yusoff, 2019), there are six steps in the content validation process:

i. Creating a form for content validation
ii. Selecting an expert review panel
iii. Validation of content
iv. Analyzing the items and domain
v. Assigning each item a score
vi. Calculation of CVI

The individual has chosen "to evaluate and criticise an assessment instrument (e.g., questionnaire) based on their knowledge of the issue to be researched. Table 3.9 shows how the recommended number of experts affects the CVI acceptable cut-off score (Yusoff, 2019).

Table 3.9
The Number of Experts and the Acceptable Cut-Off score of CVI

Number of experts	**Acceptable CVI values**	**Source of recommendation**
Two experts	At least 0.80	Davis (1992)
Three to five experts	Should be 1	Polit et al. (2007); Polit & Beck (2006)
At least six experts	At least 0.83	Polit et al. (2007); Polit & Beck (2006)
Six to eight experts	At least 0.83	Lynn M. R. (1986)
At least nine experts	At least 0.78	Lynn M. R. (1986)

Source: (Yusoff, 2019a)

CVI consists of two forms: CVI for the item (I-CVI) and CVI for scale (S-CVI). Two techniques for computing the S-CVI are used: the average of the I-CVI scores for all scale items (S-CVI/Ave) and the proportion of scale items that receive a relevance scale of 3 or 4 from all experts (S-CVI/UA) (Yusoff, 2019).

Content validity was conducted for this research. Six (6) experts were selected for the content validity. The reviewer form is attached in Appendix 7. The I-CVI for this research is 0.94, and the S-CVI is 0.94. The cut-off point for I-CVI is 0.78 (Lynn., 1986) and for S-CVI is 0.86 (Smith et al., 2004). The number of experts and their implication on the acceptable cut-off score of CVI is attached in Appendix 8. The summary of expert reviewers is attached in Appendix 9.

3.13.2 Respondent Driven Pretesting

A respondent-driven pre-test was undertaken in this research to assess the suitability of the questionnaire's questions to respondents. The questionnaires were pre-tested from the 23 January 2025 - 3 February 2025. After making the required adjustments, the questionnaires were distributed to three (3) facility managers. Some sentences in the questionnaire were further simplified based on the feedback given by the respondents. Overall, the respondents said there were no significant issues in the questionnaire. All the three employees said they understood the questionnaire. This evaluation aims to ensure that content items adequately portray the research's variables, make logical sense and are contextually relevant, communicate effectively, and avoid respondent misinterpretation (Slattery et al., 2011; Lietz, 2010).

3.14 Pilot Test

The pilot research is a smaller version of the main research used to evaluate the research design and research instrument. Pilot studies are essential because they increase the probability of success in the primary research and offer additional insight into the conduct of the major research by researchers. The pilot analysis can then be used to improvise any existing flaws within the structure and questionnaire of the research.

Sekaran & Bougie, (2016) contend that a sample size of ten to thirty respondents for the pilot survey would be sufficient and beneficial when financial resources become scarce. However, Cooper & Schindler (2011) recommended that the pilot research's group scale ranges from 25 to 100 subjects.

Survey hyperlinks to Google forms were distributed to facility managers across Malaysia, and sixty (60) tested elements were included. The pilot test was carried out from 10 February 2025. Sixty respondents responded to the online google form. Data were extracted for further analysis using SPSSv20 and SmartPLS. Following that, an investigation was performed to determine the validity and reliability of the research variables. Internal reliability, content validity, predictive validity, and construct validity are some of the types of validity and reliability that must be met before a research can be conducted (Nunnally & Bernstein, 1994) .

The majority of the respondents were from residential buildings (33.33%), located in the Central Region (85%), and not using BIM in FM (67.2%). Most have never use BIM (58.33%), and a smaller portion reported using BIM in FM for more than 10 years (20%) (Refer to Appendix 10). The Cronbach's alpha estimations exceeded 0.60 in the pilot research, indicating that they were suitable for further analysis because they exceeded the minimum threshold of 0.60 (Hair et al., 2007). As a result, the test instruments were considered reliable and utilised to gather data from respondents during the research's duration (Refer to Appendix 11). This research aimed to determine the composite reliability (CR) of all constructs. It established that the CR values are greater than the recommended value of 0.70 (Hair et al., 2007; Reinartz et al., 2009). The measurement model's reliability" can be inferred from this research's CR values of 0.575-1.064. The convergent validity of this analysis was determined by assessing Average Variance Extracted (AVE) values.

AVE is employed with a threshold value of 0.50 or greater to identify an element of convergence in the construct's measurements (Hair et al., 2012; Henseler et al., 2009). With an AVE of 0.50, convergent validity is considered acceptable. The results suggest that the AVE value for all constructs is higher than the threshold value of 0.50 and ranges between 0.603-0.826 (Hair et al., 2012; Henseler et al., 2009)(Refer to Appendix 11). In this research, the discriminant validity of Fornell & Larcker (1981) measures is being replaced with the most recent method, known as Heterotrait-Monotrait Correlations (HTMT), to evaluate the discriminant validity of reflective constructs. None of the constructs had a value greater than 0.85, as determined by the results (Refer to Appendix 12).

3.15 Statistical Analyses

The data analysis process involved systematically assigning data to the relevant constructs and establishing relationships between them. The data obtained from the completed questionnaires underwent a series of analytical procedures. Initially, the data were processed, which included editing, coding, and classification, before being entered into IBM SPSS statistical software for analysis. Subsequently, descriptive statistical analyses were conducted using SPSS version 29. Furthermore, to assess the predictive capability of the structural model and examine the relationships between the constructs, SmartPLS 4.0 software was utilized. Thus, the statistical analyses for this research were performed using two software applications: IBM SPSS version 29 and SmartPLS version 4.0.9.5 (Sarstedt et al., 2022).

3.15.1 Statistical Analyses Using SPSS

Following data collection, respondents' questionnaires were coded and entered into SPSS Version 4.0.9.5 for further analysis. The analysis began with data screening, which involved identifying and addressing data entry errors, straight lining and missing data. Next, an assessment of outliers was conducted to detect any extreme values that could affect the analysis. This was followed by an assessment of normality to determine whether the data distribution met the assumptions required for further statistical analyses. Additionally, multicollinearity was assessed to identify potential correlations among independent variables that could affect the reliability of regression analyses.

Subsequently, descriptive statistical analyses were performed to summarize and compare demographic information, including measures such as mean, frequency, standard deviation, percentage, and range (Sekaran & Bougie, 2016b). The dataset was further evaluated using the Harman single-factor test to check for common method bias. All analyses were conducted using the Statistical Package for Social Sciences (SPSS) Version 29 on a Windows operating system (Saunders et al., 2019). Figure 3.8 shows the Microsoft Excel and SPSS Data Analysis Process.

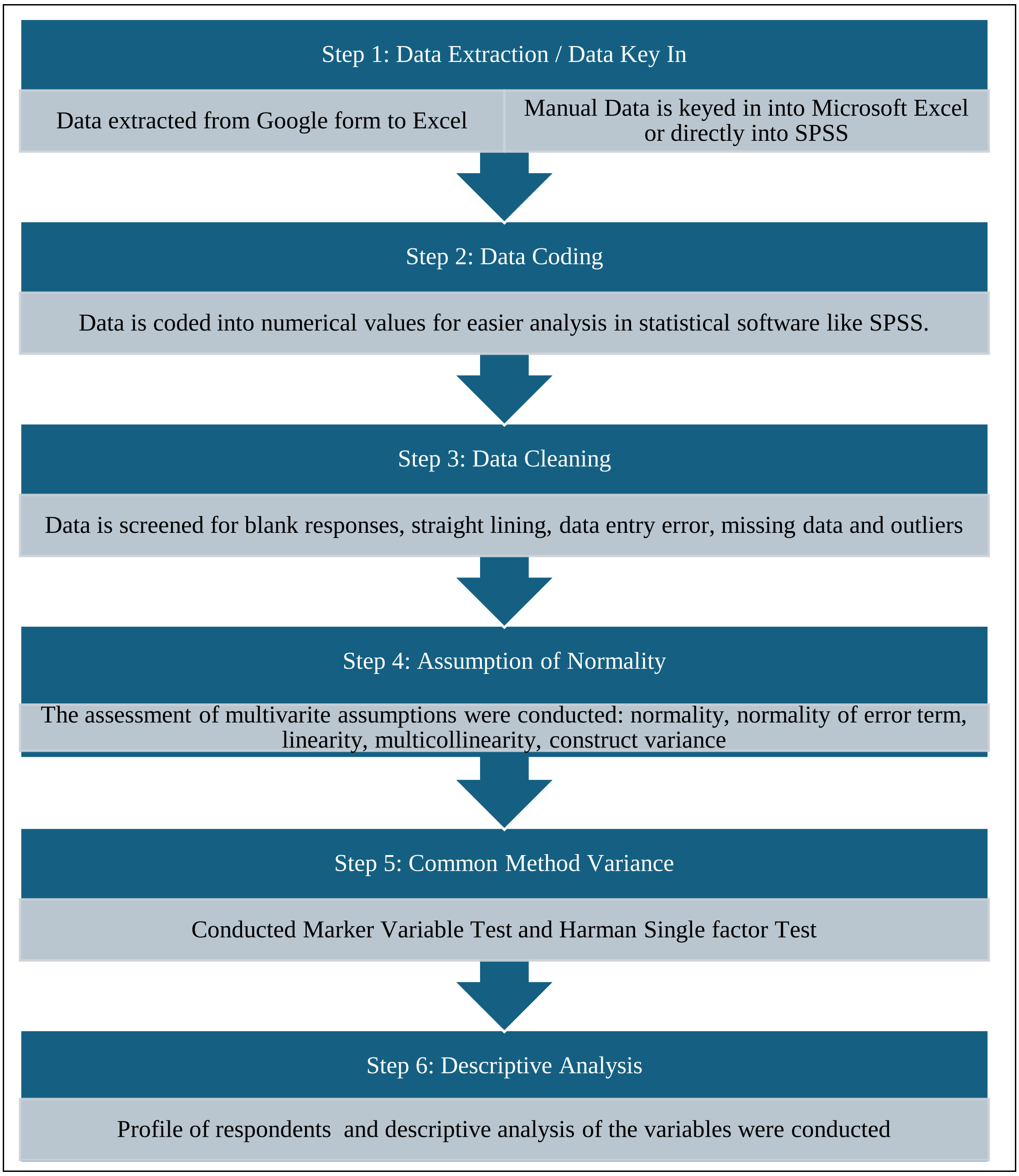

Figure 3.8 Microsoft Excel and SPSS Data Analysis Process.

3.15.2 Straight Lining

Straight-lining, also referred to as non-differentiation response behavior, occurs when a respondent selects the same answer for all or most questions within a survey, particularly in Likert-scale or matrix-style items (Podsakoff et al., 2012). This response pattern can signal lack of engagement, cognitive fatigue, satisficing, or careless responding, where participants provide answers without carefully considering the content of each question (Ward & Meade, 2018). Given that survey-based research often relies on self-reported data, detecting and addressing straight-lining is essential to ensure the accuracy, reliability, and validity of the collected responses (Krosnick, 1991).

3.15.2.1 Assessment of Outliers

Following the treatment of missing data, the next critical step in data preparation is the identification and validation of outliers. An outlier is an observation that deviates significantly from the overall pattern of the data and may result from various sources, including data entry errors, extreme values within the target population, or other inconsistencies (Hair Jr et al., 2014). The presence of outliers distorts statistical analyses, affects model estimates, and compromises the reliability of research findings, making their detection and treatment essential (Hair, Ringle, et al., 2019).

To systematically identify multivariate outliers, this research employs Mahalanobis Distance (D^2), a statistical measure that assesses the distance of each observation from the centroid of all variables in a multivariate space. The Mahalanobis D^2 value for each observation is computed and compared against the critical Chi-square (χ^2) value at a stringent significance level ($\alpha = 0.001$) with degrees of freedom equal to the number of predictor variables (Hair et al., 2006). Any case with a Mahalanobis D^2 value exceeding the corresponding χ^2 threshold is considered a potential outlier.

Once detected, outliers are further examined to determine whether they result from errors or represent genuine extreme observations. Erroneous outliers, such as those caused by incorrect data entry, are removed from the dataset, whereas valid extreme cases are retained if they provide meaningful insights into population variance. Addressing outliers appropriately ensures the robustness of subsequent statistical analyses and enhances the accuracy of research conclusions.

3.15.2.2 Assessment of Normality

Assessment of normality is a fundamental assumption in multivariate analysis, ensuring that data distribution aligns with a normal curve, which is crucial for the validity of parametric statistical techniques (Hair, Matthews, et al., 2017). Normality affects hypothesis testing, confidence intervals, and regression estimates, making its evaluation essential in data analysis. Normality testing is used to determine whether a distribution is normal; thus, variation in sufficiently large data sets affects statistical test results (Hair, Ringle, et al., 2019). It is vital to make sure that the data are normally distributed. However, PLS-SEM is a tolerant model that makes no expectations about the normality of data distributions and is a non-parametric statistical method that does not require data to be regularly distributed (Hair & Alamer, 2022). Types of Normality Assessments:

i. Normality – Examines whether individual variables are normally distributed, ensuring that skewness and kurtosis values fall within acceptable (Hair, Ringle, et al., 2019)
ii. Normality of Error Terms – In regression models, residuals (errors) should be normally distributed, ensuring unbiased estimations and reliable inferences (Kline, 2018).
iii. Linearity – Tests whether relationships between independent and dependent variables are linear, which is necessary for accurate predictions in regression models (Hair, 2014).
iv. Multicollinearity – Assesses whether independent variables are highly correlated, as excessive correlation can distort coefficient estimates in regression analysis (Hair & Alamer, 2022). When the results are .90 or higher, multicollinearity means a high correlation between independent variables (Pallant, 2010). It is essential to apply SPSS software to determine the variance inflation factor (VIF) in collinearity and the potential of multicollinearity if the tolerance value is larger than 0.1 but less than 10 in order to detect multicollinearity (Pallant, 2010).
v. Construct Variance – Evaluates the variance explained by constructs in structural equation modelling (SEM), ensuring measurement validity and reliability (Fornell & Larcker, 1981).

3.15.2.3 Descriptive Analysis

Descriptive analysis is a crucial step in research that provides an overview of the dataset before conducting inferential analysis. It is divided into two key components: descriptive analysis of respondents and descriptive analysis of variables (Hair et al., 2019).

The descriptive analysis of respondents examines demographic characteristics such as gender, age, education, and occupation to ensure that the sample represents the target population (Sekaran & Bougie, 2020). Statistical measures like frequencies, percentages, mean, and standard deviation are commonly used to summarize respondent data.

The descriptive analysis of variables focuses on understanding data distribution for further statistical analysis. Key measures include central tendency (mean, median, mode), dispersion (standard deviation, variance), and normality indicators (skewness, kurtosis) (Kline, 2018).

3.15.2.4 Path Model Estimation

As mentioned previously in the section on data analysis methodology, the data were analysed using Partial Least Squares-Structural Equation Modelling (PLS-SEM). PLS-SEM is a technique for modelling complex multivariate interactions between observable and latent variables using statistical path modelling (Hair, Matthews, et al., 2017; Henseler et al., 2009). The PLS-SEM approach is a robust, powerful, and adaptable technique for developing statistical models and validating and forecasting theories (Ringle et al., 2015; JHair & Alamer, 2022; Hair, Matthews, et al., 2017). PLS-SEM is a variance-based prediction approach focusing on endogenous target constructs, and maximising explained variance. (i.e., R2 value) (Hair et al., 2012a; Hair, Ringle, et al., 2019).

Before the PLS-SEM technique can be used, numerous parameters must be defined, including the structural model weighting scheme, the algorithm's initial values, the data metric, and the maximum number of repetitions. The report supports the researcher in validating the structural model's first conclusions about the outer weight, external loads, path coefficients, and R2 values (J. F. Hair, Ringle, et al., 2019).

3.15.2.5 Statistical Analysis and Justification for using Structural Equation Modelling

The research model was evaluated using PLS-SEM (Partial Least Suares). PLS-SEM has several advantages over CB-SEM, which are stated in Appendix 13. PLS-SEM has recently been established as a unique method for researching composite-based path models, resolving the CB-SEM versus PLS-SEM debate (Al Issa & Abdelsalam, 2021; Rigdon et al., 2017). However, applied research must choose between the two SEM approaches. Therefore, PLS-SEM should be chosen by researchers (Hair, Ringle, et al., 2019):

i. When the research's goal is to predict a theoretical framework.
ii. When a structural model is complex and has a large number of constructs, indicators, and/or model relationships
iii. When the sample size is constrained by a relatively small population (for example, in business-to-business research), PLS-SEM performs well; nevertheless, it also performs well with bigger sample sizes
iv. In situations where distributional concerns, such as a lack of normality, are a concern.
v. When latent variable scores are required for subsequent analysis.
vi. PLS-statistical SEM's power is greater than that of CB-SEM, therefore, researchers gain from using it.

The preceding justifications justify the research's usage of the PLS-SEM methodology. Additionally, it has been demonstrated that structural equation models using Partial Least Squares are preferred models for researching mediation since they perform better than regression models in terms of estimation (Preacher & Hayes, 2004). When the bootstrapping technique is used, empirical evidence shows that a statistical report for the overall impact of the sum of direct and indirect effects among both two constructs and measurement error gives quite accurate and clear estimates of the mediation effect (Hair et al., 2012a; Sarstedt et al., 2022).

The statistical properties of the PLS-SEM algorithm are heavily reliant on the data and model parameters utilised. Additionally, the PLS-SEM method's properties have an effect on how the results are evaluated. There are four critical issues to consider when using PLS-SEM (Hair et al., 2012a; Hair, Ringle, et al., 2019): (1) characteristics of data, (2) model features, (3) model estimation, and (4) model evaluation. Table 3.10 recapitulates the PLS-SEM method's essential properties relevant to this investigation.

Table 3.10
PLS-SEM Method's Essential Properties Relevant

PLS-SEM	Properties
1. Data Characteristic	
Sample Size	• It is possible to achieve high levels of statistical power with small ample sizes. • The reliability (i.e., consistency) of PLS-SEM estimations is improved when sample sizes are increased.
Distribution	• PLS-SEM is a nonparametric method that makes no assumptions about distributions. • Outliers with significant influence and collinearity may have an impact on the results.
Missing Values	• Missing values are kept to a tolerable level, and the system is quite robust (less than 5%)
Scale of Measurement	• Works with metric data and variables scaled in a quasi-metric (ordinal) manner.
2. Model Characteristic	
Number of items in each construct's measurement model	• Single and multi-item measurements are used to measure constructs.
Relationships between constructs and their indicators	• Reflective and formative measuring models are easily integrated.
Model complexity	• Handles complex models with a large number of structural model relationships.
3. **Model Estimation**	
Objective	• The goal is to increase the amount of unexplained variance in the dependent measures as much as possible (i.e., maximise the R2 values)
Efficiency	• After a few iterations, it converges on the optimal solution (i.e., the algorithm is very efficient)
Nature of constructs	• Composites are viewed as proxies for the latent concept under research.
Constructs scores	• They were calculated as a linear combination of their indicators (i.e., they are determined) • Used to make predictions. • Can be used as an input for further analysis
Parameter estimates	• When solutions are derived using data from common factor models, structural model relationships are often underestimated, while measurement model relationships are generally understated. • When estimating data from composite models, be unbiased and consistent. • High statistical power when compared to other methods such as CB-SEM.

PLS-SEM	Properties
4. **Model Evaluation**	
Evaluation of the overall model	• As established in CB-SEM, the model fit idea does not apply to PLS-SEM. Attempts to implement model fit measurements have typically been ineffective in PLS-SEM. • The indicator reliability, internal consistency reliability, convergent validity, and discriminant validity of reflective measurement models are all assessed.
Evaluation of the structural model	• Collinearity between predictor construct sets. • Path coefficients' significance and relevance • Predictive power
Additional analyses	• By introducing new modelling, assessment, and analysis processes, methodological research has significantly extended the original PLS-SEM method. ○ Higher-order constructs ○ Measurement model invariance ○ Mediation analysis

Source: (Hair et al., 2011; Hair et al., 2022)

3.15.2.6 PLS SEM Analysis

The PLS-SEM methodology necessitates using measurement theory and structural theory to build and evaluate the model (Hair, et al., 2016; Hair et al., 2022). A structural model shows how the research variables are correlated, while measurement model explains how the variables are defined and measured. According to Hair et al. (2022), the PLS-SEM technique is a robust multivariate statistical analysis technique that enables the researcher to simultaneously analyse measurement and structural models. In contrast to the exploratory character of factor analysis, SEM is most typically employed to support a prior hypothesis; consequently, planning is essential for any SEM analysis, including confirmatory factor analysis (CFA) (Tabachnick & Fidell, 2013) and confirmatory composite analysis (CCA) (Hair et al., 2020). According to Hair et al. (2020), researchers can utilise CFA or CCA to accomplish measurement confirmation goals when establishing or adjusting multi-item measures.

The researcher evaluated the research model using the two-step approach given by PLS-SEM (Hair et al., 2011). After establishing the measurement models' reliability and validity, the researcher analysed the structural model's estimations. CFA is used to increase the reliability of items and scales, detect and suggest items that need to be modified or, in certain cases, deleted for content validity, assist the attainment of convergent and discriminant validity, and eliminate error variance.

3.15.2.7 Measurement Model

Measurement and structural models were analysed using PLS, as suggested by (Henseler et al., 2009). The steps listed in Table 3.11 below must be performed to conduct a CFA with reflecting measurement models.

Table 3.11
Steps in CFA with Reflective Measurement Models

Steps	**Description**
Step 1	Estimate of Loadings and Significance
Step 2	Indicator Reliability (items)
Step 3	Composite Reliability (construct)
Step 4	Average Variance Extracted (AVE)
Step 5	Discriminant Validity – HTMT

Source: Joseph F. Hair et al. (2019)

The measurement model's reliability and validity were evaluated. After that, a measuring model was developed to assess internal consistency (reliability), convergent validity (loadings, average variance extracted (AVE), and composite reliability (CR)), and discriminant validity (HTMT) (Hair, Ringle, et al., 2019; Henseler et al., 2015; Ramayah et al., 2018). After proving the reliability of the items, the measuring model's validity was evaluated—this in-depth analysis of convergent and discriminant validity. Convergent validity assessed whether an item in a latent variable measured what it was supposed to measure (Sharma & Kim, 2013). In contrast, discriminant validity assessed the degree of differentiation between items in a latent variable (Henseler et al., 2009).

Before evaluating measurement models, it is necessary to distinguish and identify the assessed constructs reflectively or formatively (Hair et al., 2011). The critical choice principles established by Coltman et al., (2008) and Petter et al., (2007) are utilised to determine if the constructs are reflective or formative. The first rule is to determine whether the latent construct is being developed. The second rule is to consider the causation between the items and the latent construct; if it tends to reflect, causality is from the construct to the items; if it is formative, causality is from the construct to the items. The third rule is to examine the characteristics of the items used to measure the construct; if the construct is reflective, the items should share a common theme, be interchangeable, and the deletion or addition of an item does not affect the construct's meaning; if the construct is formative, the items do not share a common theme, are not interchangeable, and the deletion or addition of an item alters the construct's conceptual meaning.

a) Internal Consistency

Typically, internal consistency is the first requirement to be evaluated. The standard criterion for internal consistency is Cronbach's Alpha. Kock & Lynn (2012) define reliability as a metric of instrument quality. Different respondents should answer each item question about the latent variable identically. The reliability of latent variables is determined by the scale's capacity to deliver consistent results. According to Hair, et al., (2016), Cronbach's Alpha has limits and is more appropriately used in conjunction with other internal consistency reliability measures, referred to as composite reliability. Composite reliability is interpreted in the same way as Cronbach's Alpha (Aibinu & Al-Lawati, 2010; Hair, et al., 2016). Values between 0.60 and 0.70 for composite reliability are considered acceptable in exploratory research, and values between 0.70 and 0.90 are considered satisfactory in more advanced stages of inquiry.

b) Convergent Validity

Urbach & Ahlemann, (2010) described convergent validity as the degree to which individual items reflecting a construct converge compared to items measuring different constructs. To assess a reflective construct's convergent validity, researchers must investigate both the outer loadings of the indicators and the extracted average variance (AVE) (Hair et al., 2016).

A construct with a higher outer loading implies that the associated indicators have a high degree of similarity. According to Hair et al. (2016), a widely accepted practice is for standardised outer loadings to be 0.70 or greater. Nevertheless, in some circumstances, the structures exhibit lower (<0.70) loadings (Hulland, 1999). As a result, Hair et al. (2016) recently advocated that outer loading on indicators ranging from 0.40 to 0.70 be dropped only when it improves composite reliability or extracted average variance (AVE).

c) Discriminant Validity

The phrase "discriminant validity" refers to a construct's capacity to be distinctively different from other constructs (Hair, et al., 2016; Straub et al., 2004). Historically, researchers have examined discriminant validity from two perspectives. The first method for determining an indicator's discriminant validity is through cross-loadings, while the second method is through the Fornell-Larcker criterion (Hair et al., 2016). The square root of the AVE values is used to compare the correlations between latent variables. Each construct's AVE should be higher than the highest correlations of any other construct (Fornell & Larcker, 1981).

Heseler et al. (2015) present an alternate approach to analysing the correlations' heterotrait-monotrait ratio (HTMT) for discriminant validity. The HTMT is defined as "the mean of all correlations between indicators measuring different constructs (i.e., heterotrait-heteromethod correlations) in comparison to the (geometric) mean of the average correlations between indicators measuring the same construct (i.e., montrait-heteromethod correlations for the HTMT's formal definition)" (Henseler et al., 2015). Henseler et al. (2015) proposed a threshold of 0.90 for path models with extremely comparable conceptual structures and a more conservative threshold of 0.85 for path models with pretty similar conceptual constructs. Thus, scores greater than 0.90 are interpreted as indicating a lack of discriminant validity.

3.15.2.8 Structural Model

After establishing the measurement models' reliability and validity, the researcher analysed the structural model in accordance with the recommendations of Joseph F. Hair et al. (2012). Following validation of the measurement model, collinearity issues in the structural model were investigated using the Variance Inflation Factor (VIF) (Ramayah et al., 2018). Some other tests are the coefficient of determination (R2), the effect size (f2), and predictive relevance (predictive relevance) (Q2) (Ramayah et al., 2018).To ascertain the structural model's significance, scholars advocate assessing its path coefficient, effect sizes, coefficient of determination (R2), and predictive relevance (Q2) (Hair et al., 2012).

a) Path-Coefficient

In a model, the path coefficients denote the intensity and direction of relationships. As a result, we evaluated the p-values (< 0.01) and t-values (> 1.645) while computing the path coefficients in order to emphasise the importance of hypothesis testing (Kock, 2016; Ramayah et al., 2018). If the t-value exceeds 1.645, it is considered significant and can be used for the proposed hypothesis (Shahzad & Irfan, 2024).

b) Effect Size (f2)

Hair Jr et al. (2016) suggested that researchers test their structural model with an appropriate effect size. The term effect size refers to the percentage of exogenous latent variables contributing to the R2 value of the endogenous latent variable (Hair et al., 2016). The authors define effect size as the power of correlations between variables (Chin & Newsted., 1999). The size of the effect can be classified as large (0.35), medium (0.15), or minor (0.02) (Cohen, 1988a).

c) Co-efficient of Determination (R^2)

The coefficient of determination (R2 value) is the most often used metric for evaluating structural models (Hair, et al., 2016). Additionally, the value of R2 measures the extent of variance explained by all exogenous or independent variables in the dependent or endogenous variables. Hair et al. (2016) regard R2 = 0.20 as a suitable value for such studies. However, R2 = 0.10 is also acceptable for endogenous variables (Falk & Miller, 1992).

d) Predictive Relevance (Q2)

Hair,. et al. (2016) recommend using Stone-Q2 Geisser's measure as a predictor precision and estimating R2. The Q2 value quantifies the effectiveness with which observable values are transformed using a certain model and set of parameters (Chin & Peter R. Newsted., 1999). As a result, when assessing the Q2 value, we must ensure that the Q2 threshold value is greater than zero (> 0). (Hair, et al., 2016).

To calculate Q2 values, SmartPLS blindfolds the procedures. In SmartPLS, the blindfolding option was the omission distance of 7 (default). However, a 5 to 10-point omission distance is recommended for the majority of research (Hair et al., 2012). Following the execution of the procedure, the results for the target endogenous construct are provided as cross-validated redundancy values (Q2 measures).

3.16 Validation Framework

This research included a framework validation phase to validate the proposed BIM–FM integrated framework is credible, conceptually robust, and practically applicable to FM organizations, encompassing both BIM and non-BIM users. Consistent with the overall research methodology, the validation was executed in Phase 3 (Framework Development and Validation) following the completion of the main questionnaire survey (RO1–RO3) and subsequent SEM analysis. The validation adopted an expert panel approach, commonly utilized for validating conceptual models and frameworks through informed professional judgment (Beecham et al., 2005; Fox, 2001).

Framework validation was conducted through structured expert review interviews employing a validation questionnaire. This approach enabled consistent review across experts and allowed the collection of both quantitative score and qualitative opinions, thereby supporting in the modification of the framework before its finalisation (Hawkins et al., 2020). Employing structured interviews in conjunction with an assessment tool aligns with the expert-based framework validation recommendation in the literature (Beecham et al., 2005; Hawkins et al., 2020).

A total of five experts were participated in the validation phase. Experts were chosen through purposive sampling based on two primary criteria which are relevant professional experience in facility management and knowledge of FM information practices, encompassing either direct involvement in BIM implementation or significant operational experience in managing FM information and deliverables. Furthermore, priority was provided to participants who had engaged in previous phases of this research, particularly the questionnaire survey phase, to ensure continuity of contributions during framework development. The continuity of expert participants is acknowledged as advantageous for enhancing evaluative contributions, as these participants can more effectively evaluate conceptual coherence and offer more informed refinements (Agarwal, 2011; Creswell & Poth, 2016; Hallowell & Gambatese, 2010; Okoli & Pawlowski, 2004). The panel size is deemed suitable for content validation, since five experts are recommended as the minimal threshold for evaluating the content validity of an instrument or model (Lynn, 1986). Chapter 6 presents the demographic characteristics and professional background of the validation respondents.

3.17 Ethical Considerations

Ethical considerations were observed throughout all stages of this research to protect the rights, privacy, and welfare of the participants. Participation in the research need analysis, main questionnaire survey, and expert validation was voluntary. Before taking part, participants were informed about the purpose of the study, the nature of their involvement, and how the collected information would be used. Informed consent was obtained, and participants were informed that they could decline to answer any question or withdraw from the study at any time without any penalty.

Confidentiality and anonymity were maintained throughout the research process. Personal identifiers and sensitive organizational information were not disclosed in the thesis or any related publication. Responses from industry experts and survey participants were coded and reported in aggregate form, while expert quotations were identified using labels such as Expert V1 instead of personal names. This approach ensured that the views and information provided by participants could not be directly linked to their identities or organizations.

All collected data were used solely for academic and research purposes. The data were stored securely and were accessible only to the researcher and authorized academic supervisors. The researcher also ensured that the findings were reported accurately, honestly, and without fabrication, falsification, or misrepresentation. These measures were taken to ensure that the research was conducted responsibly and in accordance with accepted ethical research practices.

3.18 Chapter Summary

This section discusses the theoretical framework and methodology used in the research, which includes the research design, sample design, data collection, and analysis. The process involves designing and distributing the questionnaire, collecting feedback and analysing the data. The research's respondents are Facility Managers. SPSSv20 will be used to clean the data, and Smart PLS 3.0 will be utilised to analyse the data in an attempt to address the research question and hypotheses stated previously.

CHAPTER 4
RESULT AND DATA ANALYSIS

4.1 Introduction

This chapter exhibits the results, presents statistical analyses, and discusses the findings of this research. The chapter begins with data preparation and followed by the preliminary examination to test the underlying assumptions of multivariate analysis. Subsequently, the descriptive statistics of respondents' profiles are presented. As this research applied SPSS and the PLS-SEM technique, the analyses of the measurement and structural path models were conducted and reported. The chapter ends with the reporting of moderation analyses.

4.2 Data Preparation

Preparing the information is the first stage in data analysis before evaluating the research model. Data preparation involves editing, coding, and data entry to ensure the precision and adequacy of the data (Hair et al., 2020). All the questions in this research were pre-coded ahead of data collection. The questions of independent, moderator and dependent variable were pre-coded from 1 to 5 (1=strongly disagree to 5=strongly agree). The use of such codes through Likert scale facilitated the data entry process. Data entry for this research was done using SPSS version 29 software. In this process, the data were defined to include variable names, variable labels, value labels and missing values.

4.2.1 Data Screening

4.2.1.1 Blank Responses

The first step in data cleaning is checking for the blank responses among the collected questionnaires, and Microsoft Excel was used to conduct the procedure. Cases with more than 25% blank responses on the independent variables or any blank response on the dependent variables are excluded from the sample. Using the COUNTBLANK(item$_1$ to item), it is found that there is no blank response in the data, confirming all questions were answered by the respondents.

4.2.1.2 Straight Lining

This research also tests the response pattern to detect if there is a straight lining pattern, which occurs when a participant or respondent provides the same feedback or response for most of the questions (Hair et al., 2017). The straight lining assessment in this research was conducted using Microsoft Excel 2016. Among all 240 cases there were 2 cases were detected with straight lining and there were excluded from further analysis, leaving the total of 238 remaining cases to be analysed.

4.2.1.3 Missing Values

The subsequent data cleaning stage is to identify any missing data or parts of the data collection. The significance of missing data is contingent upon its configuration, quantity, and reason for absence. This research employs a four-step process for identifying missing data and implementing corrections (Hair et al., 2018).

The steps to follow are as follows:

i. Determine the nature of the missing data (ignorable or non-ignorable) There are two types of missing data. The first category is ignorable when questions are asked, but respondents may choose not to answer them. Non-ignorable missing data might occur due to a researcher's error during data input or the respondent's reluctance to answer particular items in the questionnaire (Hair et al., 2018). Regarding the non-ignorable missing data, it is critical to determine the degree of the missing data and examine the pattern before implementing any cure. All questions pertaining to the structural model are unavoidable in this research. As a result, the next step is determining the extent to which data is missing.

ii. The SPSSv29 was employed to test the degree of missing data. As seen in Appendix 14 there were no missing data was found from the latent variables.

4.2.1.4 Outliers

Outliers are data that exhibit a unique mix of traits that distinguish them from what is considered normal. Outliers are responses that are out of the ordinary for a given topic or a group of questions (Hair et al., 2018; Sarstedt et al., 2017). Because outliers can negatively impact the normalcy of data and lead to erroneous results, it is critical to carefully exam(Hair et al., 2018; Tabachnick & Fidell, 2013). Outliers can be useful in indicating characteristics of the population that are not seen during the regular course of research. Conversely, detrimental outliers are not representative of the population, are inconsistent with the research objectives, and may be very misleading in statistical studies (Hair et al., 2018). The outliers in this research were identified through the use of multivariate detection methods across all of the independent and dependent variables.

The Mahalanobis D^2 measure is used to identify outliers. It is a multivariate evaluation of each observation over a set of variables (Hair et al., 2018). This approach, which utilises SPSSv29, determines the distance between each observation in the multidimensional space of all observations. A greater D^2 value indicates that the data should be eliminated from the observation generation distribution.

The researcher first identified the total number of research variables, which was 6 (with information quality being the dependent variable). Then, based on the chi-square statistical table, the researcher will determine the number of outliers based on the value of degrees of freedom, which is 5 (total number of variables, which is 6-1). In contrast, according to (Mishra et al., 2013), the value of *p* shall be set at 0.001, as shown in Table 4.1. Based on the chi-square statistical table, the chi-square value obtained is 20.515.

Table 4.1
Chi-square Statistical Table

Df	*p-value*					
	0.1	**0.05**	**0.025**	**0.01**	**0.005**	**0.001**
1	2.7055	3.8415	5.0239	6.6349	7.8794	10.8276
2	4.6052	5.9915	7.3778	9.2103	10.5966	13.8155
3	6.2514	7.8147	9.3484	11.3449	12.8382	16.2662
4	7.7794	9.4877	11.1433	13.2767	14.8603	18.4668
5	9.2364	11.0705	12.8325	15.0863	16.7496	20.515
6	10.6446	12.5916	14.4494	16.8119	18.5476	22.4577
7	12.017	14.0671	16.0128	18.4753	20.2777	24.3219
8	13.3616	15.5073	17.5345	20.0902	21.955	26.1245
9	14.6837	16.919	19.0228	21.666	23.5893	27.8772
10	15.9872	18.307	20.4832	23.2093	25.1882	29.5883
11	17.275	19.6751	21.92	24.725	26.7568	31.2641
12	18.5493	21.0261	23.3367	26.217	28.2995	32.9095
13	19.8119	22.362	24.7356	27.6882	29.8195	34.5282
14	21.0641	23.6848	26.1189	29.1412	31.3193	36.1233
15	22.3071	24.9958	27.4884	30.5779	32.8013	37.6973
16	23.5418	26.2962	28.8454	31.9999	34.2672	39.2524
17	24.769	27.5871	30.191	33.4087	35.7185	40.7902
18	25.9894	28.8693	31.5264	34.8053	37.1564	42.3124
19	27.2036	30.1435	32.8523	36.1909	38.5823	43.8202

Any case with Mahalanobis D^2 of 20.515 and above is a multivariate outlier. According to Table 4.2, the sample contains 3 outliers with a Mahalanobis Distance larger than 20.515.

Table 4.2
Multivariate Outlier Detection

No	**Case Number**	**Mahalanobis (D^2)**
1	104	28.29839
2	121	23.24908
3	98	21.68880

After deleting the 3 outliers, a total of 235 data remains. The deleted cases are as mentioned above. The researcher then conducted a multiple regression analysis to determine whether the outliers influenced the parameter stability of the research model.

Table 4.3
The Value of R2 before Disposal of Outliers

R	R Square	Adjusted R square	Std. Error of the Estimates
.522	.272	.256	.29255

Note: the dependent variable is IQ

Table 4.4
The Value of R_2 After Disposal of Outliers

R	R Square	Adjusted R square	Std. Error of the Estimates
.526	.277	.261	.29272

Note: the dependent variable is IQ

A multiple regression analysis was conducted to determine whether the outliers influenced the parameter stability of the research model. The main model, $R^{2,}$ was recorded with a value of 27.2% (refer to Table 4.3). However, after removing outliers, the value of R2 has increased to 27.7% (refer to Table 4.4). This proves that the change was less than 10% and the outliers did not affect much the parameter stability of the research model. This implies that the outlying cases have no significant influence over the accuracy of the regression estimates. Thus, the outlier was maintained in the data set. The next focus was to assess the assumptions underlying multivariate analysis.

4.3 Assessing Multivariate Assumptions

Following data cleaning, it is necessary to validate the statistical assumptions of the underlying multivariate analysis. There are two reasons for the need to conduct assumptions testing. Firstly, the complexity of the correlations derived from a significant number of variables may introduce distortions and bias. Second, the complexity of the analysis and results may obscure the indicators of assumption violations visible in simpler univariate analysis (Hair et al., 2018). The assessment of multivariate assumptions in this research involves the testing of normality, normality of error term, linearity, multicollinearity, construct variance and auto-correlation. This assessment is particularly important as the violation of the assumptions may lead to a biased statistical result and erroneous conclusion (Meyers et al., 2017).

4.3.1 Normality

Normality testing is critical for researchers who use CBSEM applications. By contrast, researchers who used PLS-SEM encountered no issues with the assumption of data normality (Hair et al., 2022). However, it is preferable if researchers continue to assess the normality of data, even while utilising the PLS-SEM application (Hair et al., 2022). Hair et al. (2022) recommended that researchers examine the degree of skewness and kurtosis in the research data to see whether they are normal.

The researcher then examined the data's normality using data cleaned of errors and data with outliers removed. In some cases, the skewness and kurtosis values can be used to quantify normality. As a result, the primary focus of this research was on the statistics of skewness and kurtosis in order to determine the data's normality (Tabachnick & Fidell, 2013). The multivariate skewness and kurtosis tests of Mardia's were performed, and the results are displayed in Figure 4.1 and Table 4.5 below.

Table 4.5
Mardia's Multivariate Skewness and Kurtosis

	b	**p-value**
Skewness	8.480191	0.0000
Kurtosis	60.631958	0.1036

Output of skewness and kurtosis calculation

```
Sample size:  238
Number of variables:  7

Univariate skewness and kurtosis
     Skewness SE_skew Z_skew Kurtosis SE_kurt Z_kurt
...1    0.000   0.158  0.000   -1.200   0.314 -3.818
BF     -0.904   0.158 -5.732   -1.008   0.314 -3.208
IQ     -0.613   0.158 -3.885   -0.280   0.314 -0.891
ORG    -1.011   0.158 -6.410   -0.867   0.314 -2.758
PEO    -0.716   0.158 -4.539    0.434   0.314  1.380
TAS    -0.781   0.158 -4.947   -0.176   0.314 -0.560
TEC    -0.640   0.158 -4.053   -0.342   0.314 -1.087

Mardia's multivariate skewness and kurtosis
                 b          z   p-value
Skewness  8.480191 336.380929 0.0000000
Kurtosis 60.631958  -1.627281 0.1036774
```

Figure 4.1 Mardia's Multivariate Skewness and Kurtosis

As suggested by (Hair, Jr., Hult, 2017) researcher assessed the multivariate skewness and kurtosis. The results showed the data collected was not multivariate normal, Mardia’s multivariate skewness (β = 8.480191, p< 0.0000) and Mardia’s multivariate kurtosis (β = 60.631958, p< 0.1036). The results indicate that the data is not normally distributed. A non-parametric analysis tool should be used because all tests showed that the normal distribution assumption was violated, necessitating the usage of Smart PLS.

4.3.2 Normality of Error Terms

The next assessment involved the inspection for normality of error terms. This is to verify that the residuals are normally distributed by using a Normal P-P plot. Figure 4.2 below shows that the point is close to the diagonal line, and thus, the error terms are normally distributed.

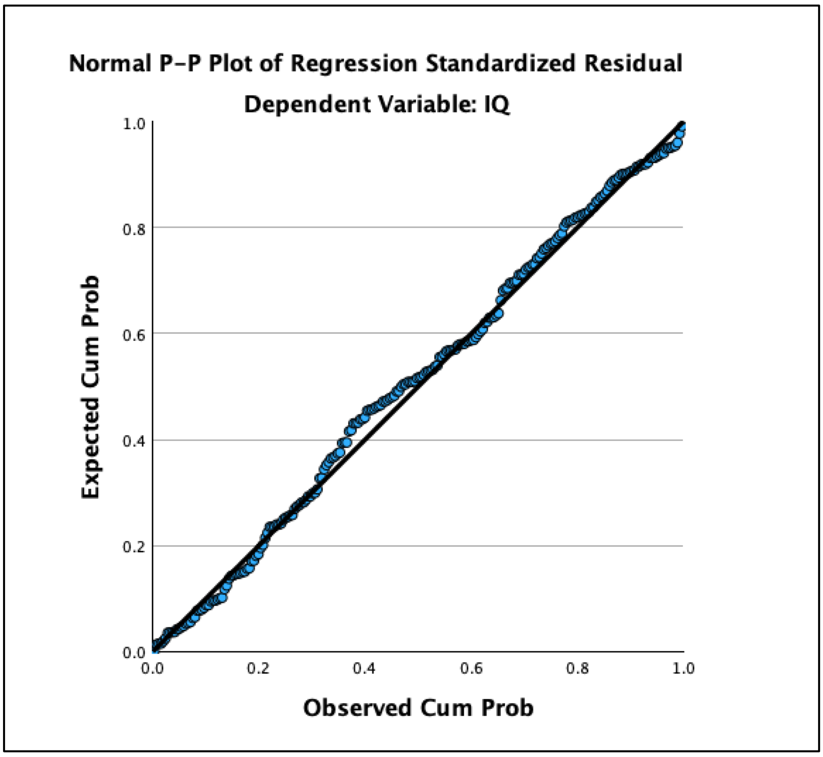

Figure 4.2 Normality of the Error Terms

4.3.3 Constant Variance

The subsequent assumption of multivariate analysis is constant variance, which tests homoscedasticity in the data. This requires the variance along the line of best fit to be in a consistent pattern. This assumption is discerned by generating a scatter plot as shown in Figure 4.3 between standardized residual (SRESID) and standardized predicted value (ZPRED), which indicated a constant pattern.

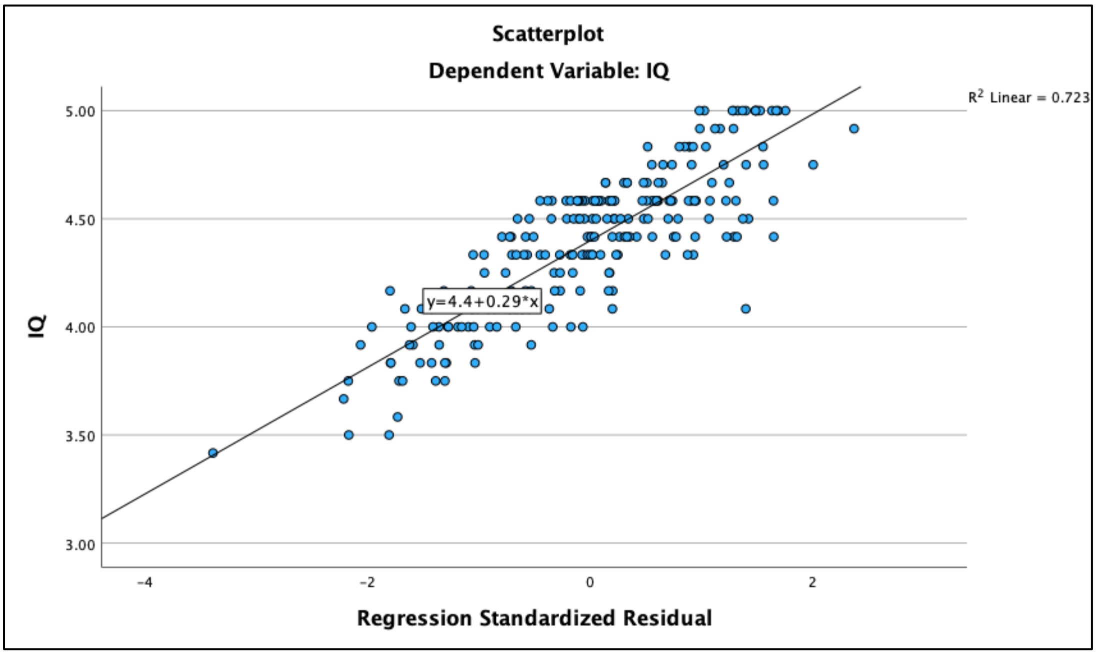

Figure 4.3 Constant Variance-Homoscedasticity

4.3.4 Multicollinearity

The absence of multicollinearity in the data is another assumption of multivariate analysis. Multicollinearity occurs when independent variables are highly correlated with each other. Multicollinearity is undesirable as it causes issues in understanding which predictor contributes to the variance explained in the dependent variable. Furthermore, it causes variables that are individually significant to become non-significant or even stipulates a reversed direction in the path coefficient when tested collectively (Hair et al., 2018).

A full collinearity test was performed to determine whether any constructs reflect the variance inflation factor (VIF) values equal to or less than 5 (Kock and Lynn, 2012). Tolerance and VIF analysis by evaluating regression results by SPSSv29 are shown in the following table. Table 4.6 states that tolerances between 0.993 and 0.997 are significantly above 0.1, and VIF are significantly less than 3.3, ranging from 1.003 to 1.007 (Hair, Black, Babin, Anderson, et al., 2010) and (Pallant, 2010) stated tolerance values above 0.10 and VIFs below three show low collinearity.

Table 4.6
Full Collinearity

		Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.127	.185		11.487	<.001		
	ORG	.141	.039	.211	3.568	<.001	.995	1.005
	TEC	.071	.034	.124	2.084	.038	.994	1.006
	PRO	.130	.023	.336	5.678	<.001	.997	1.003
	BA	-.032	.020	-.094	-1.583	.115	.993	1.007
	PEO	.173	.020	.456	8.785	<.001	.978	1.002

a. Dependent Variable: IQ

Note: PEO-People, ORG-Organization, TEC-Technology, PRO-Process, BA- BIM Attributes

4.4 Common Method Variance

Given that the data collected in this research is from a single source, common method variance (CMV) is a possible concern even though a few procedural remedies have been taken before distributing the questions. CMV is defined as a systematic error variance that is shared among variables which are measured from the same sources or methods (Richardson, 2009). Testing on the threats of CMV is crucial when the data is collected via self-administered questionnaire and particularly when the predictor and criterion variables are obtained from the same person (Podsakoff et al., 2012). CMV may threaten the validity of the constructs and creates a systematic bias in a research (Tehseen et al., 2017).

In order to reduce the CMV, this research opts for both procedural and statistical remedies before and after data collection. For statistical remedies, Harman’s single-factor test, and marker variable technique are used to test the CMV. Harman's single-factor test is used to see if a single factor emerges from principal component analysis or if a distinct factor explains the majority of covariance among variables in un-rotated factor analysis (Podsakoff et al., 2003). Suppose there is one factor that explains the majority of research data variance (through factor analysis techniques). In that case, the research data is considered to have a common method bias problem (H. Lin et al., 2014).

The Harman single-factor test method can be implemented through factor analysis without rotation. The researcher concludes that based on the Harman single-factor test, the common method bias problem did not exist as its 14.782%, which is below 50% (Chang et al., 2010), as shown in Appendix 15. The results show that CMV is not a serious problem since no single major factor emerges.

4.5 Descriptive Analysis

For this research, data were gathered from the Facility Managers in Malaysia. The survey method resulted in the distribution of 300 survey questionnaires. In total, 240 responses were received. Two (2) responses from the received survey questionnaires were rejected because the respondent marked the same answer, also known as a "straight-line" or unengaged response and uncompleted survey forms. The questionnaires collected are summarised in Table 4.7 and Table 4.8 below. A total of 240 questionnaires were collected out of 300 distributed questionnaires. The rate of useable responses was 99.12% (N=238). It can also be seen from Table 4.8 that most data were collected from the Central region (N=96, 40.34%), followed by the Northern region (N=85, 35.71%), and Southern region (N=27, 11.34%).

Table 4.7
Description of Responding Method and Response Rate of Collected Questionnaires

Total questionnaires sent: 300	Email	Percentage (%)
Returned	240	80%
Returned (Useable)	238	79%
Returned (Unusable)	2	0.8%
Response Rate (%)		80%
Rate of Usable Responses		99.12%

Table 4.8
Description of a Responding Method Based on Regions In Malaysia

Regions	Email	Percentage (%)
Northern	85	35.71%
East Coast	15	6.30%
Central	96	40.34%
Southern	27	11.34%
East Malaysia	15	6.30%
Total	**238**	**100%**

4.5.1 Profile of Respondents

The SPSSv29 tool was used to define the profile of the respondents. Respondents were asked questions pertaining to gender, age, education, location, occupation, years of service, race and marital status. Data was collected to provide an insight into the subjects as this may contribute to interpreting the analysis results. The demographic profile characteristics selected for this research are shown in Table 4.9 below.

Table 4.9
Demographic Profile of Respondents

Demographic	Frequencies	Percentage (%)
Years in operations and maintenance		
1-5 years	68	28.57%
6-10 years	74	31.09%
11-20 years	76	31.93%
More than 20 years	20	8.4%
Nature of Organization		
Residential	45	18.91%
Health Facility	41	17.23%
Government Building	51	21.43%
Airport	31	13.03%
Educational Building	29	12.18%

Demographic	Frequencies	Percentage (%)
Commercial Building	41	17.22%
Awareness of BIM usage in FM		
Not aware at all	50	21.01%
Aware a bit	60	25.21%
Neutral	39	16.39%
Aware	52	21.85%
Very Aware	37	15.55%
Knowledge of BIM in FM		
Not knowledgeable at all	52	21.85%
Knowledgeable a bit	60	25.21%
Neutral	45	18.91%
Knowledgeable	44	18.49%
Very Knowledgeable	37	8.40%
Organization a BIM user in FM		
Yes	42	17.65%
No	196	82.35%
Years of Organization been using BIM in FM		
1 - 5 years	13	5.46%
6 - 10 years	40	16.81%
more than 10 years	38	15.97%
Never use BIM	147	61.76%

From the total respondents, the largest proportion had 11–20 years of experience in operations and maintenance, representing 31.93% (n=76). This was followed closely by respondents with 6–10 years of experience at 31.09% (n=74), and those with 1–5 years at 28.57% (n=68). Only a small proportion of respondents, 8.40% (n=20), reported having more than 20 years of experience in operations and maintenance.

In terms of the nature of organization, the highest representation came from Government Buildings, accounting for 21.43% (n=51) of the respondents. This was followed by Residential buildings at 18.91% (n=45), Health Facility at 17.23% (n=41), and Commercial Buildings at 17.22% (n=41). Other respondents were from Airports (13.03%, n=31) and Educational Buildings (12.18%, n=29), indicating a diverse range of facility types represented in the research.

Regarding awareness of BIM usage in FM, the largest group of respondents indicated that they were aware a bit, accounting for 25.21% (n = 60). This was followed by those who were aware at 21.85% (n=52) and those not aware at all at 21.01% (n=50). Respondents who reported a neutral level of awareness constituted 16.39% (n=39), while 15.55% (n=37) indicated that they were very aware of BIM usage in FM.

For knowledge of BIM in FM, the highest proportion of respondents reported being knowledgeable a bit, representing 25.21% (n=60). This was followed by those who were not knowledgeable at all at 21.85% (n=52) and respondents with a neutral level of knowledge at 18.91% (n=45). Meanwhile, 18.49% (n=44) indicated that they were knowledgeable, and a smaller group, 8.40% (n=37), reported being very knowledgeable about BIM in FM.

In terms of organizational BIM usage in FM, the majority of respondents indicated that their organizations do not use BIM, accounting for 82.35% (n=196). In contrast, 17.65% (n = 42) reported that their organizations use BIM in FM, suggesting that BIM adoption in FM is still relatively limited among the sampled organizations.

Finally, with regard to the years of BIM usage in FM, 61.76% (n=147) of respondents reported that their organizations have never used BIM. Among organizations that have adopted BIM, 5.46% (n = 13) have used BIM for 1–5 years, followed by 16.81% (n = 40) for 6–10 years, and 15.97% (n=38) for more than 10 years.

4.5.2 Descriptive Analysis of the Instrument

Using the Statistical software IBM for SPSSv29, the mean, standard deviation, the variance was calculated. Appendix 16 shows the descriptive analysis for all the indicators in the research by reporting the mean, standard deviation, variance, minimum, and maximum value for each item. Among all the constructs, people (PEO) recorded the highest mean of 3.289. This is followed by IQ with a mean of 3.0725, TEC with a mean of 3.045, PRO with a mean of 3.0420 and ORG with a mean of 2.978. The lowest mean scores are recorded by BA, with a mean 2.6190.

4.6 Model Assessment

The research model of this research was analysed using SmartPLS 4 software version 4.1.1.2. The measurement models were assessed for their psychometric qualities prior to assessing the structural model following a two-step approach proposed by (Anderson et al., (1988). PLS algorithm for this analysis was set at path weighting scheme, with a maximum iteration of 300. The analyses of significance for all the loadings, weights, standard errors, and path coefficients of the structural model were undertaken using a 10,000-sample re-sample bootstrapping procedure. This procedure was executed with an advanced setting of BCa bootstrap confidence interval method and one-tailed test at significance level of 0.05 (Ramayah et al., 2018).

4.7 Assessment of Measurement Models

The present research consists of reflective measurement models making up the multi-item constructs. The reflective measurement models were assessed by testing their internal consistency reliability, convergent validity, and discriminant validity. These assessments and their findings are discussed as follows:

4.7.1 Assessment of Reflective Measurement Model

4.7.1.1 Estimate of Loadings and Significance

The first assessment conducted is to evaluate the outer loading. As demonstrated in Table 4.10, the items exhibit acceptable indicator reliability (varying from 0.786 to 0.939), and the loadings were also in the acceptable range (Hair, Risher, et al., 2019). Three items were deleted due to low loadings (ORG 5, TEC 9 and TEC 10).

Table 4.10
Measurement Model for the First Order Constructs

First Order Construct	Items	Loadings	VIF	CA	AVE	CR
People	PEO1	0.871	2.393	0.869	0.790	0.918
	PEO2	0.895	2.319			
	PEO3	0.900	2.158			

First Order Construct	Items	Loadings	VIF	CA	AVE	CR
Teamwork (TWK)	ORG1	0.917	4.037	0.942	0.850	0.958
	ORG2	0.923	3.464			
	ORG3	0.909	3.858			
	ORG4	0.939	4.592			
Training. (TRNG)	ORG6	0.843	3.544	0.779	0.567	0.856
	ORG7	0.859	3.864			
	ORG8	0.807	3.767			
	ORG9	0.813	2.933			
Organizational Resources (ORG RES)	ORG10	0.901	3.223	0.923	0.805	0.943
	ORG11	0.904	2.784			
	ORG12	0.897	2.933			
	ORG13	0.888	4.075			
System Quality (SYS QUAL)	TEC1	0.868	3.476	0.961	0.784	0.967
	TEC2	0.932	6.002			
	TEC3	0.885	3.637			
	TEC4	0.899	4.58			
	TEC5	0.847	3.142			
	TEC6	0.878	3.527			
	TEC7	0.883	3.495			
	TEC8	0.889	3.830			
Service Quality (SER QUAL)	TEC11	0.914	3.126	0.700	0.510	0.798
	TEC12	0.905	3.439			
	TEC13	0.904	3.578			
Process (PRO)	PRO1	0.892	3.011	0.940	0.807	0.954
	PRO2	0.911	3.968			
	PRO3	0.907	3.814			
	PRO4	0.886	3.230			
	PRO5	0.896	3.249			
BIM Attributes (BA)	BA1	0.901	5.427	0.974	0.828	0.977
	BA 2	0.932	6.059			
	BA 3	0.908	5.928			
	BA 4	0.906	5.69			
	BA 5	0.915	4.337			
	BA 6	0.921	5.773			
	BA 7	0.902	4.571			
	BA 8	0.902	4.729			

First Order Construct	Items	Loadings	VIF	CA	AVE	CR
	BA 9	0.902	4.148			
Completeness (COM)	IQ1	0.814	1.519	0.766	0.682	0.865
	IQ2	0.790	1.505			
	IQ3	0.870	1.797			
Accuracy (ACC)	IQ4	0.786	1.485	0.777	0.691	0.870
	IQ5	0.851	1.740			
	IQ6	0.855	1.654			
Format (FOR)	IQ7	0.831	1.595	0.759	0.675	0.861
	IQ8	0.789	1.438			
	IQ9	0.843	1.603			
Currency (CUR)	IQ10	0.813	1.57	0.786	0.700	0.875
	IQ11	0.830	1.612			
	IQ12	0.867	1.919			

Note: ORG 5, TEC 9 and TEC 10 were deleted due to loadings

4.7.1.2 Indicator Reliability

The second assessment conducted is evaluating the internal consistency. It was performed using Cronbach's Alpha. Based on Table 4.10, the values for Cronbach alpha in this research range from 0.700 to 0.961, which meet the threshold of 0.7 recommended by Hair et al. (2010). There have been debates over the validity of Cronbach's Alpha (α) as a measure of reliability. On the other hand, Cronbach's Alpha (α) score is thought to be an underestimation of genuine reliability (J. F. Hair, Hult, et al., 2017). As a result of this shortcoming, (McNeish, 2017) proposed an alternative reliability test, the Composite Reliability (CR) Index.

4.7.1.3 Composite Reliability

Initially, internal consistency is used to measure the consistency of the result between test items. It measures whether the proposed items used for measuring a construct produce similar scores (Joseph F. Hair, Jr., G. Tomas M. Hult, 2017). (Chin, 1998) regards CR as a much more robust measure of reliability than Cronbach's alpha because it can decide whether or not the specific indicators adequately represent the relevant constructs (Fornell, C., & Larcker, 1981). Therefore, through examining CR, internal consistency reliability was evaluated in this research. Unlike Cronbach's alpha, CR does not presume an equivalent indicator loading of the construct, according to (Hair et al., 2017). CR ranges from 0 to 1; the threshold value should not be lower than 0.60 (Henseler et al., 2009), but the most acceptable value is 0.70 and above (Joseph F. Hair, Jr., G. Tomas M. Hult, 2017; Reinartz et al., 2009). At this point, the CR values for all the reflective constructs were in the range of 0.798 to 0.977, which exceeded the cut off value of 0.70 (Hair et al., 2022), asserting the internal consistency reliability of the reflective measures.

4.7.1.4 Convergent Average Variance Extracted (AVE)

Next, convergent validity refers to the extent to which the measures of the same constructs are theoretically related to each other (Henseler et al., 2009b). Convergent Validity is a term that refers to the degree to which individual indicators accurately reflect the constructions when compared to indicators measuring other constructs (Urbach N., 2010). Therefore, the degree of correlation between the measures of the same construct is shown (Hair et al,. 2017). Convergent validity is examined by inspecting the AVE and outer loadings. It is suggested that AVE should take a value of higher than 0.5 to ensure that the latent variable explains at least 50% of the variance in each indicator (Ramayah et al., 2018). The AVE value is calculated using the PLS Algorithm in SmartPLS 4.0, and Table 4.10 contains the AVE values for all the constructs. All constructs had AVE values greater than 0.5 (Hair et al., 2012; Henseler et al., 2009a). SER QUAL (0.510) has the lowest AVE, followed by TRNG (0.567), FOR (0.675), COMP (0.682), ACC (0.691), CURR (0.700), SYS QUAL (0.784), PEO (0.790), ORG RES (0.805), PRO (0.807) and BA (0.828). TWK has the highest AVE, which is 0.850. These findings indicate that the measurement model exhibited sufficient convergent validity.

4.7.1.5 Discriminant Validity

Following that, the model's discriminant validity is evaluated. Discriminant validity is the degree to which items distinguish between constructs or measure distinct concepts. It is determined by determining the correlations between measures that have the potential to overlap (Ramayah et al., 2018). In this research, discriminant validity is cross-loading and the HTMT technique, which was developed by (Henseler et al., 2015).

Firstly, discriminant validity is also measured by the AVE value of a specific latent variable (Fornell & Larcker, 1981). The Fornell and Larcker (1981) method is used in this research to investigate discriminant validity. They proposed that the square root of AVE of all latent constructs is placed on the correlation matrix diagonal, as shown in Table 4.11 with the bold and italic value, and that the square roots of AVE be greater than the correlations within latent variables. According to the research's findings, the square roots of AVE are greater than the correlation values among all latent variables. As a result, it is confirmed that the latent research constructs are distinct from one another and fulfil the requirement for discriminant validity.

HTMT is defined as the "ratio of between-trait correlations to the correlation between traits (Hair et al., 2017). The HTMT values should be < .85 (Kline et al., 2011) value, or the mode lenient criterion which is <0.90. As shown in Table 4.12, most of the respective constructs violated HTMT 0.85 when using the PLS Algorithm but complied with the lenient criterion which is less than 0.90. As a result, it is possible to conclude that the research's reliability and validity requirements have been met. The data can then be analysed further for structural measurement

Secondly, the cross-loadings were assessed to determine the discriminant validity. Additionally, as (Hair, 2014) proposed, discriminant validity can also be determined by researching the outer loadings of the indictors. They argue that discriminant validity can be demonstrated when an indicator's outer loading on a construct is greater than its cross-loading on other constructs. Table 4.13 reveals no problem with discriminant validity with the rest of the items because the loadings are more than 0.5, and no other indicator has a loading greater than the one being measured.

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Table 4.11
Discriminant Validity –Fornell & Larker Criterion

	ACC	**BA**	**COMP**	**CURR**	**FORM**	**ORG RES**	**PEO_**	**PRO_**	**SERV QUAL**	**SYS_Q UAL_**	**TWK**	**TRNG**
ACCURACY_	***0.831***											
BIM_ATTR_	-0.13	***0.91***										
COMPLETENESS_	0.761	-0.135	***0.826***									
CURRENCY_	0.716	-0.144	0.764	***0.837***								
FORMAT_	0.777	-0.054	0.626	0.718	***0.821***							
ORG_RESOURCES_	0.09	0.054	0.09	0.03	0.073	***0.897***						
PEO_	0.418	-0.061	0.372	0.374	0.367	-0.127	***0.889***					
PRO_	0.306	-0.015	0.249	0.323	0.339	-0.085	-0.023	***0.898***				
SERV_QUALITY_	0.215	0.056	0.25	0.211	0.183	0.053	0.034	-0.04	***0.927***			
SYS_QUALITY_	-0.013	-0.078	0.011	-0.019	0.045	0	0.041	-0.011	0.019	***0.885***		
TEAMWORK_	0.145	-0.087	0.112	0.179	0.123	-0.073	-0.02	0.119	0.006	-0.029	***0.922***	
TRAINING_	0.111	-0.063	0.122	0.115	0.128	-0.006	-0.06	0.008	-0.005	-0.006	-0.162	***0.909***

Note: Values in italic represent square root of AVE

Table 4.12
Discriminant Validity – HTMT

	ACC	BA	COMP	CURR	FORM	ORG RES	PEO_	PRO_	SERV QUAL	SYS_QUAL_	TWK	TRNG
ACCURACY_												
BIM_ATTR_	0.161											
COMPLETENESS_	0.874	0.171										
CURRENCY_	0.890	0.149	0.860									
FORMAT_	0.780	0.057	0.759	0.825								
ORG_RESOURCES_	0.083	0.054	0.127	0.060	0.08							
PEO_	0.468	0.061	0.436	0.446	0.437	0.15						
PRO_	0.364	0.041	0.254	0.371	0.398	0.101	0.038					
SERV_QUALITY_	0.275	0.072	0.314	0.247	0.218	0.071	0.06	0.046				
SYS_QUALITY_	0.045	0.082	0.041	0.046	0.055	0.052	0.053	0.039	0.038			
TEAMWORK_	0.132	0.09	0.099	0.202	0.139	0.069	0.045	0.121	0.03	0.037		
TRAINING_	0.154	0.073	0.182	0.122	0.142	0.043	0.072	0.043	0.036	0.028	0.172	

Table 4.13
Discriminant Validity – Cross Loadings

	ACC	BA	COMP	CURR	FORM	ORG RES	PEO_	PRO_	SERV QUAL	SYS_QU AL_	TWK	TRNG
BA_1	-0.086	0.901	-0.089	-0.087	-0.016	0.016	-0.026	0.013	0.076	-0.059	-0.097	-0.127
BA_2	-0.142	0.932	-0.144	-0.15	-0.045	0.051	-0.049	-0.028	0.053	-0.079	-0.104	-0.037
BA_3	-0.063	0.908	-0.087	-0.085	-0.016	0.051	-0.029	-0.011	0.076	-0.104	-0.103	-0.071
BA_4	-0.082	0.906	-0.061	-0.073	-0.013	0.071	-0.028	0.02	0.068	-0.057	-0.089	-0.002
BA_5	-0.164	0.915	-0.168	-0.192	-0.088	0.073	-0.098	-0.016	0.022	-0.052	-0.114	-0.022
BA_6	-0.128	0.921	-0.137	-0.144	-0.076	0.033	-0.081	-0.035	0.001	-0.114	-0.068	-0.022
BA_7	-0.085	0.902	-0.093	-0.104	-0.063	0.061	-0.044	0.009	0.078	-0.077	0.012	-0.086
BA_8	-0.077	0.901	-0.092	-0.091	-0.011	0.064	-0.038	-0.014	0.102	-0.075	-0.075	-0.112
BA_9	-0.14	0.902	-0.139	-0.146	-0.046	0.024	-0.048	-0.023	0.046	-0.035	-0.062	-0.084
IQ_1	0.572	-0.182	0.813	0.617	0.485	0.143	0.302	0.153	0.201	0.028	0.06	0.124
IQ_2	0.707	-0.061	0.79	0.633	0.562	0.041	0.296	0.246	0.159	-0.04	0.139	0.017
IQ_3	0.617	-0.089	0.872	0.644	0.51	0.039	0.324	0.222	0.253	0.033	0.085	0.152
IQ_4	0.786	-0.048	0.63	0.493	0.501	0.086	0.35	0.21	0.119	-0.047	0.151	0.014
IQ_5	0.852	-0.089	0.617	0.639	0.757	0.064	0.345	0.293	0.182	0.027	0.07	0.097
IQ_6	0.854	-0.173	0.653	0.642	0.666	0.077	0.35	0.256	0.226	-0.016	0.141	0.153
IQ_7	0.668	-0.029	0.482	0.539	0.832	0.038	0.3	0.327	0.165	0.011	0.076	0.038
IQ_8	0.593	-0.057	0.519	0.582	0.788	0.082	0.26	0.264	0.118	0.056	0.071	0.158
IQ_9	0.651	-0.047	0.541	0.645	0.844	0.062	0.341	0.246	0.166	0.044	0.152	0.122
IQ_10	0.535	-0.101	0.595	0.812	0.554	-0.028	0.326	0.244	0.196	-0.005	0.13	0.126
IQ_11	0.641	-0.126	0.673	0.832	0.636	0.024	0.31	0.309	0.171	0.002	0.161	0.117

	ACC	BA	COMP	CURR	FORM	ORG RES	PEO_	PRO_	SERV QUAL	SYS_QU AL_	TWK	TRNG
IQ_12	0.618	-0.134	0.646	0.866	0.609	0.082	0.302	0.254	0.163	-0.045	0.156	0.041
ORG_1	0.101	-0.056	0.088	0.134	0.088	-0.053	0.001	0.12	-0.011	-0.028	0.917	-0.166
ORG_2	0.169	-0.095	0.109	0.184	0.142	-0.095	0.019	0.138	-0.021	-0.046	0.923	-0.179
ORG_3	0.082	-0.06	0.08	0.145	0.091	-0.069	-0.063	0.056	0.022	-0.021	0.909	-0.113
ORG_4	0.156	-0.097	0.126	0.181	0.118	-0.046	-0.039	0.111	0.035	-0.011	0.939	-0.133
ORG_6	0.095	-0.056	0.106	0.102	0.104	0.005	-0.068	0.028	0.037	-0.017	-0.149	0.915
ORG_7	0.125	-0.056	0.134	0.13	0.144	0.019	-0.035	0.002	0.002	-0.004	-0.122	0.932
ORG_8	0.034	-0.063	0.065	0.039	0.062	-0.053	-0.079	-0.015	-0.028	-0.004	-0.141	0.888
ORG_9	0.111	-0.058	0.111	0.107	0.121	-0.021	-0.054	0.005	-0.039	0	-0.181	0.901
ORG_10	0.07	0.055	0.074	0.031	0.078	0.901	-0.133	-0.083	0.106	-0.022	-0.099	-0.035
ORG_11	0.093	0.038	0.105	0.022	0.055	0.904	-0.086	-0.048	-0.002	-0.032	-0.056	0.013
ORG_12	0.091	0.062	0.083	0.039	0.076	0.897	-0.123	-0.089	0.042	0.032	-0.056	0.009
ORG_13	0.04	0.012	0.004	-0.011	0.029	0.888	-0.123	-0.113	0.066	0.068	-0.024	-0.03
PEO_1	0.262	-0.055	0.26	0.292	0.233	-0.154	0.871	-0.01	0.035	0.032	-0.044	-0.053
PEO_2	0.399	-0.08	0.351	0.33	0.325	-0.132	0.895	-0.045	0.037	0.069	0.013	-0.049
PEO_3	0.423	-0.03	0.362	0.363	0.394	-0.068	0.9	-0.005	0.021	0.01	-0.027	-0.057
PRO_1	0.313	-0.02	0.231	0.34	0.356	-0.035	-0.003	0.892	-0.028	0.01	0.102	0.033
PRO_2	0.241	-0.037	0.21	0.282	0.261	-0.105	-0.074	0.911	-0.006	-0.018	0.08	0.034
PRO_3	0.261	0.026	0.209	0.253	0.286	-0.08	-0.001	0.907	-0.04	-0.017	0.078	-0.055
PRO_4	0.255	0.028	0.197	0.263	0.289	-0.08	0.002	0.886	-0.065	-0.013	0.1	-0.006
PRO_5	0.291	-0.055	0.264	0.3	0.317	-0.088	-0.03	0.896	-0.042	-0.015	0.166	0.02
TECH_1	-0.009	-0.085	0.008	0.002	0.043	-0.047	0.051	0.043	-0.04	0.868	0.01	-0.01

	ACC	BA	COMP	CURR	FORM	ORG RES	PEO_	PRO_	SERV QUAL	SYS_QU AL_	TWK	TRNG
TECH_2	-0.017	-0.065	0.012	-0.011	0.046	-0.021	0.041	-0.001	0.008	0.932	-0.047	0.032
TECH_3	-0.032	-0.017	0.009	0.008	0.047	-0.006	0.027	0.011	0.038	0.885	-0.022	0.002
TECH_4	-0.056	-0.018	-0.016	-0.062	0.005	0.041	0.003	-0.044	0.008	0.899	-0.07	-0.021
TECH_5	0.001	-0.07	0.014	-0.045	0.012	0.021	0.036	-0.081	-0.029	0.847	-0.022	-0.038
TECH_6	0.026	-0.09	0.042	-0.033	0.04	0.012	0.084	0.003	0.033	0.879	-0.025	-0.022
TECH_7	0.023	-0.1	-0.001	-0.023	0.056	0.013	0.002	0	0.077	0.883	-0.008	-0.027
TECH_8	-0.035	-0.097	0.005	0.013	0.049	-0.005	0.043	-0.039	0.006	0.889	-0.027	0.021
TEC_11	0.227	0.033	0.247	0.216	0.173	0.072	0.089	-0.019	0.929	0.004	0.018	-0.028
TEC_12	0.202	0.035	0.206	0.178	0.178	0.029	0.029	-0.055	0.926	0.025	0.002	0.014
TEC_13	0.166	0.09	0.241	0.191	0.159	0.045	-0.031	-0.039	0.928	0.024	-0.003	0.003

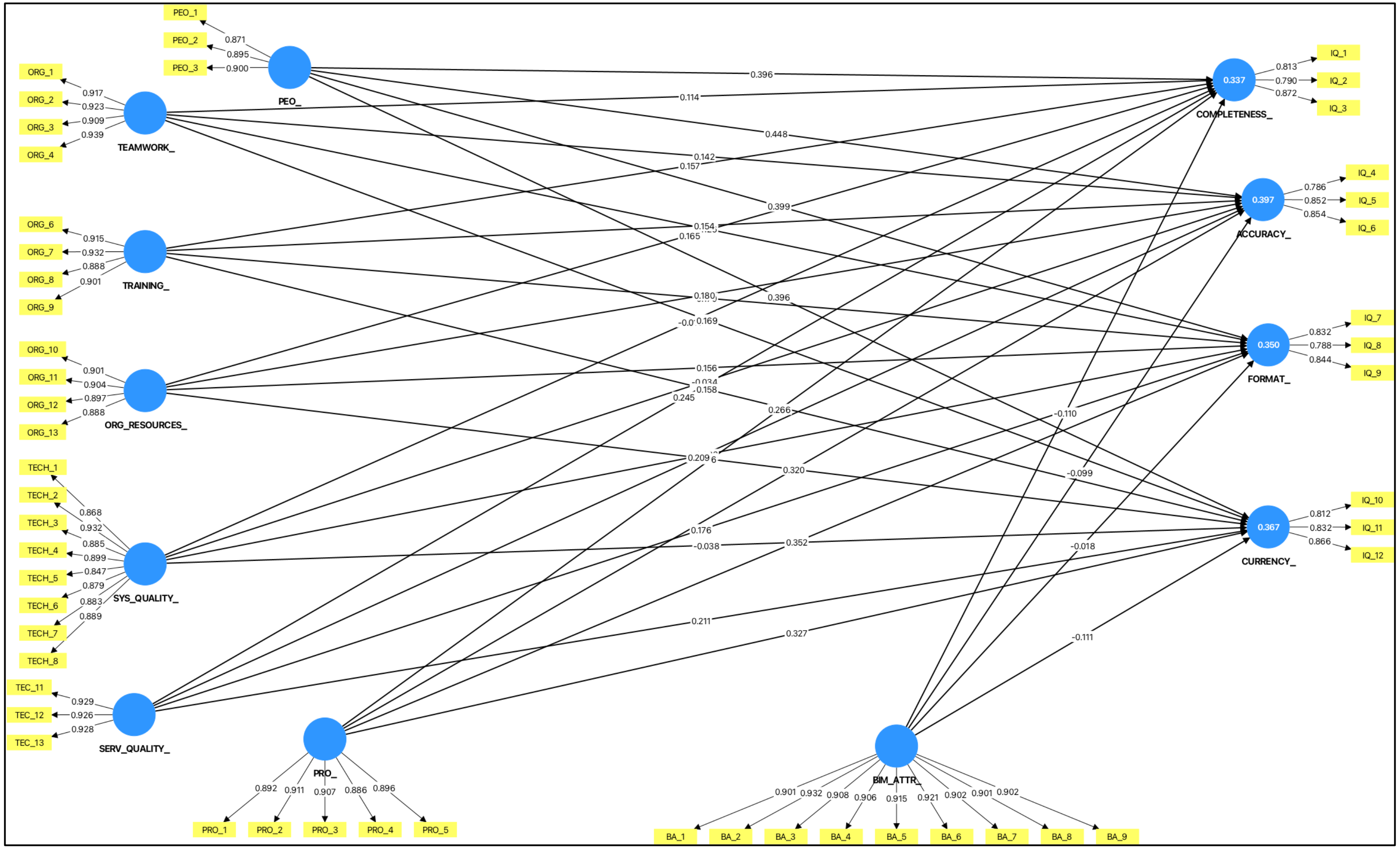

Figure 4.4 Measurement Model: Lower Order Construct

4.7.1.6 Establishment of the Second Order Constructs

Higher-order constructs contribute to model parsimony by reducing the number of path model relationships (Johnson et al., 2011; Sarstedt et al., 2019). Researchers can eliminate the need to specify interactions between several independent and dependent constructs in a path model by instead specifying relationships between a higher-order construct and its lower-order components (Hair et al., 2022; Sarstedt et al., 2019). Multiple methodologies have been presented for describing and estimating higher-order constructs (also known as hierarchical component Models) in PLS-SEM. Past research on higher-order structures using PLS-SEM has highlighted the prevalence of the reflective-reflective and reflective-formative higher-order types across a variety of field settings (Ringle et al., 2012; Sarstedt et al., 2019). The author has opted to select the reflective-formative higher-order as its one of the prominent type (Sarstedt et al., 2019).

The (extended) repeated indicators technique and the two-stage approach are the most prominent (Ringle et al., 2012). The author chose the two-stage approach because it shows better parameter recovery of paths in the path model that lead (1) from exogenous constructs to the higher-order construct and (2) from the higher-order construct to an endogenous construct (Sarstedt et al., 2019). In the path model, the author used the disjoint two-stage approach, which only looks at the lower-order parts components of a higher-order construct (that is, without the higher-order components). For the disjoint two-stage approach to work, researchers must then save the construct scores, but only for the lower-order components. In the second stage, lower order components are measured based on these scores. The second stage is to use these scores to measure the higher-order construct (Hair et al., 2022).

The current research employed three second-order latent constructs: ORG, TEC and IQ. Thus, prior to doing path model analysis, it is critical to determine if the first-order latent variables can be conceptually explained by their corresponding second-order latent variables. Thus, second-order constructs must be adequately supported by their first-order latent variables, which must also exhibit convergent and discriminant validity.

RG is a second-order construct composed of three first-order constructs: Teamwork (TWK), Training (TRANG), and Organizational Resources (ORG RES). The disjoint two-stage approach was applied to validate the construct. The inner VIF values for each indicator fall below the threshold of 5 (TWK = 1.033, TRANG = 1.027, ORG RES = 1.006), indicating no issues of multicollinearity. In terms of relative weights, TWK (0.804, $t = 3.660$, $p = 0.075$) and TRANG (0.660, $t = 2.657$, $p = 0.004$) showed strong and significant contributions to the ORG construct, while ORG RES (0.368, $t = 1.441$, $p = 0.002$) also made a significant contribution. The absolute weights reinforce this with TWK (0.671, $t = 2.618$, $p = 0.004$), TRANG (0.528, $t = 1.976$, $p = 0.024$), and ORG RES (0.605, $t = 2.923$, $p = 0.003$) all displaying substantial and statistically significant effects. This second-order measurement of ORG is valid and reliable.

TEC is a second-order construct defined by two first-order dimensions: System Quality (SYS QUAL) and Service Quality (SER QUAL). The VIF values for SYS QUAL and SER QUAL were both 1.000, which is well below the multicollinearity threshold, indicating no collinearity concern. Regarding relative weights, SER QUAL had a perfect weight of 1.000 ($t = 15.334$, $p < 0.001$), suggesting a dominant influence, whereas SYS QUAL had a negligible and non-significant weight (-0.028, $t = 0.134$, $p = 0.447$). However, absolute weights reveal meaningful contributions from both: SYS QUAL (0.649, $t = 2.018$, $p = 0.044$) and SER QUAL (1.000, $t = 15.402$, $p < 0.001$). This indicates that while system quality may not be relatively stronger when compared, it still has a statistically significant absolute effect in defining the TEC construct. This second-order measurement of TEC is valid and reliable.

IQ is a second-order construct that encompasses five first-order constructs: Accuracy (ACC), Format (FOR), Currency (CURR), Completeness (COMP), and possibly System Quality (SYS QUAL), although your data focuses on the four mentioned. The VIF values for the IQ dimensions are within acceptable range: ACC (3.684), FOR (2.954), CURR (3.114), and COMP (3.140), indicating moderate but acceptable collinearity. In terms of relative weights, ACC (0.418, $t = 2.872$, $p = 0.002$) and CURR (0.366, $t = 2.565$, $p = 0.005$) contribute significantly, while FOR (0.197, $t = 1.363$, $p = 0.086$) and COMP (0.128, $t = 0.903$, $p = 0.183$) contribute less substantially. However, in terms of absolute weights, all dimensions show strong and significant effects: ACC (0.931, $t = 28.291$, $p < 0.001$), FOR (0.865, $t = 17.304$, $p < 0.001$), CURR (0.905, $t = 22.430$, $p < 0.001$), and COMP (0.849, $t = 16.846$, $p < 0.001$). This second-order measurement of IQ is valid and reliable

Table 4.14
Variation Inflated Factor (VIF)

	VIF		VIF		VIF
ORG RES -> ORG	1.006	SYS QUAL-> TEC	1.000	ACC -> IQ	3.684
TWK ->ORG	1.033	SER QUAL-> TEC	1.000	FOR -> IQ	2.954
TRANG-> ORG	1.027			CURR -> IQ	3.114
				COMP -> IQ	3.140

Table 4.15
Higher Order Construct Validity

RELATIVE	Weights	t-value	p-value	RELATIVE	Weights	t-value	p-value	RELATIVE	Weights	t-value	p-value
ORG RES -> ORG	0.368	1.441	0.002	SYS QUAL-> TEC	-0.028	0.134	0.447	ACC -> IQ	0.418	2.872	0.002
TWK ->ORG	0.804	3.66	0.075	SER QUAL-> TEC	1.000	15.334	0.001	FOR -> IQ	0.197	1.363	0.086
TRANG-> ORG	0.66	2.657	0.004					CURR -> IQ	0.366	2.565	0.005
								COMP -> IQ	0.128	0.903	0.183

Table 4.16
Higher Order Construct Validity

ABSOLUTE	Weights	t-value	p-value	ABSOLUTE	Weights	t-value	p-value	RELATIVE	Weights	t-value	p-value
ORG RES -> ORG	0.605	2.923	0.003	SYS QUAL-> TEC	0.649	2.018	0.044	ACC -> IQ	0.931	28.291	0.000
TWK ->ORG	0.671	2.618	0.004	SER QUAL-> TEC	1.000	15.402	0.001	FOR -> IQ	0.865	17.304	0.000
TRANG-> ORG	0.528	1.976	0.024					CURR -> IQ	0.905	22.43	0.000
								COMP -> IQ	0.849	16.846	0.000

Following a successful evaluation of the outer model (measurement model), in which the latent variables show satisfactory reliability and validity; the next step was the inner model (structural model) evaluation. However, because the original framework is based on what was discovered in the literature, it needs to be revised and amended now that the outer model assessment has been completed. This is due to the analysis of the outer model, which resulted in the deletion of only three indicators out of 55. However, none of the constructs was eliminated because they had a sufficient number of indicators (Hair et al., 2012).

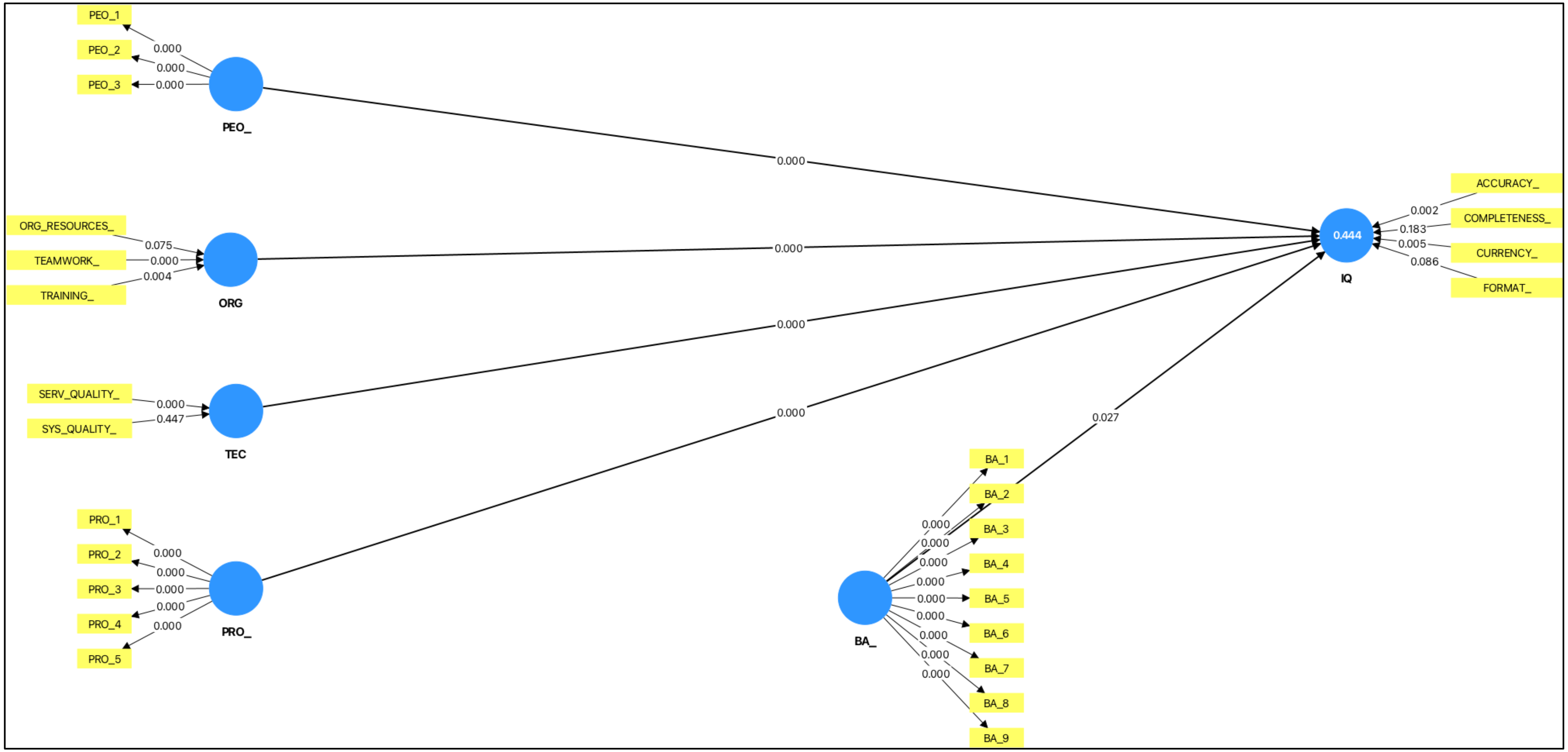

Figure 4.5 Measurement Model: Higher Order Construct

4.8 Assessment of the Structural Model

The assessment of structural model focuses on the inner model analysis. This assessment entails the examination of lateral collinearity, coefficient of determinant (R^2 value), structural model path coefficients, significance of the hypothesized relationships, effect sizes as well as the predictive power of the model (Hair et al.,2019; Ramayah et al., 2018). The significance of the path coefficients, p-values, t-values and standard errors are reported based on the bootstrapping procedure using 10,000 subsamples, one-tailed test and BCa confidence intervals. As p-values are criticized for their biasness towards the sample size, a combination of criteria including t-values, confidence intervals and the effect size (f^2) were used to test the significance of hypotheses in this research (Hahn, 2017).

4.8.1 Assessment of the Structural Model for Collinearity Issues

The structural model was first assessed to address the possibility of predictor-criterion collinearity affecting the findings (Kock & Lynn, 2012). As depicted in Table 4.17 the VIF values for all the predictors were between 1.007 and 1.026, meeting the VIF threshold of 5 (Hair et al., 2011). Thus, evidencing the absence of any substantial collinearity issues.

Table 4.17
Assessment of Structural Model

	Relationship	Std. Beta	Std. Dev	p-value	t-value	BCI LL	BCI UL	f^2	Effect size	VIF
Direct effects	,									
H1	PEO -> IQ	0.452	0.048	0.000	9.473	0.375	0.530	0.361	Strong	1.017
H2	ORG -> IQ	0.253	0.054	0.000	4.722	0.152	0.330	0.113	Weak	1.026
H3	TEC-> IQ	0.234	0.046	0.000	5.066	0.155	0.301	0.098	Weak	1.007
H4	PRO-> IQ	0.346	0.050	0.000	6.909	0.260	0.425	0.213	Medium	1.007
Coefficient of Determination										
Endogenous variables		R^2								
IQ		0.444								

4.8.2 Assessment of the Significance of Structural Model Path Coefficients

This research tested four direct hypotheses (H1–H4) to evaluate the influence of social and technical factors on Facility Management Information Quality (FMIQ). The results from the PLS-SEM bootstrapping procedure revealed that all four hypothesized direct paths were statistically significant at $p < 0.001$, as shown in Table 4.17. The standardized path coefficients (β) ranged from 0.234 to 0.452, all falling within the acceptable range of 0 to +1, which indicates meaningful and positive relationships among the constructs (Hair et al., 2022).

Firstly, the effect of People (PEO) on Information Quality (IQ) was examined. The analysis revealed that PEO is significantly and positively related to IQ with a path coefficient of $\beta = 0.452$, $t = 9.473$, and $p < 0.001$. This result indicates that personnel knowledge among FM staff play a crucial role in enhancing the quality of facility management information. The effect size (f^2) is 0.361, which falls into the strong category. Therefore, H1 is supported.

Secondly, the path from Organization (ORG) to Information Quality (IQ) was tested, yielding a statistically significant result with $\beta = 0.253$, $t = 4.722$, and $p < 0.001$. This indicates that organizational support elements such as teamwork, training, and resource availability have a positive effect on the quality of FM information. However, the effect size ($f^2 = 0.113$) indicates a weak effect. Hence, H2 is supported.

Thirdly, the relationship between Technology (TEC) and Information Quality (IQ) was evaluated. The results showed a significant path coefficient of $\beta = 0.234$, $t = 5.066$, and $p < 0.001$. This suggests that the quality of FM systems and services influences how users perceive information quality. The effect size ($f^2 = 0.098$) is also in the weak range. Therefore, H3 is supported.

Lastly, the influence of Process (PRO) on Information Quality (IQ) was investigated. The findings demonstrated a significant positive relationship, with a path coefficient of $\beta = 0.346$, $t = 6.909$, and $p < 0.001$. This highlights that efficient processes, procedures, and task management significantly contribute to enhanced information quality in FM. The effect size ($f^2 = 0.213$) is medium. Thus, H4 is supported.

4.8.3 The Coefficient of Determination (R^2)

The coefficient of determination (R^2) indicates the in-sample explanatory power of the structural model by measuring the proportion of variance in the endogenous construct that is explained by its exogenous predictors. R^2 values range from 0 to 1, with higher values reflecting greater predictive accuracy (Hair et al., 2017; Rigdon, 2012). Table 4.17 presents the R^2 value for the Information Quality (IQ) construct in the current research model. Based on the findings, the four predictors People (PEO), Organization (ORG), Technology (TEC), and Process (PRO) collectively explained 44.4% of the variance in IQ ($R^2 = 0.444$). According to (Cohen, 1988b) guidelines, an R^2 value above 0.26 indicates substantial predictive accuracy. Therefore, the R^2 value obtained in this research reflects a moderately strong explanatory power of the model in predicting information quality in facility management through the combined influence of social and technical factors.

4.8.4 Assessment of the Effect Size (f^2)

The effect size (f^2) measures the relative contribution of each exogenous construct to the R^2 value of the endogenous variable, providing insight into the substantive impact of each path. While statistical significance (e.g., p-values) indicates whether an effect exists, effect size (f^2) reveals how much impact that effect has. According to Cohen's (1988) guideline, f^2 values of 0.02, 0.15, and 0.35 represent small, medium, and large (substantial) effects, respectively. As reported in Table 4.17, the effect size of People (PEO) on Information Quality (IQ) is 0.361, which is considered substantial. This suggests that individual-level knowledge are strong drivers of information quality in FM practices.

Meanwhile, the effect of Organization (ORG) on IQ yielded an f^2 value of 0.113, indicating a small effect. This shows that while teamwork, training, and resources contribute to IQ, their relative influence is less pronounced compared to individual people factors. The path from Technology (TEC) to IQ has an $f^2 = 0.098$, which also falls within the small effect range, indicating that technology (system and service quality) plays a supportive, yet not dominant, role in shaping information quality.

Lastly, process (PRO) demonstrated an $f^2 = 0.213$, reflecting a medium effect size. This highlights the importance of task structures and standardized procedures in delivering consistent and high-quality information in facility management operations. Overall, among the four predictors, People (PEO) has the strongest relative impact, followed by Process (PRO), while Organization (ORG) and Technology (TEC) contribute more modestly to the variance in Information Quality.

4.8.5 Assessment of Moderation Analysis

After testing the direct effect, the moderation hypothesis is tested. A moderator is characterised as a third construct that can change or affect the relationship between the independent and dependent variables (Hair et al., 2016). This research used continuous types of data as the moderation, and the analysis is conducted using the SmartPLS 4.

This research hypothesised that:

H5: Higher BIM attributes will strengthen the positive relationship of Social (people) and Facilities Management Information Quality.

H6: Higher BIM attributes will strengthen the positive relationship of Social (organization) and Facilities Management Information Quality.

H7: Higher BIM attributes will strengthen the positive relationship of Technical (Technology) and Facilities Management Information Quality.

H8: Higher BIM attributes will strengthen the positive relationship of Technical (Process) and Facilities Management Information Quality.

The moderation assessment follows the Orthogonalising Approach (Henseler et al., 2009). This approach builds on the indicators approach and requires creating all product indicators of the interaction terms (Ramayah et al., 2018). The first step is to create the interaction effect (BA) between the indicators of PEO, ORG, TEC, PRO and IQ. The R^2 for the main model (without the interaction) is 0.444, and with the interaction effect model, the R^2 is 0.517. The R^2 change of 0.151 indicates that with the addition of four interaction term, the R^2 change about 0.15% (additional variance). Next, the effect size is calculated using the following formula:

$$f^2 = \frac{\text{R2 included moderator} - \text{R2 excluded moderator} -}{1 - \text{R2 included moderator}} \tag{4.1}$$

$$= \frac{0.517-0.444}{1-0.517}$$

$$= 0.151$$

Based on the guideline by Kenny (2016), 0.005, 0.01 and 0.025 respectively show the standards for small, medium, and large effects sizes. Therefore, based on the value of 0.151, it can be concluded that there large effect size (Kenny, 2016).

Hence, to obtain the significant of the relationship, the bootstrapping procedures are conducted. As shown in Table 4.18, the interaction effect of BIM*PEO on IQ yielded a standardized beta coefficient of $\beta = 0.134$, $t = 1.555$, and $p = 0.060$, with an effect size (f^2) of 0.027. Although the effect is categorized as small based on Kenny's (2016) guideline, the result is marginally non-significant at $p < 0.05$, Therefore, H5 is not supported.

Next, the interaction between BIM*ORG and IQ resulted in $\beta = 0.140$, $t = 1.762$, and $p = 0.039$, with an effect size (f^2) of 0.030**,** indicating a small but significant effect. Therefore, H6 is supported. Further for H7, BIM*TEC on IQ was also significant, with a path coefficient of $\beta = 0.106$, $t = 1.790$, $p = 0.037$, and $f^2 = 0.019$, indicating a small effect size. Therefore, H7 is supported. In contrast, the interaction effect of BIM*PRO on IQ was not significant, with $\beta = 0.035$, $t = 0.547$, $p = 0.292$, and a negligible effect size ($f^2 = 0.002$). Thus, H8 is not supported.

Table 4.18
Moderation Model Assessment

	Std.Beta	**t value**	**f^2**	**p Values**
BIM*PEO -> IQ	0.134	1.555	0.027	0.060
BIM*ORG -> IQ	0.140	1.762	0.030	0.039
BIM*TEC-> IQ	0.106	1.790	0.019	0.037
BIM*PRO -> IQ	0.035	0.547	0.002	0.292

4.9 Predictive Power Assessment

In the previous subsections, the values of R^2 and f^2 provided insights into the in-sample explanatory power of the structural model. This section shifts focus to evaluating the model's out-of-sample predictive power using PLS-Predict, a holdout-sample-based procedure designed to generate case-level predictions of key endogenous constructs (Shmueli et al., 2019). Given the sample size exceeded 200, the procedure was configured with 10 folds (k = 10) and 10 repetitions (r = 10), in accordance with guidelines from Ringle et al. (2022). The Root Mean Squared Error (RMSE) was used as the primary metric to assess prediction accuracy, while the interpretation was centered on the model's ability to predict Facility Management (FM) Information Quality, the key endogenous variable.

To assess predictive power, the PLS-SEM RMSE values were compared against a naïve linear model (LM) benchmark. According to Shmueli et al. (2019), if the PLS-SEM yields higher RMSE than the LM benchmark for all indicators, the model is said to lack predictive power. Conversely, if the PLS-SEM model produces lower RMSE values than LM for all or most indicators, the model is interpreted to have high or medium predictive power, respectively.

As summarized in Table 4.19, the PLS-SEM model outperformed the naïve LM benchmark for all four indicators of information quality which are Accuracy, Completeness, Currency, and Format. Specifically, the RMSE differences (PLS-LM RMSE) were all negative. These negative values demonstrate that PLS-SEM consistently resulted in lower prediction errors than the LM model. Furthermore, all indicators recorded Q^2predict values above 0, ranging from 0.071 to 0.270, confirming relevant predictive relevance (Hair et al., 2019).

Based on these findings, it can be concluded that the model possesses high predictive power in forecasting FM Information Quality, thus reinforcing the robustness and practical relevance of the proposed structural model.

Table 4.19
Predictive Power Assessment

	Q^2predict	PLS-SEM_MAE	LM_RMSE	PLS-LM RMSE
ACCURACY_	0.270	0.443	0.667	-0.224
COMPLETENESS_	0.248	0.559	0.892	-0.333
CURRENCY_	0.118	0.302	0.552	-0.25
FORMAT_	0.071	0.292	0.558	-0.266

4.10 Summary of Hypotheses Testing

Table 4.20 summarizes all the hypothesized relationships that are being tested in this research along with their results based on the testing using different statistical methods. Figure 4.6 shows the final path model.

Table 4.20
Summary of Testing of Hypotheses

Research Question	Hypothesis	Statement of Hypotheses	Decision
RQ	H1	Social (people) has a positive relationship with FM information quality.	Supported
	H2	Social (organisation) has a positive relationship with FM information quality.	Supported
	H3	Technical (technology) has a positive relationship with FM information quality.	Supported
	H4	Technical (Process) has a positive relationship with FM information quality.	Supported
RQ2	H5	BA moderates the relationship between Social (people) and FM information quality.	Not supported
	H6	BA moderates the relationship between Social (organisation) and FM information quality.	Supported
RQ3:	H7	BA moderates the relationship between Technical (technology) and FM information quality.	Supported
	H8	BA moderates the relationship between Technical (Process) and FM information quality.	Not supported

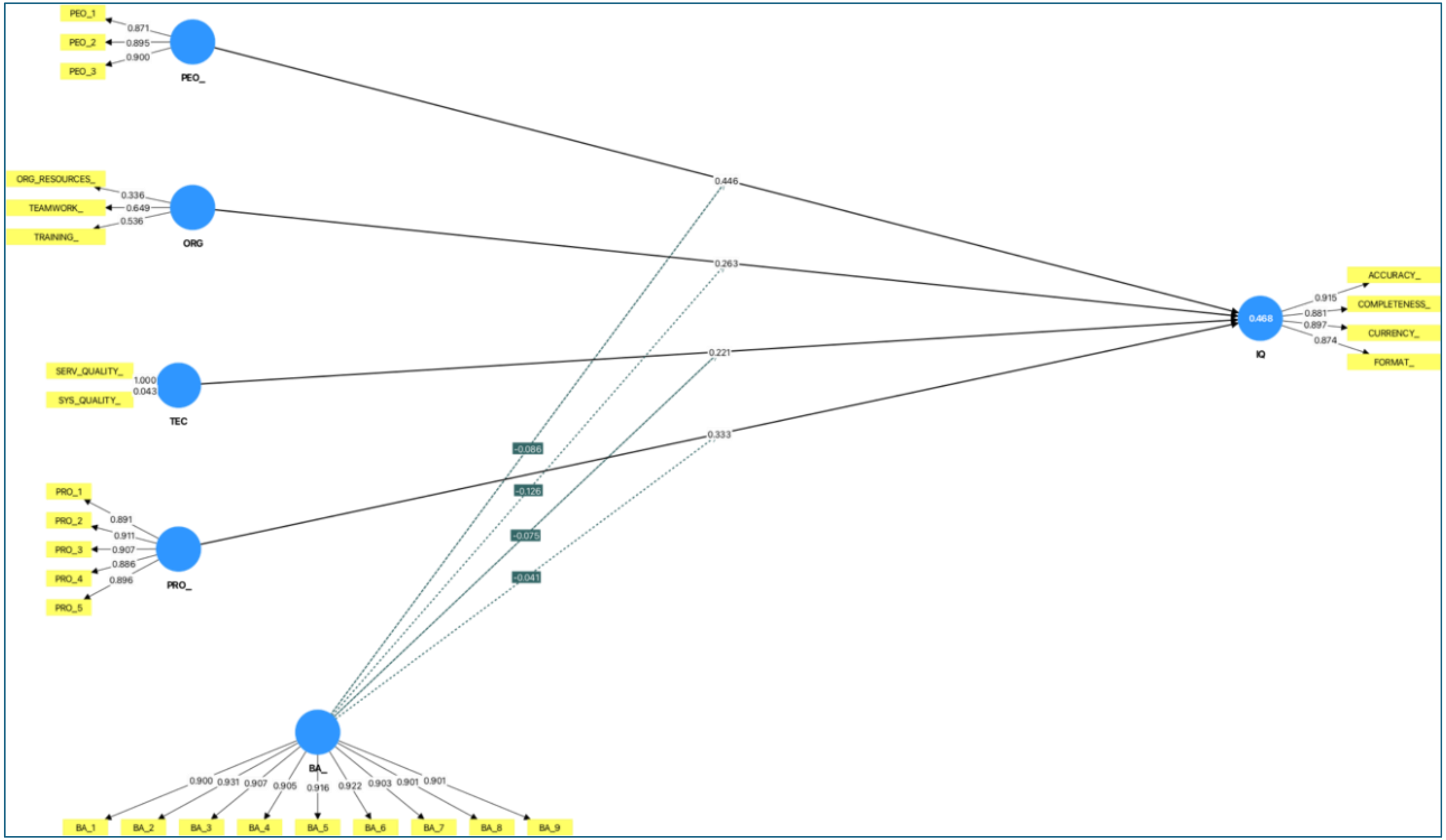

Figure 4.6 Final Path Model

4.11 Chapter Summary

The preceding pages of this chapter discussed the quantitative statistical analysis of data acquired via survey questionnaires issued to facility management organization in Malaysia. The chapter discussed the response rate results. After that, the data were examined and screened using the following procedures: missing value analysis, outliers analysis, normality analysis, and finally, multicollinearity analysis. Next, a descriptive analysis of the respondents is presented, followed by an assessment of the Path Model, Measurement Model, and Structural Model with PLS-SEM. Finally, the results of hypothesis testing based on the evaluation of the inner model are reported.

CHAPTER 5
DISCUSSION OF FINDINGS

5.1 Introduction

This chapter discusses the findings of the present research. First, the entire research is recapitulated in terms of its aim, research questions, theory, and context to facilitate the discussion. This is followed by a thorough discussion of the findings Finally, a summary encapsulating the overall findings is provided to wrap- up the research**.**

5.2 Recapitulation of Research's Findings

This research provides robust empirical insights into the determinants of Facility Management Information Quality (FMIQ) by integrating an extensive literature review with primary data from Malaysian facility management organizations. Focusing on both BIM users and non-users at the firm level, the research addresses four specific objectives and research questions, all rooted in practical challenges and knowledge gaps within Malaysia's digital FM landscape. The research's purpose is to inform a strategic framework that can elevate the quality of information in FM through a rigorous, evidence-based approach.

The research is anchored in Socio-Technical Systems (STS) theory, which asserts that optimal organizational outcomes depend on the optimization of social (people and organizational factors) and technical (technology and process) elements. By applying STS theory, this research systematically examines how these interdependent components influence information quality within FM organizations, especially in the context of increasing digitalization and BIM adoption.

The core variables investigated include People (knowledge), Organization (teamwork, training, resources), Technology (system and service quality), Process, BIM Attributes (BA), and Information Quality (completeness, accuracy, format, and currency). The research model tests direct relationships between these social and technical constructs and FMIQ, as well as the moderating effects of BA. Eight hypotheses are developed to evaluate both main and interaction effects, thus offering a holistic view of the mechanisms driving information quality in FM.

The findings confirm that all four core predictors People, Organization, Technology, and Process significantly and positively impact FMIQ, with People exerting the strongest influence. Moderation analysis reveals that BIM Attributes significantly strengthen the impact of Organization and Technology on FMIQ, while their moderating effect is not significant for People and Process. The inclusion of BA increases the model's explanatory power (R^2 rises from 0.444 to 0.517), indicating the value of integrating BA to boost FMIQ. These results underline the critical importance of a balanced approach to social and technical development, as well as the strategic integration of digital tools in FM practices.

The research advances the application of STS theory within the FM sector by empirically demonstrating how the interplay of social and technical subsystems, complemented by BA, contributes for FMIQ. For practitioners, the findings highlight actionable strategies, such as investing in BA, fostering staff knowledge and teamwork, and standardizing processes, all of which can drive substantial improvements in FMIQ and organizational effectiveness.

The research employed a quantitative, cross-sectional survey targeting G7-grade FM organizations across all Malaysian regions, using stratified random sampling and simple random sampling to ensure broad representation. Data were collected through structured, self-administered questionnaires, primarily utilizing 5-point Likert scales. The analysis utilized SmartPLS 4 to assess measurement and structural models, verifying reliability, validity, and hypothesis support. This methodological rigor ensures that the results are robust and generalizable within the Malaysian FM context.

In summary, this research delivers a comprehensive examination of the socio-technical factors and BIM integration pathways that underpin high-quality information in facility management organizations. The research not only enriches the academic discourse but also provides FM practitioners in Malaysia with actionable recommendations to enhance information quality, digital adoption, and operational excellence. Future research directions include exploring sectoral variations, longitudinal impacts, and the potential roles of additional moderating variables in shaping FMIQ outcomes.

5.3 Discussion of Findings

This section provides a comprehensive discussion of all the hypothesized relationships between the research variables based on the research hypotheses and the PLS-SEM path modelling

5.3.1 Relationship between Social and Technical with FMIQ

Research Question 1: What is the impact of social (people and organizational) and technical (technology and process) on FM information quality?

H1: People have a positive impact on FM information quality

H2: Organizational have a positive impact on FM information quality

H3: Technology have a positive impact on FM information quality

H4: Process have a positive impact on FM information quality

Research Objective 1 determine the impact of the social (people and organizational) and technical (technology and process) on FM information quality. Therefore, this section discusses each social and technical separately in relation to FM information quality. This research develops and tests four direct and positive hypotheses about the relationships between social and technical and information quality.

a) H1: People have a Positive Impact on FM information quality

The findings of this research reveal that PEO has a positive and significant impact on FMIQ. The results indicate that PEO is a significant predictor of FMIQ, particularly in facility management organization. Furthermore, the significant effect enhances the positive beta coefficient exerted by the people. The demographic profile of respondents in this research further enhances the interpretation of the positive relationship observed between PEO and IQ. The data reveal that a significant proportion of respondents (over 90%) possess more than five years of experience in facility management operations. This extensive experience among FM personnel provides strong contextual support for the research's findings, suggesting that respondents possess sufficient practical understanding and exposure to FM processes and systems, thereby strengthening the validity of their perceptions regarding information quality.

Several studies have confirmed the positive relationship between PEO and FMIQ. Salahuddin et al. (2019) highlight explicitly that competent and engaged personnel significantly reduce errors, enhancing the reliability of data. Akter et al. (2017) similarly found that well-trained personnel are better equipped to utilize information systems for comprehensive and relevant information management, especially when information needs are complex and context dependent. In addition, Hansen et al., 2025) emphasized that technological investments alone are insufficient whereas what matters is how end users adapt, engage with, and interpret digital tools. This aligns with Abdelalim et al., (2024), who argued that technical investments yield maximal benefit only when matched by equivalent efforts in human capacity development, especially in complex FM environments.

Moreover, knowledge sharing and a collaborative workplace culture have been shown to boost information quality outcomes. For instance, Fernandes et al., (2024) found that when FM organizations facilitate open communication and peer learning, staff are more capable of identifying and correcting errors, resulting in more reliable data across the organization. Meanwhile, industry trends consistently validate the academic emphasis on human factors. According to Wills, (2023) organizations which implement structured upskilling and professional development programs for FM staff experience a measurable reduction in data inconsistencies and reporting delays which challenges that are endemic to large and complex FM portfolios. This supports the argument that people are not just passive recipients of systems and processes but are key agents of change who can elevate overall information quality by bridging gaps between technology, policy, and practice.

Taken together, both scholarly and industry evidence underscore the argument that for Malaysian FM organizations striving to enhance information quality especially in the context of digital transformation investing in people is not a peripheral concern, but a core strategic priority that unlocks value from all other organizational initiatives (Chua et al., 2024; Naji et al., 2024b). Hence, the strong impact of people on information quality is well-explained by the STS theory, which asserts that organizational effectiveness depends on the social (people) (P Zhang et al., 2025; Thomas, 2024) . In the FM context, when people are competent and engaged, they are better able to achieve high information quality, validating the core premise of STS theory.

Moreover, the evidence that PEO exert the strongest influence on information quality demonstrates the ongoing relevance and centrality of the social subsystem within STS. Prior literature substantiates this theoretical perspective. Bostrom & Heinen, (1977) asserted that the ultimate effectiveness of any information system depends not only on the technology, but also on the individuals who use it and the organizational structures that support them. Supported by Ben Ghrbeia & Alzubi, (2024 Naji et al., 2024b) that employee engagement and digital literacy are foundational for successful digital transformation in FM, reinforcing that people are critical for leveraging technological investments.

Based on both the empirical findings of this research and the supporting literature, it can be concluded that people through their knowledge play a vital role in determining the quality of information in facility management organizations. Thus, the hypothesis (H1) that people have a positive and significant effect on information quality is strongly supported. FM organizations are encouraged to continue investing in staff development and digital literacy to sustain high standards of information management.

b) H2: Organizational have a Positive Impact on FM Information Quality

The findings of this research reveal that ORG has a positive and significant impact on FMIQ. The results indicate that ORG is a significant predictor of FMIQ, particularly in facility management organization. Furthermore, the significant effect enhances the positive beta coefficient exerted by the organization.

There is broad consensus in the literature that organizational support structures are fundamental to achieve and sustaining high levels of information quality in FM. For instance, Salahuddin et al. (2020) highlight that teamwork and clear communication channels across departments facilitate faster identification and correction of information discrepancies. Similarly, training both periodic and in response to system upgrades ensures that FM personnel remain current with evolving technologies and practices (Zhi & Husain, 2024). Organizational resources, including sufficient staffing and access to digital tools, have also been identified as predictors of successful FM information management (Pishdad-Bozorgi et al., 2018). When FM departments are equipped with the right quantity and quality of resources, they are better able to implement standard operating procedures, thus reducing information fragmentation and error rates.

However, some scholars caution that the mere existence of organizational resources is not enough and what matters is how these resources are mobilized through leadership and a culture of collaboration (Waseel et al., 2025). As research by Santos et al., (2024) reveal that FM organizations with strong interdepartmental cooperation and proactive management support experience higher information quality and greater readiness for digital transformation. Recent research emphasizes the importance of organizational learning and adaptability. Oluleye et al. (2023) argue that FM organizations that prioritize continuous improvement and staff feedback are better at detecting information management challenges and optimizing their procedures, which leads to enhanced information outcomes.

Meanwhile, Toulimat & Marwah Faris, (2024) found that FM organizations investing in comprehensive training and fostering teamwork reported up to 30% fewer information errors in their maintenance records and compliance reporting. Akbar et al., (2025) identified a direct correlation between investment in digital resources and improved information quality particularly in organizations that established dedicated teams for digital FM implementation. Malaysian FM organizations cited as benchmarks, such as those managing government and healthcare facility, have demonstrated that forming cross-functional project teams and implementing ongoing professional development are vital in addressing the increasing complexity of FM data management (Salleh & Johari, 2022). Organizations also reported better preparedness in meeting statutory reporting requirements and responding to operational disruptions, is due to structured teamwork and clear organizational protocols (Umoren & Odum, 2024).

This research's findings further validate and elaborate upon the organizational dimension within STS theory. Molleman & Broekhuis (2001) contended that organizational arrangements, such as participative structures and supportive management, are necessary for technology driven improvements to translate into meaningful information quality gains. Similarly, Trist & Bamforth (1951) originally observed that cohesive work groups with shared goals are better equipped to adapt to technological changes without sacrificing operational quality. Moreover, Bujang (2025) and Naji et al. (2024) found that the effectiveness of digital transformation in FM is contingent on organizational culture and leadership commitment underscoring that, even in highly digitized contexts, organizational support remains indispensable for information quality enhancement. Thus, this research's results reaffirm that organizational factors serve as critical bridges between people, technology, and process improvements, substantiating their central role within STS frameworks.

In sum, this research supports the view that organizational factors manifested through teamwork, continuous training, and provision of resources make a significant positive contribution to information quality in FM. This validates H2 and offers both theoretical and practical implications for FM organizations to achieve and sustain high FMIQ, they must not only invest in resources but also nurture a culture of collaboration, learning, and management support.

c) H3: Technology Have a Positive Impact on FM information quality

The findings of this research reveal that TEC has a positive and significant impact on FMIQ. The results indicate that TEC is a significant predictor of FMIQ, particularly in facility management organization. Furthermore, the significant effect enhances the positive beta coefficient exerted by the technology.

The foundational importance of technology in delivering high-quality information in FM settings has been extensively documented in the literature. Abdelalim et al. (2025) affirm that well-designed and user-friendly FM systems significantly reduce information errors and inconsistencies by streamlining data entry processes and facilitating real-time monitoring. Furthermore, Hamdat et al. (2024) emphasize that the robustness and responsiveness of information systems directly influence the accuracy, completeness, and timeliness of data, thereby substantially enhancing decision-making.

However, according to Wills (2023) the mere availability of advanced technologies does not automatically guarantee improved information quality. Instead, the critical factor lies in how effectively FM personnel use these technological resources, reinforcing the earlier discussed significance of the social-technical interplay in the STS framework. Similarly, Shaheen & Németh (2022) and Tsang (2002) note that even the most sophisticated technology can fall short of expectations without adequate support structures, including ongoing technical service and timely system maintenance.

Recent studies further argue that FM systems that support ease of use, clear navigation, and user-friendliness significantly improve users' ability to generate high-quality information. For example, Santos et al. (2024) found that FM organizations employing intuitive, reliable, and well-maintained digital tools consistently outperform those without such technical advantages in terms of accuracy and efficiency of their data management. Likewise, Chatsuwan et al. (2025) observe that FM systems designed with robust functionality and simplicity significantly reduce error rates and streamline operational workflows.

Meanwhile, according to the Santos et al. (2024c), FM organizations that adopt intuitive and robust information systems report significant improvements in data accuracy, timeliness, and compliance management. Further, Mawed (2024) recent industry review underscores this, highlighting that FM organizations with dedicated technical support teams and well-maintained FM information systems experience notably higher levels of operational efficiency and improved regulatory compliance.

Furthermore, leading Malaysian FM organizations, particularly within critical sectors such as healthcare, have demonstrated substantial benefits from strategic investments in user-friendly FM technologies (Mazlan et al., 2025). Pinti & Codinhoto, (2022) highlight that effective technology implementation in FM often translates directly into more reliable and comprehensive information, facilitating faster decision-making during routine operations and emergencies alike. In these successful cases, technology is not only a tool but a strategic asset that strengthens operational resilience and information reliability.

The findings presented herein extend the theoretical understanding of technology's role within STS theory. Within this framework, technology specifically in terms of system quality is recognized as essential, yet its efficacy is contingent upon seamless integration with organizational and human factors (Thakurta, 2025). From a STS perspective, Babüroğlu & Selsky (2021) assert that technological systems must be designed in alignment with user capabilities and organizational workflows to realize their full potential. Wills, (2023) further argue that FM systems optimized for usability and continuous technical support significantly enhance organizational adaptability, fostering an environment where technology positively reinforces people's productivity and organizational processes. Additionally, Manchana (2022) emphasize the critical need for responsive and robust technical support, noting that technology's effectiveness diminishes rapidly without proactive system maintenance and accessible service assistance. Thus, this research's confirmation of technology’s significant positive influence on FMIQ reinforces STS theory’s core assertion that effective technological integration demands parallel optimization of both human capabilities and organizational support structures.

In summary, the empirical results and corroborating literature validate the hypothesis (H3) that technology factors significantly enhance information quality within FM organizations. This indicates a clear imperative for FM practitioners and decision-makers to strategically invest not only in advanced technological solutions but also in ongoing technical support, responsive maintenance, and user-centric system design. Only through such balanced investments can FM organizations fully leverage technology to deliver reliable information.

d) H4: Process Have a Positive Impact on FM information quality

The findings of this research reveal that PRO has a positive and significant impact on FMIQ. The results indicate that PRO is a significant predictor of FMIQ, particularly in facility management organization. Furthermore, the significant effect enhances the positive beta coefficient exerted by the process.

Critically, the current findings align seamlessly with extensive literature emphasizing the importance of well-defined and standardized processes in achieving high-quality information within FM contexts. Leygonie (2020), for instance, provide compelling empirical evidence that structured processes significantly improve the accuracy, completeness, and reliability of facility management data. Similarly, Matarneh et al. (2022) argue persuasively that clearly articulated, standardized, and compliant processes substantially minimize human errors and inconsistencies, directly enhancing data reliability and consistency. This research’s findings reinforce these earlier assertions, validating that systematic and structured processes are fundamental drivers of robust information management practices.

Furthermore, Oluleye et al. (2023) and Santos et al. (2024) emphasize process governance and continuous assessment as critical mechanisms for sustaining superior information quality. The importance of structured facility management processes and consistent performance evaluations in identifying inefficiencies and directing process enhancements is underscored by the research. The results suggest that operational efficacy is restricted by reactive and unstructured reporting practices, whereas systematic assessment promotes continuous improvement, responsiveness, and accountability in FM operations. Consequently, the present research not only confirms but also strengthens the argument presented in existing literature, highlighting that structured operational processes are indispensable in facilitating sustained improvements in information quality within the FM industry.

Industry evidence robustly corroborates these scholarly findings, underscoring that structured process management is not merely beneficial but strategically essential for FM organizations. Oluwaseun Lawoyin et al. (2023) explicitly highlights that FM organizations investing in structured and standardized operational processes demonstrate significantly fewer errors, higher compliance rates, and improved operational efficiencies. Similarly, the Hosseini et al. (2025) clearly indicates that FM organizations employing automated and structured process workflows report enhanced data reliability, reduced information fragmentation, and increased regulatory compliance compared to those operating with informal or manual processes.

Additionally, practical cases within Malaysian FM sectors, particularly healthcare consistently reveal that structured and clearly defined operational procedures directly translate into improved operational performance and higher information accuracy (Ismail et al. 2025). These industry cases demonstrate conclusively that structured processes are more than procedural requirements they represent critical strategic assets enabling FM organizations to achieve and maintain high standards of information quality, thereby validating the practical importance of structured processes as indicated by the empirical findings of this research.

Importantly, the demographic profile of respondents adds another layer of analytical depth, as more than 90% possess extensive practical FM experience with five or more years. This extensive operational experience implies that respondents possess a nuanced understanding of FM processes and their impact on information quality. Consequently, the significant relationship observed between structured processes and IQ resonates deeply with the practical knowledge and insights of experienced FM practitioners, further strengthening the reliability and applicability of these empirical findings.

In summary, this research robustly validates the hypothesized positive relationship (H4) between process and IQ, supported by compelling evidence from scholarly literature, practical industry experiences, and relevant demographic insights. The findings clearly establish that structured, standardized, and systematically managed processes are foundational to achieving sustained high-quality information outcomes, reinforcing the strategic importance of structured process management within Malaysian FM organizations.

5.3.2 Moderating Effect of BIM on FMIQ

Research Questions 2: What is the moderation effect of BIM Attributes on the relationship between social (people and organizational) and FM information quality?

H5: BA positively moderate the relationship between people and FM information quality

H6: BA positively moderate the relationship between organization and FM information quality

Research Questions 2 to determine the moderation effect of BIM Attributes on the relationship between social (people and organizational) and FM information quality. This research develops and tests two indirect and positive hypotheses about the relationships between moderation effect of BA between social and (PEO and ORG) and information quality.

a) H5: BA Positively Moderate the Relationship between People and FM information quality

BA positively moderates the relationship between people and information quality, was not supported by the empirical data. The analysis showed that while both people and BA independently have significant effects IQ, the interaction term (People × BA) did not yield a statistically significant effect. This suggests that, contrary to some expectations, the presence of advanced BIM attributes does not amplify the positive influence of people on IQ within the FM organizations.

This result presents a contrast to much of the literature. Numerous studies, including Matarneh et al. (2022) and Toochukwu (2025), contend that BIM does not replace human expertise, but rather enhances it by providing collaborative tools, real-time information, and integrated workflows. Consequently, FM professionals are able to implement their knowledge more effectively, resulting in the production of higher-quality information.

Nevertheless, the results of this research are consistent with recent research that argues against the assumption that digital platforms alone are sufficient to improve human-driven outcomes. For instance, Tennakoon et al. (2021) emphasize that the moderating effect of BIM on people may be restricted if it is not implemented in conjunction with targeted change management, organizational culture adjustments, and ongoing training. In other words, the impact of human factors can only be amplified by BIM if there is sufficient organizational readiness, workflow alignment, and sustained user engagement.

From an industry perspective, Elkadi, (2024) and Toochukwu (2025) report that the full value of BIM as a moderator is realized only in organizations that integrate BIM into daily practices and invest in comprehensive upskilling of staff. In many FM setting, BIM is utilized in a fragmented or incomplete manner, mainly for documentation purposes rather than as an integrated operational instrument (Erciyas, 2024). Therefore, the non-significant finding in this research is likely representative of the reality that BIM's potential as a moderator is frequently left unrealized as a result of fragmentary implementation, limited user adoption, or organizational resistance.

From the STS perspective, this finding underscores the principle that technological tools alone do not automatically enhance social system contributions joint optimization and alignment are essential. The non-significant moderation effect signals that unless BIM attributes are truly embedded into FM social practices, their synergistic potential may not be achieved.

In conclusion, while literature and industry best practice suggest that BIM can moderate and enhance the impact of people factors on FMIQ, this research’s empirical evidence indicates that, within the current context of Malaysian FM organizations, this moderating effect is not yet realized. Organizations should thus focus not only on implementing BIM technologies but also on building the social readiness and culture necessary for BIM to serve as an effective moderator.

b) **H6: BA Positively Moderate the Relationship between Organization and FM information quality**

The results show a significant positive moderation by BA on the organization IQ relationship. The interaction between organizational factors and BA yields a notable positive beta coefficient, indicating that organizations with robust BIM capabilities derive even greater information quality benefits from effective teamwork, training, and resource allocation than those with less digital integration.

These findings are strongly consistent with recent scholarship. Singh & Kumar, (2024) and Toulimat & Marwah Faris (2024) demonstrate that BIM enabled workflows are most effective when embedded in organizations with established governance, compliance culture, and strong interdepartmental collaboration. BIM acts as a “force multiplier” in these environments, automating routine tasks, supporting transparent data management, and reinforcing best practices. Alnajjar et al. (2025) further argue that the moderating power of BIM is maximized when organizational policies and resources align with BIM’s attributes, supporting smoother implementation and higher data quality outcomes.

Meanwhile, according to Matniyazov et al. (2024) and Rajabi et al. (2022), organizations that integrate BIM into their standard operating procedures, and whose teams have undergone BIM specific training, report superior data accuracy, consistency, and decision-making capability. FM organizations that have fully adopted BIM in tandem with process reengineering and culture change have demonstrated sustained improvements in information quality and compliance reporting. In summary, the findings support H6, confirming that BIM Attributes significantly strengthen the positive impact of organizational factors on IQ. This suggests that for FM organizations, the path to enhanced information quality lies not only in acquiring BIM technology but also in nurturing supportive organizational environments characterized by teamwork, resources, and training that can fully leverage BIM’s potential as a moderating enabler.

5.3.3 Moderating effect BIM between Technical and FM Information Quality

Research Questions 3: What is the moderation effect of BIM Attributes on the relationship between technical (technology and process) and FM information quality?

H7: BA positively moderate the relationship between technology and FM information quality

H8: BA positively moderate the relationship between process and FM information quality

Research Questions 3 to determine the moderation effect of BIM Attributes on the relationship between technical (technology and process) and FM information quality. This research develops and tests two indirect and positive hypotheses about the relationships between moderation effect of BA between technical (technology and process) and information quality.

a) H7: BA Positively Moderate the Relationship between Technology and FM Information Quality

BA positively moderates the relationship between technology and IQ. The analysis shows that the positive effect of technological capabilities and IQ is significantly enhanced when advanced BIM attributes are present and integrated into FM workflows. This finding is strongly supported in the literature. Studies by Alkhard, (2024) and Bock (2023) argue that BIM's interoperability, data visualization, and automation amplify the value of existing FM technologies, especially in environments with complex asset data. Mannino et al. (2021) further demonstrate that automation tools have a greater impact on information accuracy and timeliness when they are embedded within BIM-supported systems, due to real-time validation and seamless data exchange.

This empirical support underlines the argument that BIM does not just serve as another digital tool it acts as a "force multiplier" for technical systems (Lehotsky & Base, 2022). When BIM is strategically adopted, it harmonizes different technology platforms, facilitates integration, and optimizes information flows, resulting in a more complete, accurate, and accessible information environment (Toochukwu, 2025) . Industry benchmarks reinforce these academic findings. According to Ahmed et al., (2024), Malaysian FM organizations that have adopted BIM alongside other advanced technologies report superior performance in information accuracy, system reliability, and regulatory compliance. Matniyazov et al. (2024) and Reddy et al. (2025) also finds that organizations integrating BIM into their technical infrastructure realize significant improvements in data consistency, error reduction, and decision support, particularly in sectors with high data complexity.

These results substantiate the STS theory, demonstrating that technological advancement alone is insufficient as the synergy between technology and enabling digital platforms like BIM is essential for optimizing information quality. In summary, the empirical evidence, reinforced by literature and industry practice, confirms that BA significantly strengthens the positive relationship between technology and FMIQ. This highlights the importance of not only adopting advanced technologies but ensuring their integration through BIM for maximal information quality improvements in FM organizations.

b) H8: BA Positively Moderate the Relationship between Process and FM information quality

H8 is not supported by the data. The analysis did not find a statistically significant moderation effect of BA on the relationship between process and FMIQ. This suggests that the presence of BIM attributes does not significantly alter the impact of structured processes on information quality in FM organizations. Several studies highlight that simply having BIM attributes does not guarantee their integration with organizational processes. Antinozzi et al. (2026) and Cann et al. (2022) argue that many FM organizations implement BIM as a stand-alone tool rather than embedding it into their core process workflows. If BIM is used only for documentation or visualization, rather than for process automation or real-time workflow management, its moderating effect on process-driven improvements to information quality is minimal. In such environments, process improvement and standardization remain largely manual or system-specific, without leveraging BIM’s full capabilities in automating, integrating, or validating processes. As a result, even well-structured processes do not realize additional benefits from BIM attributes if the technology is not widely adopted or embedded into process management (Alnajjar et al., 2025)

Meanwhile, P Marsh (2024) report that FM organizations that lack BIM implementation experience minimal improvement in process-driven data quality, regardless of how well processes are documented or standardized. Organizations at the early stages of BIM adoption often use the platform for isolated tasks, rather than as an integrated process management tool, limiting its moderating impact (Azmi et al., 2024; Chatsuwan et al., 2025). From a STS lens, this finding reiterates that technological enhancement must be matched by actual process integration and user adoption to realize its potential. If BIM is not embedded in daily operational processes, its potential as a process moderator for information quality cannot be achieved.

Therefore, while global literature and best practice suggest BIM can powerfully moderate process driven improvements to information quality, Abdulqader et al., (2025), Azmi et al., (2024), Yusnida et al., (2022) shows that such moderation is not yet realized in Malaysian FM contexts with low BIM adoption. For FM organizations seeking to leverage BIM as a process enabler, the priority should be not just acquiring BIM capabilities but ensuring deep integration into workflow management and broad-based user adoption.

5.3.4 Establishing an Integrated BIM-FM Framework for FM Information Quality

Research Questions 4: How would BIM and FM integration improve the facilities management information quality?

This section addresses Research Objective 4 to develop and validate an integrated BIM-FM framework designed to enhance FMIQ in Malaysian FM organizations. Drawing from both empirical evidence and existing literature, the framework synthesizes key socio-technical factors and highlights the role of BIM integration as a strategic enabler of information quality.

The empirical findings of this research clearly indicate that BIM integration within FM processes leads to measurable improvements in information quality. Specifically, BIM enabled organizations reported higher levels of data accuracy, completeness, timeliness, and accessibility. The moderating effects of BIM attributes were especially significant for strengthening the positive impact of social and technical factors on FMIQ. However, these benefits were conditional upon factors such as digital adoption, organizational readiness, and staff training. Where BIM usage was limited, the potential for information quality enhancement was not fully realized.

Supporting literature confirms that BIM-FM integration creates a centralized and collaborative data environment that reduces information silos, automates data updates, and ensures standardized information formats across the asset lifecycle (Druhmann, et al., 2019a; Nojedehi et al., 2022). These mechanisms improve data reliability and usability for maintenance, compliance, and strategic decision-making (Deng et al., 2021b; Bock, 2023; Pavón et al., 2021). Additionally, BIM's visualization and interoperability features facilitate real-time asset tracking, predictive maintenance, and proactive Facility management.

The conceptual framework presented in Chapter Two served as the theoretical foundation that guided the data analysis and interpretation. Based on the empirical findings discussed in this chapter, the framework was refined and developed into an integrated BIM–FM framework to enhance information quality in Facility management. A comprehensive explanation, detailed component mapping, and validation outcomes of the framework will be provided in Chapter 6, where the proposed model is elaborated, tested, and refined based on expert feedback.

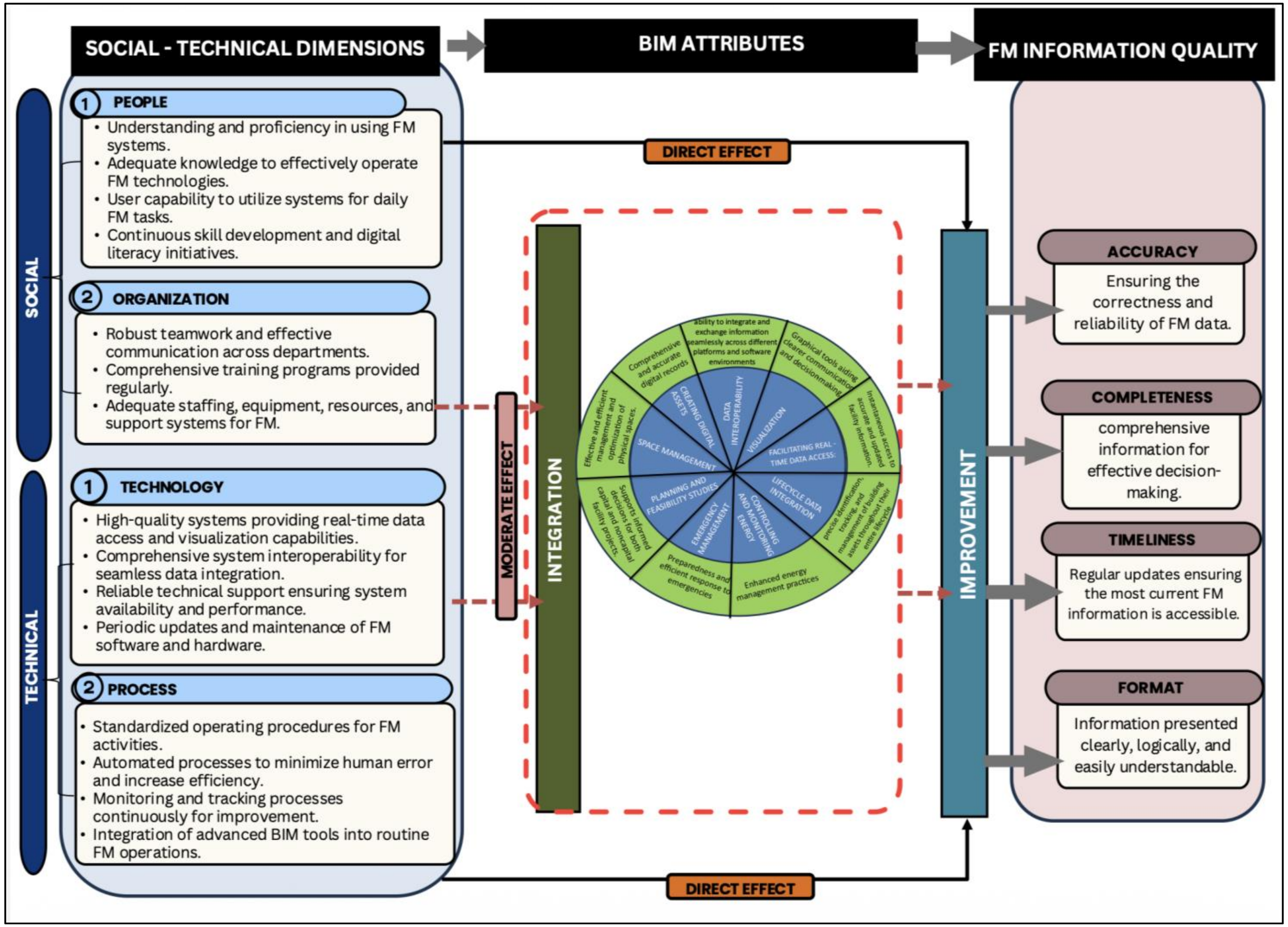

Figure 5.1 A Framework Integrating Socio-Technical Systems Approach and BIM for FM Information Quality

5.4 Summary of Findings

Empirical quantitative analysis in this research demonstrates that several factors have a positive and significant relationship with Facility Management Information Quality (FMIQ) in Malaysian organizations. The findings show that both social and technical determinants namely People, Organization, Technology, and Process contribute meaningfully to the improvement of FM information quality. Furthermore, the research finds that BIM attributes play a significant moderating role, particularly in strengthening the influence of Organizational and Technological factors on information quality, in line with the Socio-Technical Systems (STS) theory. However, the moderation effect was not significant for the People and Process constructs, reflecting the current state of BIM adoption and digital readiness within the sample organizations.

Analysis of organizational support shows these factors have a significant effect on the improvement of FM information quality, especially if organizations adopt BIM integration. Conversely, in organizations with limited BIM implementation, the enhancement of information quality is primarily driven by traditional social and process-based improvements. Overall, the research findings confirm that integrating BIM in FM offers significant added value, especially when coupled with robust organizational support and advanced technological infrastructure. The results further suggest that the benefits of BIM-FM integration are more pronounced in organizations that have achieved a higher level of digital maturity.

However, as with any empirical quantitative research, there are practical limitations. The use of a structured questionnaire may constrain respondents to predetermined options, often focusing on “what” rather than “how” or “why” certain practices are implemented. This limitation restricts the depth of explanation regarding the mechanisms behind information quality improvement. To address this gap and support the quantitative findings, this research also includes a validation by experts through direct interviews. This approach provides deeper insights into the underlying processes and contextual factors influencing BIM-FM integration and FM information quality. Further discussion of these qualitative results is presented in the following chapter.

5.5 Chapter Summary

In conclusion, Chapter 5 discussed the study's findings based on the research objectives and linked the results to the literature and the study's theoretical basis. Overall, the findings show that FM information quality is significantly influence of people, organisation, technology, process. Overall, this chapter clarified the implications of the supported and unsupported relationships and established the basis for the next chapter, which addresses Research Objective 4 by presenting, validating, and finalising the proposed BIM–FM integrated framework for FM information quality.

CHAPTER 6
THE BIM-FM INTEGRATED FRAMEWORK FOR FACILITIES MANAGEMENT INFORMATION QUALITY

6.1 Introduction

This chapter presents the final stage of the research objectives, which is to establish a framework for BIM-FM integration for FM information quality. The development of this framework is based on the analyses and findings from several stages of the research methodology which are initial data collection (structured questionnaire survey), main data analysis (using Smart PLS), and the validation process, as discussed in Chapter Three. The framework for BIM-FM integration and FM information quality is developed on the premise that evidence from one data source (questionnaire responses from both BIM users and non-BIM users at the firm level) is supported by empirical analysis (PLS-SEM results) and further validated by expert feedback. The use of multiple data sources and validation methods is believed to provide stronger, evidence-based research and enhance the credibility of the findings. Furthermore, the conceptual framework introduced in Chapter Three forms the theoretical foundation for developing the integrated BIM-FM framework. The integration of social (people and organizational) and technical (technology and process) elements, together with BIM Attributes (BA) as a moderating variable, underpins the framework's structure and content. The results of the empirical analysis and the expert validation contribute to the refinement and final establishment of the proposed framework for FM information quality through BIM-FM integration.

6.2 A Proposed Framework of BIM FM Integrated for FM Information Quality

This section addresses the fourth research objective to develop and validate a framework that integrates BIM-FM for FM information quality. Figure 6.1 presents the proposed framework of BIM-FM integration for FM information quality. The framework consists of three interconnected parts: Part 1 outlines the core socio-technical components, Part 2 describes the moderating role of BIM Attributes (BA) and Part 3 highlights the anticipated outcomes in FM information quality. Each part is discussed in detail below.

6.2.1 Part 1: Socio-Technical Components in FM Information Quality

The first part of the framework focuses on the core socio-technical elements that influence FM information quality. Based on the Socio-Technical Systems (STS) theory, these elements are divided into two primary dimensions:

i. Social Components: These include People and Organizational (training, teamwork and resources). The survey findings indicated that effective team collaboration, skill workers, adequate training, and a resource organizational were among the most significant factors influencing the quality of FM information. The PLS-SEM results further confirmed that both people and organizational constructs demonstrated strong, positive, and statistically significant relationships with FM information quality. This supports earlier literature which argues that the human and organizational environment is critical for accurate and reliable information quality (Salahuddin et al., 2019).

ii. Technical Components: These encompass Technology (system quality and system services) and Process. The descriptive analysis showed that technology factors such as interoperability, system reliability, and data security were perceived as highly important by respondents. Process including standardization of data formats and clarity in task responsibilities, were also ranked as significant contributors. PLS-SEM results confirmed that both technology and process dimensions positively influenced FM information quality, aligning with previous research that underscores the role of integrated technology and process optimization in enhancing data accuracy and accessibility.

6.2.2 Part 2: Moderating Role of BIM Attributes (BA)

The second part of the framework focuses on the BIM Attributes (BA) that moderate the relationship between socio-technical components and FM information quality. These attributes represent the specific technological and functional capabilities of BIM systems that strengthen the effectiveness of people, organizations, technology, and processes in producing high-quality FM information.

Drawing from both the literature (Chapter Two and Three) and the empirical analysis in Chapter Four, nine core BIM attributes were identified as critical to enhancing FM information quality. The PLS-SEM findings demonstrated that these attributes significantly amplify the positive effects of socio-technical factors on FM information quality, meaning that organizations that adopt BIM attributes achieve greater accuracy, timeliness, completeness, and consistency in their FM data. The nine attributes are described in detail below:

i. Lifecycle Data Integration: precise identification, tracking, and management of building assets throughout their entire lifecycle
ii. Controlling and Monitoring Energy: Enhanced energy management practices through continuous monitoring and analysis.
iii. Emergency Management: Preparedness and efficient response to emergencies using BIM data
iv. Planning and Feasibility Studies: Supports informed decisions for both capital and non-capital facility projects
v. Space Management: Effective and efficient management and optimization of physical spaces.
vi. Creating Digital Assets: Comprehensive and accurate digital records for improved information management
vii. Data Interoperability: ability to integrate and exchange information seamlessly across different platforms and software environments
viii. Visualization: Graphical tools aiding clearer communication and decision-making through continuous monitoring and analysis.
ix. Facilitating Real-Time Data Access: Instantaneous access to accurate and updated facility information.

6.2.3 Part 3: Outcomes –FM Information Quality

The fourth part of the framework focuses on the anticipated outcomes of effective BIM-FM integration, as validated by the research's results. FM information quality is characterised by:

i. Accuracy – Data reflects actual conditions and is free from errors.
ii. Completeness – All required information for FM operations is available.
iii. Timelines– Information is up to date and accessible when needed.
iv. Format– Uniform data formats and standards are maintained across systems.

From the PLS-SEM analysis, FM information quality was found to have significant implications for better decision-making, reduced operational costs, improved maintenance planning, and enhanced lifecycle asset management. Expert validation confirmed that achieving these outcomes requires not only socio-technical readiness but also strong BIM attributes to support the integration process. This aligns with literature that positions BIM-enabled FM as a strategic tool for achieving operational excellence, cost efficiency, and improved service delivery (Elkadi, 2024).

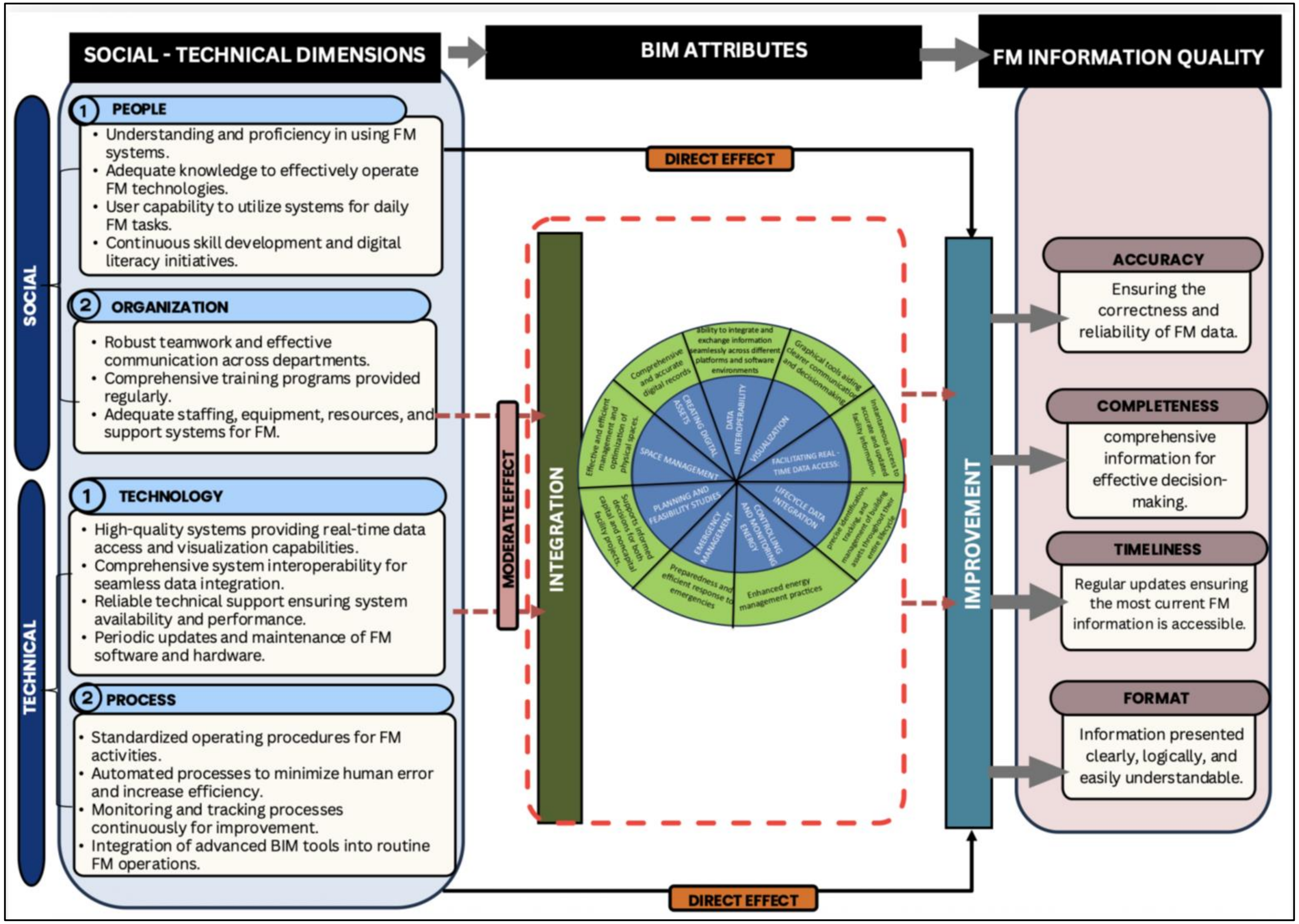

Figure 6.1 Framework of BIM FM Integrated FM Information Quality

6.3 Benefits of the Framework

The proposed BIM-FM Integrated Framework, as illustrated in Figure 6.1, offers substantial benefits for enhancing information quality in Facility Management (FM) through the strategic integration of socio-technical elements and BIM attributes. The framework addresses long-standing challenges in FM related to fragmented data, inconsistent information quality, and inefficient operational processes by providing a structured and evidence-based approach that links people, organizations, technology, processes, and BIM capabilities to measurable improvements in FM information quality.

6.3.1 Holistic Integration of Social and Technical Dimensions

One of the primary benefits of the framework is its balanced consideration of both social and technical dimensions, grounded in the principles of the Socio-Technical Systems (STS) theory. Many FM technology initiatives fail because they focus solely on the technical solution without accounting for human readiness, organizational, and process alignment. By incorporating people and organization alongside technology and process, the framework ensures that human capacity building, cross-departmental communication, leadership support, and process standardization are integral to BIM-FM integration. This holistic perspective enhances adoption rates, reduces resistance to change, and improves the sustainability of technology implementation.

6.3.2 Targeted Application of BIM Attributes (BA)

The inclusion of nine BIM functionality attributes such as lifecycle data integration, real-time data access, visualization, and emergency management offers a practical and targeted way to leverage BIM for FM. These attributes directly address operational needs, enabling FM teams to track asset performance across its lifecycle with minimal data loss, access accurate, real-time facility information to support rapid decision-making, visualize facility layouts and asset conditions, improving planning and communication and enhance emergency preparedness and energy efficiency through integrated monitoring and analysis. By clearly identifying these functionalities, the framework allows FM organizations to prioritize investments in the most impactful BIM capabilities, ensuring that resources are allocated strategically.

6.3.3 Enhanced FM Information Quality Across Multiple Dimensions

The framework links socio-technical factors and BIM attributes to four critical dimensions of FM information quality accuracy, completeness, timeliness, and format. This direct alignment ensures that improvements are not abstract but can be measured and evaluated through concrete indicators. These improvements translate into better decision-making, reduced operational errors, and more efficient maintenance and asset management activities.

6.3.4 Practical Relevance and Industry Applicability

The framework is not limited to academic exploration, it has strong practical relevance for FM organizations at different maturity levels, including both BIM users and non-BIM users. The explicit inclusion of organizational readiness factors, process optimization, and change management considerations ensures that it can be adapted to diverse organizational contexts. Moreover, its focus on measurable outcomes makes it a useful tool for performance monitoring, benchmarking, and continuous improvement initiatives.

6.3.5 Strategic Value for Long-Term Asset Management

From a strategic perspective, the framework positions BIM-FM integration as a driver for long-term asset management excellence. Enhanced information quality supports more accurate lifecycle costing, proactive maintenance, compliance management, and sustainability reporting. It enables FM leaders to make evidence-based capital planning decisions and align FM practices with organizational goals such as cost efficiency, risk reduction, and environmental performance.

6.3.6 Contribution to Industry Transformation

By systematically linking socio-technical readiness, BIM attributes, and information quality outcomes, the framework offers a replicable model that can contribute to industry-wide transformation. It provides a roadmap for FM organizations seeking to transition from fragmented, paper-based, or siloed systems toward integrated, data-driven, and collaborative practices that align with the broader digital transformation agenda in the built environment.

6.3.7 Alignment with National Digitalisation and Sustainability Agendas

The framework also aligns with Malaysia's national initiatives for digital transformation and sustainable development in the built environment, such as the National Fourth Industrial Revolution (IR 4.0) Policy**,** and sustainability commitments under the Thirteen Malaysia Plan (RMK 13)**.** By promoting BIM-enabled FM practices that enhance information quality, the framework supports government objectives to increase productivity, foster innovation, and achieve carbon reduction targets in facility operations.

6.4 Framework Validation

This section clarifies the final stage of the research process, which is to validate the framework developed. Validation of the framework is important in research. As explained in Chapter Three, the validation process was conducted through the expert panels as suggested by other researchers (Beecham et al., 2005; Fox, 2001)

The aim of the validation sessions for this research was to ensure accuracy of the variables, verify practicability, ensure significance, and validity of the framework. Validation by the expert panels is obtained using the questionnaire by means of a structured interview in line with the research work (Beecham et al., 2005). The interviews were carried out with eight experts comprising practitioners that were selected for their knowledge and experience in the areas of FM. These include facility managers in a FM organization. The purpose is to validate the findings from the survey, to see the appropriateness and possibility of the framework to be applied in the real setting. According to Lynn, (1986), five experts is the minimum number to determine the validity of an instrument's content. As suggested by AlHogail (2015) the experts with a wide range of experience could establish a reliable consensus of opinions about the appropriateness of the framework elements. Parratt et al. (2016) stated that the evidence of their expertise included relevant books, paper publications, complex team management experience, work involving teamwork, employment as leadership, or teamwork consultants.

Table 6.1 presents the details of the respondents who participated in the validation process. A total of eight out of eight respondents were involved representing 100% response rate. Out of eight respondents, seven were involved with the previous data collections. Respondents who had previously participated in the research were selected to obtain the continuity of information and enhance the validity of the data as mentioned by (Agarwal, 2011). The results indicated that most respondents hold the top position in the organisations and have more than 10 years working experiences in the industry.

Table 6.1
Profile of Respondents

Respondents	**Designation of Respondents**	**Experience (FM) Years**	**Experience (BIM) Years**	**Involved in Previous Data Collection**	
				Yes	**No**
V1	Facility Manager	12	4	Yes	
V2	Facility Manager	10	4	Yes	
V3	Asset Manager	15	0		No
V4	Director	20	8	Yes	
V5	Facility Manager	10	3	Yes	
V6	Facility Manager	12	0	Yes	
V7	Facility Manager	15	0	Yes	
V8	Facility Manager	18	0	Yes	

The primary reason for selecting respondents with previous engagement in this research was to ensure continuity of information related to the development of the BIM-FM Integrated Framework for improving FM information quality. This is aligned with prior research that highlight the importance of maintaining continuity among expert participants in order to improve the quality and relevance of evaluative input. This is due to the fact that experts are better equipped to evaluate conceptual coherence and ruminate on refinements (Creswell & Poth, 2016; Hallowell & Gambatese, 2010; Okoli & Pawlowski, 2004). Additionally, the credibility and dependability of qualitative validation outcomes have been demonstrated to be enhanced by extended interactions with highly knowledgeable participants (Lincoln & Guba, 1985.)

Respondents were selected based on two main criteria: Direct involvement in previous data collection (Questionnaire Survey) and relevant professional experience in the facility management sector, with either direct exposure to BIM practices or extensive operational experience in managing FM information. The profile of the validation respondents is shown in Table 6.1, which demonstrates that all participants hold senior FM-related roles, such as Facility Manager, Asset Manager, or Director, with FM experience ranging from 10 to 20 years. BIM experience among the respondents ranges from no exposure to over 8 years, providing a balanced perspective from both BIM and non-BIM practitioners. Seven out of the eight respondents had participated in earlier stages of the research, which strengthens the link between the framework’s development and its validation.

This selection method aligns with Beecham et al. (2005), who define an expert as an individual possessing several years of professional experience or holding positions of significant responsibility in the relevant field. Following this definition, the feedback received from the validation process can be considered as the informed opinion of domain experts with adequate knowledge to provide credible analysis and constructive suggestions. In line with the approaches of Alhogail (2015), Lynn (1986), and Parratt et al. (2016), a validation questionnaire and feedback form was prepared (Appendix 17).

The validation instrument comprised two main parts: the first part explains the background, purpose, and briefly explains the components of the framework in BIM FM integrated improving FM information quality, the second part comprising moderating role of BA. The first and second sets of questions are to investigate the perception of the experts on the proposed framework. The respondents were requested to rate the framework based on the five Likert-scale of 1 to 5, in which 1 represented 'poor' and 5 represented 'excellent'. In addition, the respondents are requested to comment on the rate given. The first set of questions deals with the appropriateness of each component in the proposed framework. The second set of questions requires the respondents' opinion in terms of the ease of understanding, use and benefits of the framework. Lastly, the third set of question is open-ended questions requesting respondents to provide additional comments or suggestion on the applicability of the framework in the real setting. To get the respondent's reply, the questionnaire was attached with a copy of the framework for respondents' reference.

6.4.1 Validation Results and Discussion

Table 6.2 presents the results of the validation process for the proposed framework. The results composed of three main items: appropriateness of the framework (socio-technical components, moderating role BA, and outcome), rate the framework in terms of ease of understanding of the framework, the ease of use, and beneficial use of the framework. The results will be deliberated in turn.

6.4.2 Rate the Appropriateness of the Proposed Framework

The item “rate the appropriateness of the proposed framework comprises three parts. Part 1 assesses the identification of the driving factors of FM information quality, namely Social (people), Social (organization), Technical (technology), and Technical (process). Unanimously, the results indicate that 100% of respondents rated the four driving factors of FM information quality at least “Good,” with 65% of all ratings falling in “Very Good.” As mentioned by respondents V1,V2 and V7,

> *“Part 1 is appropriate because it reflects how we actually fix information problems in FM on the social side, we need competent people, clear roles, and consistent communication across maintenance, assets, and project, on the organizational side, teamwork, training and resourcing make those behaviours stick. On the technical side, the tools must be stable and dependable for day-to-day work, and our processes and handover checklists must be standardised and audited. When these four drivers move together, the information we rely on becomes accurate, complete, timely, and easy to use.” (V1)*
>
> *“Part 1 captures the real levers we manage everyday team training and cross-unit communication, escalation lines and governance, dependable CMMS and data capture tools and mapped workflows with KPIs. If any one is weak, information breaks with all four aligned, the data we rely on becomes reliable and auditable.” (V2)*

> *"I think the framework is relevant and appropriate. In FM, information problems are normally connected. For example, poor data may be caused by staff not updating the record, lack of management monitoring, separate systems, or unclear procedures. Therefore, I agree with the framework because it combines the human, organisational, technological, and process elements." (V7)*

Table 6.2
Results of Framework Validation for BIM FM Integrated Improving FM Information Quality

Factors	**Poor**	**Satisfactory**	**Good**	**Very Good**	**Excellent**
The Appropriateness					
Part 1					
Identification of driving factors of FM information quality:					
Social (people)			5	3	
Social (technical)			5	3	
Technical (technology)			6	2	
Technical (process)			3	5	
Part 2					
Identification of Moderating Role					
BIM Attributes (BA)			6	2	
Ease of Understanding					
Ease of understanding of the framework			5	3	
Facilitate in Term of Usage					
Ease of use of framework			6	2	
Beneficial use of the framework to the stakeholders (i.e., government agencies/clients, FM organization)			5	3	

In support, respondent V3 and V6 stated that;

> *Part 1 is appropriate because accurate registers don't come from software alone. We need competent and skill people, resources of asset management, tools that don't crash in the system, and standard naming, coding and handover templates. That combination is what keeps the asset base trustworthy." (V3)*
>
> *"Overall, I think the framework is appropriate for FM practice. From my experience, information quality is a real issue because we need accurate and updated information for maintenance, asset records, contractors, and daily operations. I also agree that the framework includes people, organisation, technology, and process because FM problems normally do not come from technology alone. Sometimes the system is available, but staff do not update the data, responsibilities are unclear, or the working process is inconsistent. So, I think the framework reflects the actual FM environment." (V6)*

As mentioned by Elkadi, (2024), the accuracy of FM records depends on people with skills and competencies for information management, organisational resources, and standardised naming, coding, and handover templates. Thus, the statement from respondent V3 earlier is literally supported by V4 and V5:

> *"Part 1 is the right structure capability frameworks and accountability of people and organisation uptime and integration targets for our digital systems and governed procedures with periodic audits. However, it is believed that policy is also part of the organisation as it establishes rules and responsibilities to ensure the quality of information" (V4)*

Whilst respondent V5 further suggested that;

> *"Add a feedback loop so the framework isn't one-way. After each quarter, look at the results and use them to retrain people, tidy the SOPs, and fix the data fields" (V5)*

The *second part* is the 'identification of moderation role of BIM attributes. Once again, 40% (2 out of 5) of the total respondents rated the moderation role of BIM attributes as 'very good'. As mentioned by respondents V2 and V4;

> *“Treating BA as the moderator matches practice as lifecycle data integration, role-based access, and visualisation are what make cross-department collaboration visible in the data. With CMMS–BIM integration and clean schemas, our coordination meetings and RACI charts show up as accuracy, completeness, and timeliness. Part 2 captures that mechanism correctly.” (V2)*

> *“A shared data space, links to BMS or CMMS, automated model checks, and open standards turn training and governance into measurable quality gains. When those attributes are weak, the slope of improvement is flat, when they are strong, information quality rises sharply across sites. Part 2 is therefore appropriate and strategically vital.” (V4)*

V2 and V4 points are well supported by (Patacas et al., 2020; Pishdad-Bozorgi et al., 2018c) a Common Data Environment (CDE) with clear, role-based access and open standards improves the accuracy, completeness, and timeliness of operations data, making team coordination "show up" in the records, likewise, lifecycle data integration, visualisation, and system integration translate routine meetings and SOPs into reliable, reusable asset information at scale, especially when model structures. Thus, the statement also supported by respondent V1 and V5;

> *BIM features make our people and process improvements count. When systems connect and we can see data in real time, our records stay consistent and audit ready. Without those features, good work still turns into messy data.” (V1)*

> *Day to day, we invest first in real-time access, space management, and emergency energy tools. These features make our team’s effort show up as reliable, shareable info.” (V5)*

Meanwhile, as a non-BIM user, respondent V3, V6, V7 and V8 offered the following perspective;

> *Part 2 is appropriate even from a non-BIM user’s view. When projects hand over structured, interoperable digital assets in common formats and a shared data space with lifecycle fields and real-time updates, our CMMS imports cleanly and the registers stay current. In that way, these BIM features sit in the middle and turn our existing people and process effort into reliable, reusable information without them, we’re back to manual re-entry and stale records.” (V3)*

> *"Most of the attributes are relevant to FM, although I do not have direct experience using BIM. From an FM perspective, we need information about asset location, maintenance history, building systems, space, energy use, and emergency access. These are normal FM requirements. BIM seems to provide these types of information in a more visual and integrated form."* (V6)

> *"The attributes are generally appropriate. Even though I have not used BIM, I can understand their practical value. For example, visualisation can help staff locate assets, digital asset information can support maintenance, and space management can help with occupancy and facility planning."* (V7)

> *I think it is still relevant. Even if an organisation does not use BIM yet, the framework can help me understand what needs to be prepared first. For example, they need proper asset data, trained staff, clear responsibilities, good systems, and proper work procedures. These are important before moving towards BIM-FM integration."* (V8)

6.4.3 Rate the Framework in Term of Ease of Understanding, Ease of Use of Framework, and Beneficial Use of the Framework

In terms of the ease of understanding of the framework, it was rated as 'very good' by a majority of the respondents giving a total of 60% of response rate. The framework was mentioned as 'very clear and easy to understand' by most of the respondents. Respondents V4, V5 and V6 claimed that:

> *"Clear even for a non-BIM user. The components are labelled plainly, and I can see how they fit our daily asset work without needing extra explanation."* (V5)

> *"Visually intuitive. The structure reads left-to-right with no jargon, so it's easy to present at leadership level"* (V4)

> *"The overall idea is understandable. I can clearly see that People and Organisation are related to the social side, while Technology and Process are related to the technical side. I also understand that all these factors contribute to Information Quality. The only part that may require more explanation is the moderator. People who are not familiar with research terms may not immediately understand what moderation mean."* (V6)

Further added by respondent V1 and V2;

"The framework is easy to understand. The layout is clean and the links between people, organisation, technology, process, and outcomes are obvious (V1)

Very clear and practical. The terms are simple, and the arrows show cause effect well. (V2)

However, respondents V3 suggested that the framework could be further improved as he believed that;

"The framework is easy to understand. The layout is clean and the links between people, organisation, technology, process, and outcomes are obvious. However, as a non-BIM user feels more like a framework for those already using BIM rather than a practical roadmap that guides organisations like mine through the transition. (V3)

This implies that the framework has a good potential for application by the practitioners provided some minor adjustments could be incorporated to make it simple and precise. Following thereon, the framework is rated as 'very good' (40%) in terms of ease of use of the framework by most of the respondents. According to respondent V1 and V8;

"Yes, I do agree that the framework is simple to use for our future projects. I believed the framework could help our organisation to improve FM information quality" (VI)

"I can understand the main idea that information quality depends on people, organisation, technology, and process. The outcome is also clear, which is better information quality. For FM practitioners, this is easy to relate to because we deal with information every day" (V8)

Furthermore, respondent V3, V6 and V8 also agreed on the ease of use of the framework and stated that;

"This framework is easy to implement as it portrays a guide for industry players in the maintenance management" (V3)

"The main flow is easy to follow. The framework shows that good information quality depends on several factors working together. I also understand the final outcome, which is accurate, complete, properly formatted, and updated information" (V6)

> *"For organisations with no BIM experience, I think the framework should be used in stages. They can start by improving their existing information first, such as asset register, maintenance records, and data updating procedures. After that, they can look at system integration and later consider BIM functions such as visualisation and digital asset information." (V8)*

Meanwhile, the beneficial use of the framework was rated as 'very good' with a total score of 60%. According to respondents V3, V4, V5 and V7;

> *"The framework can be mainly beneficial for facility managers in enhancing information quality " (V3)*
>
> *"For me, the framework is beneficial for use for increasing the implementation of BIM in FM in Malayisa " (V4)*
>
> *"Practical to apply. We can assign owners, link to CMMS forms, and run a small pilot in one building no heavy rework needed. (V5)*
>
> *"The framework can help improve the consistency and reliability of FM information. Better information can support preventive maintenance, statutory compliance, asset planning, budgeting, and operational decisions. It can also improve communication because staff, contractors, and management can refer to the same information." (V7)*

Meanwhile, respondent VI and V2 suggested that;

> *" I supposed it is useful as it identifies strategy to improve FM information quality. However, the framework is more useful for authorities and consultants as they are the implementers, compared to the FM contractors" (VI)*
>
> *"The framework looks beneficial and address some pertinent factors related to information quality. However, the framework will be remained as a piece of paper on shelve provided organizations are willingly to adopt BIM technology for their projects " (V2)*

Based on the results, it can be concluded that the respondents agreed with the proposed framework in terms of ease of understanding, ease of use, and beneficial use. In particular, a majority rated the framework very good for clarity (60%), with additional positive ratings for usability and stakeholder benefit. Accordingly, the proposed BIM–FM integrated framework is accepted by industry practitioners, subject to minor amendments reflected in the revised Figure 6.2. Under the socio-technical system theory (first component), two items are suggested to be added. These are policies and feedback loop. All of the suggestions will be incorporated in the framework.

This means to say, the total number of variables in the revised framework remains intact, with the addition of policy under the Organization component and the incorporation of a feedback loop linking FM information quality outcomes back to the socio-technical drivers and BIM attributes. The proposed framework is therefore acceptable and useful as a foundation for identifying the relationships between People, Organization, Technology, Process, BIM Attributes, and FM Information Quality in the development of BIM–FM integrated practices for improving information quality in facility management. However, as highlighted in sub-chapter 2 (page 86 2.9]), the proposed framework is subjected to many challenges as namely people, process, information and technology. People-related challenges include the lack of organisational support, insufficient skills, and resistance to adopting new governance measures. Process challenges concern the reluctance of some stakeholders to consistently apply the framework or to follow the feedback loop for continuous improvement. Technology challenges are associated with the lack of interoperability, unstable system performance, and limited technical expertise in managing integrated BIM–FM platforms.

One of the interviewees from the validation process, representing a non-BIM perspective, commented that the framework appears to be more suited for organisations already using BIM rather than serving as a step-by-step roadmap for those transitioning from non-BIM to BIM environments. While this comment reflects the perspective of a non-BIM user, the framework has been intentionally developed as a strategic integration model rather than a prescriptive BIM adoption roadmap. Its purpose is to identify and connect the socio-technical drivers, BIM attributes, and FM information quality outcomes that underpin BIM–FM integration, in line with Malaysia's national agenda for digitalisation in the built environment.

The framework aligns with the objectives of the RMK13 and the National BIM Roadmap, which prioritise not only the uptake of BIM but also its integration into the operations and maintenance phase to achieve sustainable, data-driven asset management. By explicitly incorporating both BIM and non-BIM organisational contexts, the model supports progressive readiness allowing FM organisations to strengthen People, Organisation (including policy), Technology, and Process components before or during BIM adoption. For non-BIM organisations, the socio-technical elements in the framework can be implemented immediately, improving governance, standardisation, and information management practices. This approach ensures that when BIM attributes are introduced, the organisation is already structurally prepared to leverage them effectively.

Meanwhile, based on the pilot survey research and content validity exercise it was finalised that the panel of five expert practitioners from facility management organisations comprising both BIM and non-BIM users considered the variables and structure of the framework to be adequate and necessary for guiding BIM–FM integration in Malaysia. The framework is therefore applicable to organisations at varying BIM maturity levels while still fulfilling its role as a nationally relevant reference. As (Abu-Bakar & Charnley, (2024) and Shukla & Sushil, 2021) mentioned that frameworks aligned to national goals should be adaptable to diverse maturity contexts to remain relevant across the industry lifecycle.

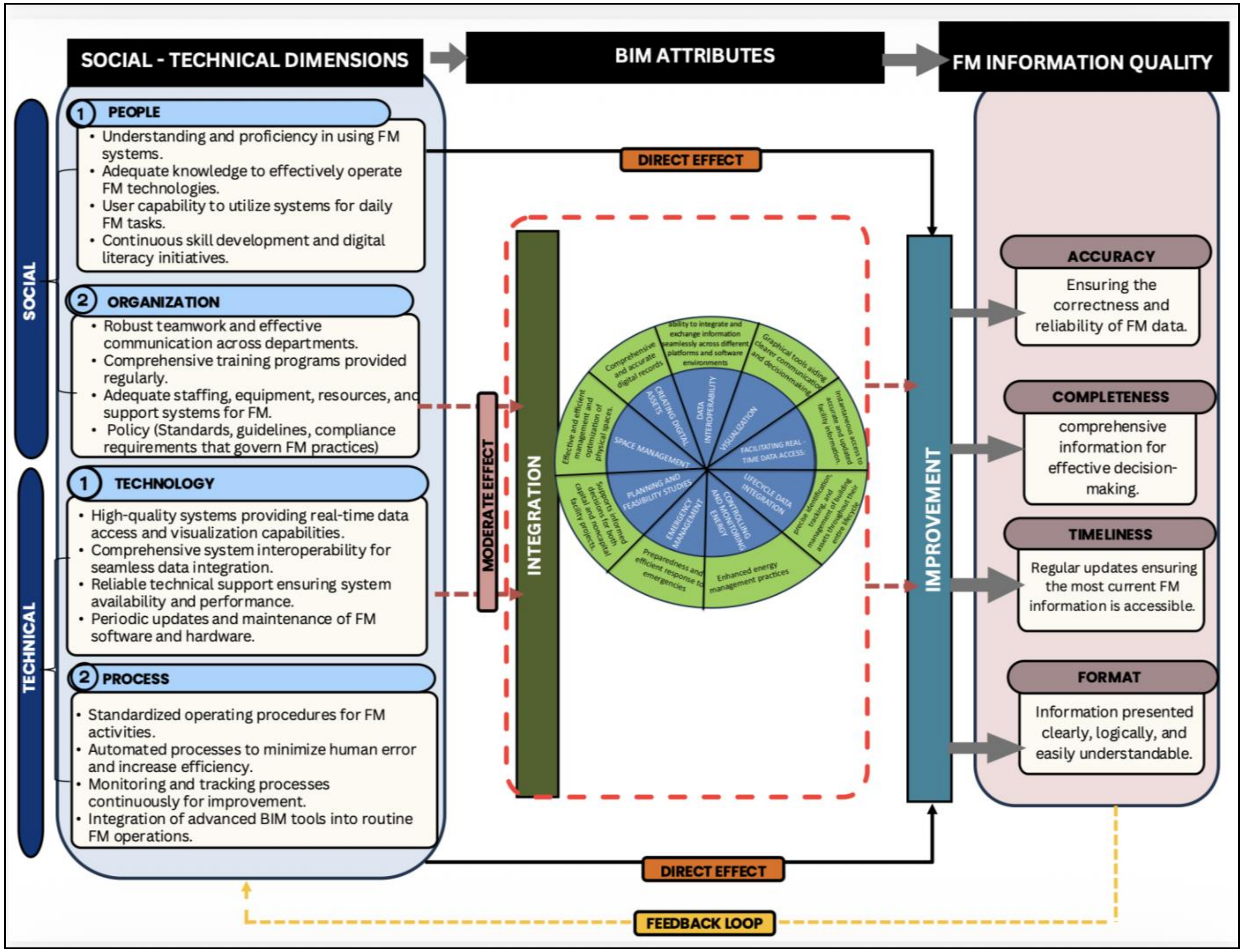

Figure 6.2 Framework of BIM FM Integrated For FM Information Quality(Modified)

6.5 Chapter Summary

This chapter has addressed Research Objective 4, which was to establish an integrated BIM–FM framework to improve Facility Management Information Quality (FMIQ). Drawing from the empirical findings of earlier chapters, the framework was developed based on Socio-Technical Systems (STS) theory, integrating Social (People and Organisation) and Technical (Technology and Process) factors, with BIM attributes positioned as a strategic moderating element.

The framework was validated by experienced facility management practitioners from both BIM and non-BIM organisations, confirming its appropriateness, clarity, usability, and practical relevance. Respondents acknowledged that the framework accurately captures the drivers of FMIQ and that BIM attributes play a crucial role in amplifying the positive effects of organisational readiness and technological capability. Two refinements were proposed and incorporated into the final model which are the inclusion of policy under the Organisation dimension to strengthen governance and accountability and the addition of a feedback loop to ensure continuous improvement by linking FMIQ outcomes back to the socio-technical drivers and BIM functionality attributes. Further, discussion of the theoretical implications, practical implications, limitations of the research and recommendations is presented in the following chapter.

CHAPTER 7
CONCLUSION AND RECOMMENDATIONS

7.1 Introduction

This chapter presents the conclusions and recommendations of the research by integrating the key findings derived from the fulfilment of the research objectives and empirical analyses. This research highlights its contributions to theory and practice by analysing the theoretical and practical implications of integrating Building Information Modelling (BIM) to improve information quality in Facility Management (FM). This chapter discusses how the findings enhance current knowledge by highlighting the importance of socio-technical perspectives in comprehending BIM–FM integration and the quality of FM information. The chapter outlines practical implications for facility management organizations, industry practitioners, and policymakers, specifically concerning BIM adoption, the enhancement of FM deliverables, and the improvement of organizational and process alignment. Finally, this chapter presents recommendations for implementation and future research, concluding the thesis by highlighting the significance of the proposed BIM–FM integrated framework in enhancing BIM-enabled FM practices, especially in the Malaysian context.

7.2 Achievement of Research Objectives

This section outlines how the empirical findings and the final research output successfully addressed and achieved the four primary research objectives established at the beginning of the study.

a) **Research Objective 1 (RO1): To identify the impact of social (people and organizational) and technical (technology and process) on the FM information quality.**

This objective was achieved through the structural model analysis (PLS-SEM), which empirically tested the direct effects of the socio-technical dimensions on Facility

Management Information Quality (FMIQ). The findings confirmed that all four core predictors which are People, Organization, Technology, and Process have a significant and positive impact on FMIQ. Notably, the People construct exerted the most substantial influence on information quality outcomes, proving that competent and engaged personnel are the most critical drivers of accurate and reliable data in FM operations.

b) Research Objective 2 (RO2): To identify the moderation effect of BIM Attributes on the relationship between social (people and organizational) and FM information quality.

c) Research Objective 3 (RO3): To identify the moderation effect of BIM Attributes on the relationship between technical (technology and process) and FM information quality.

These objectives were achieved by examining the interacting role of nine core Building Information Modelling (BIM) attributes. The moderation analysis revealed that BIM attributes act as a strategic force multiplier, significantly strengthening the positive relationships between Organizational factors and FMIQ (H6 Supported), as well as between Technological factors and FMIQ (H7 Supported). However, the data also proved that BIM's moderating effect is conditional aa it does not automatically amplify the impact of People (H5 Not Supported) and Process (H8 Not Supported) without adequate digital readiness and deep integration into daily workflows. This achieved the objective by proving that BIM implementation must be matched with organizational alignment to be fully effective.

d) Research Objective 4 (RO4): To develop and validate an integrated BIM-FM framework for FM information quality.

This ultimate objective was successfully achieved through the synthesis of the empirical PLS-SEM findings and subsequent expert validation, culminating in the final Integrated BIM-FM Framework (as illustrated in Figure 6.2). The final research output is structured around three interconnected components and their relationships:

i. **The Socio-Technical Drivers (Independent Variables):** This forms the foundation of the framework, divided into social dimensions (people, Organizational teamwork, training, and resources) and technical dimensions (technology and process). Based on expert validation, Policy was explicitly added to the Organization dimension to establish strict governance, standards, and compliance requirements. These four dimensions exert a direct effect on the quality of FM information.

ii. **The BIM Attributes (Moderator):** Positioned centrally in the framework, nine core BIM attributes exert a moderate effect. They serve as an integration mechanism that bridges the social and technical subsystems, specifically amplifying the strengths of the organization's teamwork and technological infrastructure.

iii. **FM Information Quality (Outcomes & Feedback Loop):** The framework's targeted outcomes are the enhancement of FM information across four dimensions which are accuracy, completeness, timeliness, and format. Crucially, expert validation led to the addition of a feedback loop. This loop connects the FMIQ outcomes back to the socio-technical drivers and BIM attributes, ensuring that information quality evaluations are continuously used to retrain staff, update operational policies, and refine technical systems for sustained improvement.

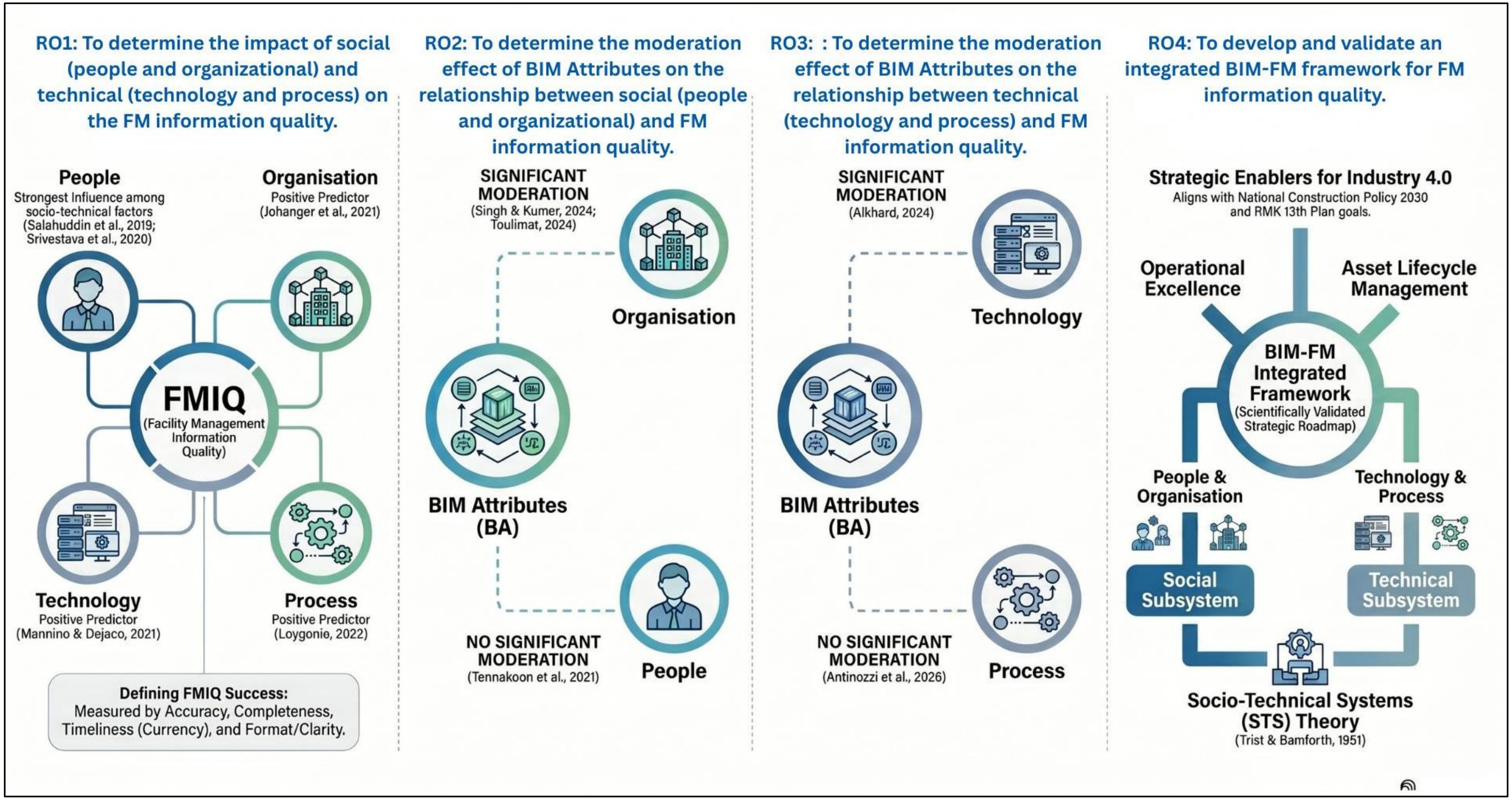

Figure 7.1 Summary Achievement of Research Objectives

7.3 Theoretical Implication

This research contributes significantly to the theoretical understanding of Facility Management Information Quality (FMIQ) through the integration of Building Information Modelling (BIM) into Facility Management (FM) practices. By anchoring the research in Socio-Technical Systems (STS) theory, this research provides empirical evidence supporting the importance of harmonizing social (people and organization) and technical (technology and process) subsystems in achieving superior FM information quality outcomes.

Firstly, from a theoretical standpoint, this research extends and enriches STS theory within the context of the FM sector, particularly by clearly identifying and empirically validating specific socio-technical factors critical for FM information quality. While existing literature commonly addresses social and technical subsystems separately or broadly, this research provides a structured empirical analysis, distinctly categorizing and examining the influence of each socio-technical dimension people, organization, technology, and process on FMIQ. Thus, the research contributes by presenting a nuanced understanding of how each dimension uniquely and collectively influences FM information quality, providing valuable clarity for future theoretical advancements in socio-technical FM research.

Secondly, this research uniquely positions BIM attributes as a moderator within the STS theoretical framework, rather than as a mere technological tool. Existing literature often views BIM predominantly as a technical solution. However, this research advances theoretical discourse by empirically validating BIM as a critical moderating factor that can significantly enhance the positive impacts of organizational readiness and technological infrastructure on information quality. Through rigorous quantitative analysis, the moderation role of BIM was statistically confirmed, particularly highlighting its significance in amplifying organizational support and robust technological systems, further enriching the understanding of BIM's strategic function within FM.

Thirdly, the empirical evidence from this research demonstrates the conditional nature of BIM moderation. Specifically, moderation was significant primarily for Organization and Technology dimensions, but not clearly for People and Process dimensions. This finding introduces a new theoretical nuance, suggesting that the effectiveness of BIM integration in FM is contingent upon the organization's existing digital maturity and technological capabilities. Such empirical clarity adds important theoretical insight, emphasizing the importance of pre-existing conditions within organizations for effective BIM adoption. This understanding broadens the theoretical framework for digital transformation strategies within FM, where the success of technology-based solutions depends heavily on the contextual readiness of organizational systems and infrastructures.

Fourth, feedback from the framework validation exercise strengthens its theoretical contribution. Validators confirmed the theoretical positioning of BIM as a moderator and suggested enhancements such as the addition of policy under the Organisation dimension and a feedback loop for continuous improvement. These refinements reinforce the framework's alignment with both academic theory and industry practice, further supporting its relevance in diverse FM maturity contexts.

Finally, this research contributes theoretically by integrating constructs from multiple academic disciplines, including information systems, organizational behaviour, construction management, and Facility management. By synthesizing constructs and findings across these traditionally isolated fields, the research provides a comprehensive and interdisciplinary theoretical perspective that enriches existing socio-technical and digital transformation literatures.

In conclusion, this research significantly advances theoretical knowledge by empirically validating and extending STS theory into FM practice, clearly positioning BIM attributes as a strategic moderator, highlighting conditional relationships, and integrating diverse disciplinary insights. This comprehensive theoretical framework provides a robust foundation for future research in facility management, digitalization, and organizational transformation in Malaysia and beyond.

7.4 Practical Implication

This research offers valuable practical implications, particularly for professionals, policymakers, and organizations involved in Facility Management (FM) and Building Information Modelling (BIM) integration initiatives. Through empirical evidence and expert validation, the findings provide clear guidance on the critical success factors required for enhancing Facility Management Information Quality (FMIQ).

Firstly, for FM organizations and practitioners, the results emphasize the importance of balancing social (People and Organization) and technical (Technology and Process) factors within their operational strategies. Specifically, FM organizations should prioritize employee training, digital skills development, and comprehensive awareness programs to strengthen their human capital capabilities. Practitioners are encouraged to systematically assess their workforce's current skill level and continuously invest in tailored professional development programs to ensure effective utilization of BIM and other digital tools.

Secondly, the significant role of organizational support and structure underscores the need for FM firms to cultivate a supportive organizational environment characterized by training, effective teamwork, clearly defined roles, and adequate resources. Organizations aiming for successful information quality must foster training, teamwork, resources and establish robust governance mechanisms. Practical initiatives, such as cross-departmental collaboration and effective communication channels, are essential for realizing the full benefits of digital transformation within FM.

Thirdly, from a technical infrastructure perspective, the findings suggest that merely acquiring technologies is insufficient. FM organizations must invest in high-quality technical infrastructure such as BIM, ensure seamless interoperability between different software systems, and provide ongoing technical support to maintain consistent system performance. Practitioners should prioritize technology solutions that facilitate real-time data access, reliable visualization tools, and intuitive interfaces that directly support their FM operational requirements.

Fourthly, this research clearly positions BIM Attributes as a significant moderator, particularly enhancing the positive effects of robust organizational frameworks and advanced technological capabilities on FM information quality. Practically, this highlights the importance of strategic implementation and integration of specific BIM functionalities, including real-time asset tracking, space management, energy control, and emergency response planning. FM organizations should strategically select and prioritize BIM functionalities that align closely with their operational priorities and digital maturity levels to achieve optimal information management outcomes.

Fifthly, the findings highlight the conditional nature of BIM integration. Organizations with lower digital maturity levels may not realize the full moderating potential of BIM attributes. Thus, FM managers should first assess their organization's current digital maturity before fully adopting BIM solutions. Incremental adoption approaches, beginning with smaller-scale pilot projects or targeted digitalization initiatives, can help organizations progressively build capacity, increase user confidence, and maximize the return on BIM investment.

Additionally, the expert validation provided key industry insights on how to practically enhance framework applicability. Experts emphasized the importance of simplifying communication about BIM's role in FM and ensuring real-world practicality. FM managers and practitioners can use the validated BIM-FM Integrated Framework as a practical roadmap to guide their digital transformation journey. By explicitly detailing clear roles, responsibilities, and expected outcomes of BIM adoption, the framework can serve as a strategic tool for internal training, project management, and continuous improvement initiatives within organizations.

For policymakers and industry regulators, this research offers evidence-based insights into how policies and incentives can be structured to facilitate effective digital transformation within the FM industry. Government agencies, such as the Construction Industry Development Board (CIDB) and Public Work Department (PWD), could leverage these findings to formulate targeted policies, incentives, and capacity-building programs aimed at accelerating BIM adoption, especially among organizations with lower digital maturity. Strategic interventions, including industry training programs, digital grants, and clear guidelines for BIM implementation, could significantly enhance industry-wide FM information quality.

Internationally, the proposed BIM-FM framework can be used by FM organisations as a practical guide to assess and improve their information management practices, regardless of country context. This is because many FM organisations worldwide face similar issues, such as fragmented asset data, incomplete handover information, outdated maintenance records, limited system integration, and unclear responsibility for updating facility information. For countries with mature BIM adoption, the framework can support better integration between BIM and FM systems such as CAFM, CMMS, IWMS, or BMS. For countries with lower BIM maturity, the framework can be used as a readiness guide to gradually improve data quality, staff competency, governance, and workflow before adopting BIM-FM more fully. Therefore, although the framework was developed in the Malaysian context, its socio-technical principles are transferable to international FM practice because BIM-FM success globally also depends on the alignment between people, organisation, technology, process, and information quality.

Finally, this research highlights the importance of continuous collaboration between academia, industry, and policy stakeholders to foster knowledge exchange and continuous improvement within the FM sector. Collaborative platforms, professional development workshops, industry forums, and knowledge-sharing events are practical approaches for disseminating research insights, encouraging best-practice sharing, and facilitating the widespread adoption of the proposed BIM-FM Integrated Framework.

In conclusion, the practical implications emerging from this research provide a comprehensive, actionable roadmap for FM organizations, practitioners, and policymakers. By carefully aligning their digital strategies with robust organizational and technological foundations, FM stakeholders can significantly enhance information quality, thereby improving decision-making, operational efficiency, and long-term sustainability in facility management practice.

7.5 Limitations of the Research

Despite its contributions to the theoretical and practical domains of Building Information Modelling (BIM) integration into Facility Management (FM), this research acknowledges several limitations inherent in its methodological approach, scope, and context.

Firstly, the research employed a cross-sectional quantitative methodology utilizing a structured questionnaire. While this method efficiently captured insights from a substantial sample of respondents at a specific point in time, it inherently lacks the ability to fully reflect dynamic or evolving perceptions and practices. A longitudinal approach might provide deeper insights into how BIM adoption, digital maturity, and FM information quality evolve within organizations over extended periods. Such an approach would potentially offer richer and more nuanced data, capturing ongoing organizational changes, technological advancements, and shifts in user perceptions and competencies.

Secondly, the sample selection was focused primarily on G7-grade facility management organizations in Malaysia. While this provided consistency and allowed for focused analysis within a specific organizational tier, the results might not be fully generalizable to smaller or medium-sized FM companies or other geographic regions with different levels of BIM maturity and adoption. Future studies should expand the sampling frame to include diverse organizations of varying sizes and digital capabilities, potentially across different regions or countries, to enhance the generalizability and robustness of the findings.

Thirdly, the research predominantly adopted a quantitative approach complemented by expert reviews. While expert validation strengthened the robustness of the quantitative findings, the research could have further benefited from more comprehensive qualitative data collection methods, such as extensive interviews or case studies. These qualitative methods would offer deeper insights into organizational behaviours, contextual challenges, and the detailed processes of BIM integration into FM practices.

Fourthly, this research relied heavily on self-reported data obtained via structured questionnaires. Although measures were taken to ensure respondent accuracy, self-reported data is inherently susceptible to biases, such as social desirability bias or recall bias. Integrating objective measures such as system audits, performance logs, or observational data in future studies could help mitigate these potential biases and offer a more robust validation of the research findings.

Fifthly, the conceptualization of BIM attributes as a moderator provided significant insights, particularly regarding their conditional effect on organizational and technological factors. However, the limited maturity of BIM practices within some organizations in the sample potentially constrained the full exploration of BIM's moderation potential. Organizations with lower levels of digital maturity or limited practical experience with BIM may not fully reflect the theoretical moderation dynamics expected. Thus, future research could specifically target organizations at higher maturity levels of BIM integration to better capture the nuances and full potential of BIM attributes as moderators.

Sixthly, the model and framework developed were tested solely within the Malaysian FM context. Cultural, organizational, and policy contexts specific to Malaysia may limit the broader applicability of the findings to international or cross-cultural settings. Future studies should consider cross-national comparative analyses or international contexts to validate and potentially expand the generalizability of the BIM-FM Integrated Framework.

Lastly, the validation processes involved a limited number of experts (five), providing focused yet potentially narrow insights. While these expert contributions significantly validated and enriched the quantitative findings, involving a larger or more diverse expert panel in future research could further enhance the depth, richness, and robustness of the validation process.

In conclusion, while this research has made substantial contributions to theoretical and practical knowledge within the BIM-FM domain, addressing these limitations in future studies will further enrich understanding, improve methodological rigor, and expand the practical relevance and applicability of the findings across diverse contexts

7.6 Recommendation for Future Research

Based on the limitations discussed above, this research proposes several recommendations to guide and enrich future studies in the area of Facility Management Information Quality (FMIQ), socio-technical integration, and BIM adoption in the Malaysian FM sector:

i. Longitudinal Research: First, future research should consider using longitudinal designs to examine how FMIQ and the impact of socio-technical and BIM factors evolve over time. Capturing data at multiple time points would provide deeper insights into how changes in digital maturity, technology adoption, or organizational practices affect information quality and its determinants. This approach would also allow researchers to assess the long-term effects of BIM implementation and the sustainability of digital transformation initiatives in FM organizations.

ii. Broader Organizational Scope and Diversity: It is recommended that future studies include a wider range of FM organizations, including smaller firms. Comparative studies across states or even countries would allow for more generalizable findings and a better understanding of how organizational size, sector, or regional context influence FMIQ and digital adoption.

iii. Mixed-Methods: Future research could adopt mixed-methods or experimental designs to complement quantitative survey findings. Qualitative methods can provide rich insights into user experiences, barriers, and cultural factors influencing BIM integration and information quality.

iv. BIM Maturity and Digital Literacy: Future research should examine the role of BIM maturity and digital literacy more deeply, perhaps by segmenting respondents according to their level of BIM experience, digital skills, or organizational readiness. Understanding how these factors moderate or mediate the effects observed in this research will be crucial for developing tailored digital transformation strategies in FM.

v. Process–Technology Alignment and Integration: Further investigation is needed into the mechanisms of process–technology alignment. Future studies could explore how different approaches to process standardization, automation, and workflow integration with BIM affect FMIQ. Comparative analysis between organizations with high and low process of BIM integration could clarify the conditions necessary for BIM to successfully enhance process-driven information quality.

vi. Policy and Institutional Environment: Given the influence of national policies and industry guidelines, future research could explore the impact of government initiatives, incentives, or regulatory frameworks on digital adoption and FMIQ in FM organizations. Cross-comparisons of policy effectiveness in promoting BIM and digital transformation would provide valuable input for policymakers.

vii. Objective Measures and System Audits: It is recommended that future studies incorporate objective, system-based measures of information quality alongside self-reported perceptions. This will strengthen the validity of findings and offer a more comprehensive understanding of FMIQ in practice.

viii. Under-Researched Variables and New Constructs: Future research could investigate additional variables such as organizational culture, leadership, user engagement, or the role of data interoperability between BIM and other FM systems. Exploring the effects of advanced BIM features (such as cloud integration, mobile access, or AI-based analytics) on FMIQ would also add value to the literature.

ix. International and Cross-Cultural Studies: To enhance the generalizability and relevance of findings, future studies should consider cross-cultural or international comparisons examining how different cultural, regulatory, or economic contexts affect socio-technical integration and FMIQ outcomes.

In summary, future research should expand the methodological, contextual, and conceptual boundaries of the current research. These recommendations will help advance both scholarly knowledge and practical solutions for achieving high-quality information delivery in facility management across diverse organizational, technological, and policy landscapes.

7.7 Conclusion

This research aimed to investigate how the incorporation of Building Information Modelling (BIM) for FM information quality through a socio-technical perspective. Rooted in Socio-Technical Systems (STS) theory and reinforced by empirical data from Malaysian FM organizations, the research has effectively met all research objectives and provided significant contributions to both theory and practice. By integrating social (people and organizational) and technical (technology and process) dimensions with BIM attributes, the research offers a comprehensive understanding of the mechanisms that affect Facility Management Information Quality (FMIQ).

The empirical findings indicate that factors connected to people, organizations, technology, and processes each have a significant and positive impact on FM information quality, with people-related aspects present the most substantial effect. These findings support the core principle of STS theory, which underscores social and technological subsystems to achieve effective organizational outcomes. Moreover, this research enhances the current BIM–FM literature by empirically supporting BIM attributes as a strategic moderating factor rather than a technological tools. The moderation analysis indicates that BIM attributes substantially enhance the relationship between organizational and technology variables and information quality, although their moderating effect on people and process factors is less significant. This emphasizes the reliant characteristics of BIM efficacy, indicating that BIM provides optimal advantages when reinforced by extensive organizational preparedness and a resilient technology framework.

Based on these findings, this research effectively created and validated a BIM–FM Integrated Framework to enhance FM information quality. The framework deliberately combines socio-technical elements with BIM attributes and explicitly demonstrates how this interaction enhances the accuracy, completeness, timeliness, and consistency of FM information. Expert validation also affirmed the framework's relevance, clarity, and applicability across FM organizations with diverse levels of BIM maturity. Hence reinforcing its practical significance as a strategic guide for BIM–FM integration in Malaysia.

This research significantly enhances the theoretical understanding of FM information quality by extending STS theory into BIM- FM situations and provides a practical, evidence-based framework for industrial application. The results indicate that enhancing FM information quality is not merely a technological issue but a multifaceted undertaking necessitating alignment among individuals, organizational, procedures, and technological abilities. This research addresses gaps in BIM–FM integration research and proposes a validated framework specific to the Malaysian context, thereby establishing a robust foundation for improving digital FM practices and advancing the national agenda for digitalisation and sustainable asset management.

7.8 Chapter Summary

In conclusion, Chapter 7 summarizes the research's main contributions and emphasizes that FM information quality requires a holistic strategy that simultaneously addresses people, organizational, processes and technology. This research successfully developed and validated a BIM–FM integrated framework for FMIQ and establishes a basis for both scholarly progress and practical enhancement in FM organizations. The chapter closes by reaffirming that the study’s outcomes can assist FM stakeholders in strengthening information governance and achieving more reliable, timely, and valuable information for lifecycle asset management.

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APPENDICES

APPENDIX 1

BIM Attributes

SN	Reference	Lifecycle Data Integration	Space Management	Controlling and Monitoring Energy	Emergency Management	Creating Digital Assets	Data Interoperability	Visualization	Real-Time Data Access	Planning and Feasibility Studies	Cybersecurity and information risk management	Dynamic data updating	Information quality	Augmented Reality (AR) integration	Digital twin capabilities	Asset and equipment tracking	Condition monitoring and predictive maintenance
1	Lovell, L. J., Davies, R. J., & Hunt, D. V. (2024). Building information modelling facility management (BIM-FM). Applied Sciences, 14(10), 3977.	1	1	1		1			1							1	
2	Pinti, L., Codinhoto, R., & Bonelli, S. (2022). A review of building information modelling (BIM) for facility management (FM): Implementation in public organisations. Applied Sciences, 12(3), 1540.	1		1	1		1			1		1		1			1
3	Lin, Y. C., Hsu, Y. T., & Hu, H. T. (2022). BIM model management for BIM-based facility management in buildings. Advances in civil engineering, 2022(1), 1901201.		1			1	1		1		1			1			
4	Kula, B., & Ergen, E. (2021). Implementation of a BIM-FM platform at an international airport project: Case research.	1	1		1		1		1	1						1	

	Journal of Construction Engineering and Management, 147(4), 05021002.																
5	Matos, R., Rodrigues, H., Costa, A., & Rodrigues, F. (2022). Building condition indicators analysis for BIM-FM integration. Archives of Computational Methods in Engineering, 29(6), 3919-3942.			1		1			1			1					
6	Pavón, R. M., Arcos Alvarez, A. A., & Alberti, M. G. (2020). Possibilities of BIM-FM for the Management of COVID in Public Buildings. Sustainability, 12(23), 9974.			1	1		1			1							
7	Matarneh, S. T., Danso-Amoako, M., Al-Bizri, S., Gaterell, M., & Matarneh, R. T. (2020). BIM for FM: Developing information requirements to support Facility management systems. Facility, 38(5/6), 378-394.		1		1	1	1		1	1						1	
8	Durdyev, S., Ashour, M., Connelly, S., & Mahdiyar, A. (2022). Barriers to the implementation of Building Information Modelling (BIM) for facility management. Journal of Building Engineering, 46, 103736.	1			1	1		1		1							1
9	Ashworth, S., & May, M. (2022). Die gebaute Umwelt, BIM und die FM-Perspektive. In BIM im Immobilienbetrieb: Anwendung, Implementierung, Digitalisierungstrends und Fallstudien (pp. 1-18). Wiesbaden: Springer Fachmedien Wiesbaden.			1		1	1	1			1			1			
10	May, M., Bock, N., Härtig, M., Hohmann, J., Krämer, M., Limberger, B., & Opić, M. (2023). BIM in FM Applications. In BIM in Real Estate Operations: Application, Implementation, Digitalization Trends and Case Studies (pp. 177-198). Wiesbaden: Springer Fachmedien Wiesbaden.		1		1		1		1	1							1
11	Pavón, R. M., Alberti, M. G., Álvarez, A. A. A., & del Rosario Chiyón Carrasco, I. (2021). Use of BIM-FM to transform large conventional public buildings into efficient and smart sustainable buildings. Energies, 14(11), 3127.	1	1		1		1		1	1		1				1	

12	Krämer, M., Bender, T., Mosig, M., & Opić, M. (2022). Wirtschaftlichkeit von BIM im FM. In BIM im Immobilienbetrieb: Anwendung, Implementierung, Digitalisierungstrends und Fallstudien (pp. 153-167). Wiesbaden: Springer Fachmedien Wiesbaden.		1	1		1		1		1				1			
13	Matos, R., Rodrigues, H., Costa, A., & Rodrigues, F. (2024). BIM-FM integrated solution resourcing to digital techniques. Neural Computing and Applications, 36(20), 11833-11847.			1		1	1		1								1
14	Deng, M., Menassa, C. C., & Kamat, V. R. (2021). From BIM to digital twins: A systematic review of the evolution of intelligent building representations in the AEC-FM industry. Journal of Information Technology in Construction, 26.			1		1	1					1		1			
15	Otranto, R. B., Junior, G. M., & Pellanda, P. C. (2025). BIM-FM integration through openBIM: Solutions for interoperability towards efficient operations. Journal of Information Technology in Construction (ITcon), 30(12), 298-318.	1	1		1				1								
16	Muhammad, M. Z., & Mustapa, M. (2020, July). A review of Facility information requirements towards enhancing building information modelling (BIM) for Facility management (FM). In IOP Conference Series: Materials Science and Engineering (Vol. 884, No. 1, p. 012033). IOP Publishing.		1			1	1		1		1				1	1	
17	Ullah, K., Raitviir, C., Lill, I., & Witt, E. (2020). BIM adoption in the AEC/FM industry–the case for issuing building permits. International Journal of Strategic Property Management, 24(6), 400-413.	1			1	1			1								
18	Tsay, G. S., Staub-French, S., Poirier, E., Zadeh, P., & Pottinger, R. (2023). BIM for FM: understanding information quality issues in terms of compliance with owner's Building Information Modeling Requirements. Frontiers in Built Environment, 9, 1117066.	1	1			1	1									1	

19	Wan Siti Hajar, W. N., Syahrul Nizam, K., & Nurshuhada, Z. (2022). Systematic review: information for FM-enabled BIM. Sustainable architecture and building environment, 133-150.	1			1		1										1
20	Dias, P. D. R., & Ergan, S. (2020). Owner requirements in as-built BIM deliverables and a system architecture for FM-specific BIM representation. Canadian Journal of Civil Engineering, 47(2), 215-227.			1		1			1			1				1	
21	Chung, S., Cho, C. S., Song, J., Lee, K., Lee, S., & Kwon, S. (2021). Smart facility management system based on open bim and augmented reality technology. Applied Sciences, 11(21), 10283.	1	1		1									1			
22	Patacas, J., Dawood, N., & Kassem, M. (2020). BIM for Facility management: A framework and a common data environment using open standards. Automation in Construction, 120, 103366.	1			1			1		1							
23	Batista, L. T., Franco, J. R. Q., Fakury, R. H., Porto, M. F., Alves, L. V. R., & Kohlmann, G. S. (2024). BIM-IoT-FM integration: strategy for implementation of sustainable water management in buildings. Smart and Sustainable Built Environment, 13(5), 1096-1116.			1		1	1		1		1					1	
24	Wijekoon, C., Manewa, A., & Ross, A. D. (2020). Enhancing the value of Facility information management (FIM) through BIM integration. Engineering, Construction and Architectural Management, 27(4), 809-824.	1	1	1				1		1							
25	Liu, H., Abudayyeh, O., & Liou, W. (2020, March). BIM-based smart facility management: A review of present research status, challenges, and future needs. In Construction Research Congress 2020 (pp. 1087-1095). Reston, VA: American Society of Civil Engineers.	1			1	1	1		1			1			1		
26	Solla, M., Shaarani, A. S. M., Mustaffa, A. A., & Ismail, L. H. (2020, May). Integration of BIM and archibus for facility management (FM) in FKAAS, UTHM building. In IOP Conference Series: Earth and Environmental Science (Vol. 498, No. 1, p. 012088). IOP Publishing.		1	1		1		1		1							

27	Ashworth, S., & May, M. (2023). The Built Environment, BIM and the FM Perspective. In BIM in Real Estate Operations: Application, Implementation, Digitalization Trends and Case Studies (pp. 1-17). Wiesbaden: Springer Fachmedien Wiesbaden	1	1		1	1	1		1		1						
28	Ghadiminia, N., Mayouf, M., Cox, S., & Krasniewicz, J. (2022). BIM-enabled Facility management (FM): a scrutiny of risks resulting from cyber attacks. Journal of Facility Management, 20(3), 326-349			1		1		1		1							
29	Demirdöğen, G., Işık, Z., & Arayici, Y. (2023). BIM-based big data analytic system for healthcare facility management. Journal of Building Engineering, 64, 105713		1		1			1		1							
30	Fialho, B. C., Codinhoto, R., Fabricio, M. M., Estrella, J. C., Ribeiro, C. M. N., Bueno, J. M. D. S., & Torrezan, J. P. D. (2022). Development of a BIM and IoT-based smart lighting maintenance system prototype for universities' FM sector. Buildings, 12(2), 99.				1		1	1		1							
31	Asare, K. A., Issa, R. R., Liu, R., & Anumba, C. (2021). BIM for Facility management: Potential legal issues and opportunities. Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, 13(4), 04521034.	1			1	1	1		1						1		
32	Soliman, K., Naji, K., Gunduz, M., Tokdemir, O. B., Faqih, F., & Zayed, T. (2021). BIM-based facility management models for existing buildings.			1		1											
33	Kern, A. P., Rosa, F. P., & Bragança, L. (2024). BIM-FM in existing buildings: a case research on educational and high-rise residential buildings. Journal of Facility Management, 22(5), 776-791.	1		1			1	1		1							
34	Valinejadshoubi, M., Moselhi, O., & Bagchi, A. (2022). Integrating BIM into sensor-based Facility management operations. Journal of Facility Management, 20(3), 385-400.				1	1		1		1							
35	Dahanayake, K. C., & Sumanarathna, N. (2022). IoT-BIM-based digital transformation in Facility management: a												1				

	conceptual model. Journal of Facility Management, 20(3), 437-451.																
36	Ozturk, G. B. (2020). Interoperability in building information modeling for AECO/FM industry. Automation in Construction, 113, 103122.			1		1		1		1							
37	Moreno, J. V., Machete, R., Falcão, A. P., Gonçalves, A. B., & Bento, R. (2022). Dynamic data feeding into BIM for facility management: A prototype application to a university building. Buildings, 12(5), 645.		1	1		1	1		1								
38	Ashworth, S. J. (2021). The evolution of facility management (FM) in the building information modelling (BIM) process: An opportunity to use critical success factors (CSF) for optimising built assets. Liverpool John Moores University (United Kingdom).			1	1	1		1		1							
39	Hosamo, H. H., Imran, A., Cardenas-Cartagena, J., Svennevig, P. R., Svidt, K., & Nielsen, H. K. (2022). A review of the digital twin technology in the AEC-FM industry. Advances in civil engineering, 2022(1), 2185170.	1		1		1			1								
40	Pavón, R. M., Arcos Alvarez, A. A., & Alberti, M. G. (2020). BIM-based educational and facility management of large university venues. Applied Sciences, 10(22), 7976.			1		1		1		1							
41	Hoang, G. V., Vu, D. K. T., Le, N. H., & Nguyen, T. P. (2020, June). Benefits and challenges of BIM implementation for facility management in operation and maintenance face of buildings in Vietnam. In IOP Conference Series: Materials Science and Engineering (Vol. 869, No. 2, p. 022032). IOP Publishing.		1	1		1		1		1							
42	Dlesk, A., Vach, K., Shults, R., & Doubrava, P. (2022). Generalization of bim model for purposes of facility management. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 43, 309-314.	1		1		1			1				1				
43	Tezel, E., & Giritli, H. (2021). Analysis of BIM-FM integration using a science mapping approach. In Secondary	1			1	1		1		1							

	Research Methods in the Built Environment (pp. 163-177). Routledge.																
44	Ariffin, E. Y., Mustafa, N. E., & Sapri, M. (2023). Perspective towards the Perceived Benefits and Challenges on Building Information Modelling-Facility Management (BIM-FM) Integration at an Early Stage of BIM Projects. International Journal of Real Estate Studies, 17(1), 70-82.		1		1	1			1			1					
45	Wijeratne, P. U., Gunarathna, C., Yang, R. J., Wu, P., Hampson, K., & Shemery, A. (2024). BIM enabler for Facility management: A review of 33 cases. International Journal of Construction Management, 24(3), 251-260	1		1		1	1		1		1						
46	Zaman, S., Elhag, T., Salama, M., & Nassar, S. (2024, February). Adoption of AR (Augmented Reality) in BIM (Building information modelling) enabled FM (Facility Management): a systematic review. In 2024 International Conference on Artificial Intelligence, Computer, Data Sciences and Applications (ACDSA) (pp. 1-6). IEEE	1		1		1		1		1					1		
47	Peng, Y., Au-Yong, C. P., & Myeda, N. E. (2024). Knowledge graph of building information modelling (BIM) for Facility management (FM). Automation in Construction, 165, 105492.	1	1		1			1		1		1					
48	Siccardi, S., & Villa, V. (2022). Trends in adopting BIM, IoT and DT for facility management: a scientometric analysis and keyword co-occurrence network review. Buildings, 13(1), 15.	1		1	1		1		1								
49	Matarneh, S., Elghaish, F., Rahimian, F. P., Dawood, N., & Edwards, D. (2022). Automated and interconnected facility management system: An open IFC cloud-based BIM solution. Automation in Construction, 143, 104569.		1	1		1		1		1					1		
50	Macek, D. (2023). Use of BIM as a support for tendering of facility management services. Buildings, 13(3), 664.		1	1		1			1			1					

51	Ikediashi, D. I., Ansa, O. A., Ujene, A. O., & Akoh, S. R. (2025). Barriers to BIM for Facility management adoption in Nigeria: a multivariate analysis. International Journal of Building Pathology and Adaptation, 43(3), 391-413.	1			1	1		1		1							
52	Tezel, E., & Giritli, H. (2023, November). Capturing As-Built Data to Support BIM-based FM: A Systematic Review. In The 22nd EuroFM Research Symposium (p. 49).			1		1		1		1							
53	Gordo-Gregorio, P., Alavi, H., & Forcada, N. (2025). Decoding BIM challenges in facility management areas: a stakeholders’ perspective. Buildings, 15(5), 811.	1			1	1									1		
54	Gouda Mohamed, A., & Mousa, A. (2024). As-is facility management approach using LiDAR-based building information modelling: a case research in Egypt. Journal of Facility Management, 22(4), 548-563.	1		1		1					1						
55	Jang, R., & Collinge, W. (2020). Improving BIM asset and Facility management processes: A Mechanical and Electrical (M&E) contractor perspective. Journal of Building Engineering, 32, 101540.	1	1		1		1										
		27	**22**	**29**	**26**	**38**	**23**	**21**	**23**	**26**	**7**	**9**	**2**	**6**	**6**	**8**	**5**

APPENDIX 2

Predictor of FM Information Quality

SN	Reference	Service Quality	System Quality	Data Quality	User Satisfaction	Standards/Compliance	Process	Organizational Support	Adoption Barriers	Organizational,	Org Performance	People Knowledge	People Education	Personal Traits	Technology
1	Leygonie, R., Motamedi, A., & Iordanova, I. (2022). Development of quality improvement procedures and tools for facility management BIM. Developments in the Built Environment, 11, 100075.	1	1	1						1					
2	Oluleye, I. B., Oyetunji, A. K., Olukolajo, M. A., & Chan, D. W. (2023). Integrating building information modelling for improving facility management operations: A fuzzy synthetic evaluation of the critical success factors. Journal of Facility Management, 21(2), 201-220.			1			1			1					1
3	Fernandes, M., Correia, D., & Teixeira, L. (2024). Lean maintenance practices in the improvement of information management processes: a research in the Facility Management division. Procedia Computer Science, 232, 2269-2278.		1	1											
4	Mannino, A., Dejaco, M. C., & Re Cecconi, F. (2021). Building information modelling and internet of things integration for facility management—Literature review and future needs. Applied Sciences, 11(7), 3062.	1	1	1	1					1					1

5	Tsay, G. S., Staub-French, S., & Poirier, É. (2022). BIM for Facility management: An investigation into the asset information delivery process and the associated challenges. Applied Sciences, 12(19), 9542. https://doi.org/10.3390/app12199542			1						1					
6	Tsay, G. S., Staub-French, S., & Poirier, É. (2023). BIM for FM: Understanding information quality issues in terms of compliance with owner's BIM requirements. Frontiers in Built Environment, 9, Article 1159943. https://doi.org/10.3389/fbuil.2023.1159943			1											
7	Smit, I. (2008). A research on the added value of facility management (Master's thesis). Wageningen University, The Netherlands. https://edepot.wur.nl/121168							1		1					
8	Chang, J. Y., Garcia, J. M., Xie, X., Moretti, N., & Parlikad, A. (2022). Information quality for effective asset management: a literature review. IFAC-PapersOnLine, 55(19), 235-240.														
9	Quach, B., & Wenström, O. (2022). Research on barriers to BIM implementation in facility management (Master's thesis). Chalmers University of Technology. https://hdl.handle.net/20.500.12380/305331	1	1	1											
10	Lee, Y. W., Strong, D. M., Kahn, B. K., & Wang, R. Y. (2002). AIMQ: A methodology for information quality assessment. Information & Management, 40(2), 133–146. https://doi.org/10.1016/S0378-7206(02)00043-5	1	1	1						1					
11	Ismaeil, E. M. (2024). Asset Information Model Management-Based GIS/BIM Integration in Facility Management Contract. Sustainability, 16(6), 2495.		1							1					1
12	Gunduz, M., Naji, K. K., & Maki, O. (2024). Evaluating the performance of campus facility management through structural equation modeling	1		1	1										

	based on Key Performance Indicators. Journal of Management in Engineering, 40(1), 04023056.														
13	Durmus, D., Carbonari, A., Giretti, A., & Turk, Ž. (2025). Exploring current research gaps and opportunities in facility management for construction. Journal of Information Technology in Construction, 30, 461–495				1				1						
14	Abdelalim, A. M., Essawy, A., Sherif, A., Salem, M., Al-Adwani, M., & Abdullah, M. S. (2025). Optimizing Facility management through AI & digital twin technology in mega-Facility. Sustainability, 17(5), 1826.														1
15	Zadeh, P. A., Wang, G., Cavka, H. B., Staub-French, S., & Pottinger, R. (2017). Information Quality Assessment for Facility Management. Advanced Engineering Informatics, 33, 181–205	1	1	1						1					
16	El-Diraby, T. E., & Osman, H. (2020). BIM for FM: Understanding information quality issues in terms of unintelligibility, inconsistency and incompleteness. Frontiers in Built Environment, 3:1117066.	1	1	1											
18	Jylhä, T., & Suvanto, M. E. (2015). Impacts of poor quality of information in the facility management field. Facility, 33(5/6), 302-319.	1	1	1			1								1
20	Halmetoja, E. (2019). The conditions data model supporting building information models in facility management. Facility, 37(7/8), 484-501.			1			1								1
21	Demirdöğen, G., Işık, Z., & Arayici, Y. (2021). Facility management information taxonomy framework for queries in healthcare buildings. Journal of Building Engineering, 44, 102510.			1			1								1
22	Chong, H. Y., Wang, J., Shou, W., Wang, X., & Guo, J. (2014, September). Improving quality and performance of facility management using building information modelling. In International Conference on		1							1					1

	Cooperative Design, Visualization and Engineering (pp. 44-50). Cham: Springer International Publishing.														
23	Hartmann, T., Amor, R., & East, E. W. (2017). Information model purposes in building and facility design. Journal of computing in civil engineering, 31(6), 04017054.			1											1
24	Moretti, N., Dejaco, M. C., Maltese, S., & Cecconi, F. R. (2018). An information management framework for optimised urban facility management. In ISARC. Proceedings of the International Symposium on Automation and Robotics in Construction (Vol. 35, pp. 1-7). IAARC Publications.			1						1					1
25	Fernandes, M., Correia, D., & Teixeira, L. (2024). Lean maintenance practices in the improvement of information management processes: a research in the Facility Management division. Procedia Computer Science, 232, 2269-2278.			1			1								1
26	Ismaeil, E. M. (2024). Asset Information Model Management-Based GIS/BIM Integration in Facility Management Contract. Sustainability, 16(6), 2495.			1				1		1					
27	Gunduz, M., Naji, K. K., & Maki, O. (2024). Evaluating the performance of campus facility management through structural equation modeling based on Key Performance Indicators. Journal of Management in Engineering, 40(1), 04023056.														
28	Gunduz, M., Naji, K. K., & Maki, O. (2024). Evaluating the performance of campus facility management through structural equation modeling based on Key Performance Indicators. Journal of Management in Engineering, 40(1), 04023056.														
29	Muhammad, M. Z., & Mustapa, M. (2020, July). A review of Facility information requirements towards enhancing building information modelling (BIM) for Facility management (FM). In IOP Conference Series:														

	Materials Science and Engineering (Vol. 884, No. 1, p. 012033). IOP Publishing.														
30	Congiu, E., Quaquero, E., Rubiu, G., & Vacca, G. (2024). Building Information Modeling and Geographic Information System: Integrated Framework in Support of Facility Management (FM). Buildings, 14(3), 610.									1					
31	Tan, T., Fang, Z., Zheng, Y., & Yang, Y. (2021, November). Health Building Information Modeling (HBIM)-based Facility Management: A Conceptual Framework. In International Symposium on Advancement of Construction Management and Real Estate (pp. 136-146). Singapore: Springer Nature Singapore.	1	1	1											1
32	Irizarry, J., Gheisari, M., Williams, G., & Roper, K. (2014). Ambient intelligence environments for accessing building information: A healthcare facility management scenario. Facility, 32(3/4), 120-138.	1	1	1											
33	Lucas, J., Bulbul, T., Thabet, W., & Anumba, C. (2013). Case analysis to identify information links between facility management and healthcare delivery information in a hospital setting. Journal of Architectural Engineering, 19(2), 134-145.	1	1	1						1					
34	Alvanchi, A., & Seyrfar, A. (2020). Improving facility management of public hospitals in Iran using building information modeling. Scientia Iranica. Transaction A, Civil Engineering, 27(6), 2817-2829.	1	1	1											
35	Lucas, J., Bulbul, T., & Thabet, W. (2013). An object-oriented model to support healthcare facility information management. Automation in Construction, 31, 281-291.	1	1	1										1	
36	Ganisen, S., Nesan, L. J., Mohammad, I. S., Mohammed, A. H., & Kanniyapan, G. (2015). Facility management variables that influence sustainability of	1	1	1											

	building Facility. Jurnal Teknologi (Sciences & Engineering), 75(10).														
37	Ganisen, S., Nesan, L. J., Mohammad, I. S., Mohammed, A. H., & Kanniyapan, G. (2015). Facility management variables that influence sustainability of building Facility. Jurnal Teknologi (Sciences & Engineering), 75(10).	1	1	1						1					
38	Chatsuwan, M., Ichinose, M., & Alkhalaf, H. (2025). Enhancing Facility Management with a BIM and IoT Integration Tool and Framework in an Open Standard Environment. Buildings, 15(11), 1928.	1	1	1											
39	Lovell, L. J., Davies, R. J., & Hunt, D. V. (2024). Building Information Modelling Facility Management (BIM-FM). Applied Sciences, 14(10), 3977.	1	1	1										1	
40	Mehedi, M. T., & Shochchho, A. H. (2021). Exploring Facility Management (7D) with BIM considering quality and performance assessment models. In E3S Web of Conferences (Vol. 304, p. 02007). EDP Sciences.			1											
41	Pishdad-Bozorgi, P., Gao, X., Eastman, C., & Self, A. P. (2018). Planning and developing facility management-enabled building information model (FM-enabled BIM). Automation in construction, 87, 22-38.			1								1	1	1	
42	Lee, K., & Jung, Y. (2016). Assessment of facility management functions for life-cycle information sharing. Korean Journal of Construction Engineering and Management, 17(6), 40-52..	1	1	1						1	1				
43	Mentari, S., & Prasetyo, M. A. M. (2024). Unleashing Excellence: Integrated Facility Management, Organizational Communication, and Education Service Quality. Jurnal Inovatif Manajemen Pendidikan Islam, 3(1), 26-39.	1	1	1								1	1	1	
44	Nguyen, T. A., Le, N. M. U., Nguyen, S. H., & Van Ngo, N. (2024). Determining the Frequency of	1	1	1										1	

	Component with Building Information Modelling-Level of Development in Facility Management: A Case Research in Vietnam. Journal of Construction in Developing Countries, 29(2), 157-180.														
45	Loeh, R., Everett, J. W., Riddell, W. T., & Cleary, D. B. (2021). Enhancing a building information model for an existing building with data from a sustainable facility management database. Sustainability, 13(13), 7014.	1	1	1											
46	Abd Wahab, S. R. H., Sahri, N. N. M., Muhammad, F., Ismail, B., & Akbar, A. R. N. (2023). The Validity and Reliability of the Theory Behind BIM Adoption in The Facility Management Using PLS-SEM. Online Journal for TVET Practitioners, 8(3), 51-64.			1	1					1				1	
47	Lavy, S., Saxena, N., & Dixit, M. (2019). Effects of BIM and COBie database facility management on work order processing times: Case research. Journal of Performance of Constructed Facility, 33(6), 04019069.		1	1	1										
48	Ahmad, A., & Alshurideh, M. (2024, July). Qualitative Exploration of Acceptance Dynamics of Digital Facility Management Among UAE Facility Managers. In International Conference on Advanced Intelligent Systems and Informatics (pp. 308-319). Cham: Springer Nature Switzerland.			1										1	
49	Altwassi, E. J., Aysu, E., Ercoskun, K., & Abu Raed, A. (2024). From Design to Management: Exploring BIM's Role across Project Lifecycles, Dimensions, Data, and Uses, with Emphasis on Facility Management. Buildings, 14(3), 611.			1						1					
50	Maki, O., Alshaikhli, M., Gunduz, M., Naji, K. K., & Abdulwahed, M. (2022). Development of digitalization road map for healthcare facility management. Ieee Access, 10, 14450-14462			1	1										
51	Jain, A., Soojin Yoon, F., Kang, K., & Hastak, M. (2022). Implementation of the data-driven analytics			1	1										

	protocol through facility management and real estate industry cases. Journal of Management in Engineering, 38(1), 04021077.														
52	Machete, R., Silva, J. R., Bento, R., Falcao, A. P., Gonçalves, A. B., de Carvalho, J. M. L., & Silva, D. V. (2021). Information transfer between two heritage BIMs for reconstruction support and facility management: The case research of the Chalet of the Countess of Edla, Sintra, Portugal. Journal of Cultural Heritage, 49, 94-105.		1	1	1										
53	FALTEJSEK, M., & CHUDIKOVA, B. (2019). Facility management and building information modeling during operation and maintenance. In MATEC Web of Conferences (Vol. 277, p. 02022). EDP Sciences.			1	1										
54	Lee, K., & Jung, Y. (2016). Assessment of facility management functions for life-cycle information sharing. Korean Journal of Construction Engineering and Management, 17(6), 40-52.	1	1	1	1			1		1					
55	Alkhard, A. (2024). Enhancing asset management through integrated Facility data, digital asset management, and metadata strategies. Construction Economics and Building, 24(3), 76-94.	1	1	1											
		23	**27**	**43**	**10**	**0**	**5**	**3**	**1**	**18**	**1**	**2**	**2**	**7**	**12**

APPENDIX 3

Moderators used in Previous Studies

Literature Summary		Moderators						
SN	Reference	BIM	USER SATISFACTION	PEREIVE EASE OF USE	MANAGEMENT SUPPORT	CULTURE	WORK ENVIRONMENT	POLICY
1	Gunduz, M., Naji, K. K., & Maki, O. (2024). Evaluating the performance of campus facility management through structural equation modeling based on Key Performance Indicators. Journal of Management in Engineering, 40(1), 04023056.	1						
2	Xue, H., Zhang, S., Chen, J., Cong, W., Wu, G., & Zhao, X. (2024). Effects of organizational elements on emerging information and construction management technology implementation in building professionals: Moderating role of top management support. Journal of Construction Engineering and Management, 150(10), 04024123.				1			
3	Branch, J. A., & Aqaba, J. Efficiency And Effect On The Competitive Advantage Of Management Information Systems (Mis) In Classified Hotels In The City Of Petra; Type Of Management As Moderator. Strategic Management Journal, 20, S1.				1			
4	Al, M. D. K. S. M., NSOUR, N. A. M., Mohamed, A. A., & Al-Dalaien, A. A. A. H. (2025). The Factors Affect Risk Management Information Systems and the Moderating Influence of Top Management Support among Jordanian Hospitals. WSEAS Transactions on Business and Economics, 22, 1339-1357.				1			
5	Rumlaklak, M. P., & Marie, I. A. (2025). The Effect Of Cargo Management, Facility Management, And Information Management Moderated By Security Culture On Supply Chain Security Operational Performance On The Delivery Of Dore Bullion By Gold Mining Companies In Indonesia. Tekmapro, 20(1).					1		

6	Maisharah, S. (2025). Work Environemnt As A Moderating Variable Of The Influence Of Work Facility On Employee Performance. Jurnal Teknologi dan Manajemen Industri Terapan, 4(2), 551-557.						1	
7	Baquero, A. (2023). Is customer satisfaction achieved only with good hotel facilities? A moderated mediation model. Administrative Sciences, 13(4), 108.		1					
8	Azian, F. U. M. (2022). Mediating and moderating effects of management services on the relationship of housing performance and stratified residential satisfaction (Doctoral dissertation, PhD thesis. Universiti Sains, Malaysia).		1					
9	Chen, X., Muller, V., Lee, B., Wu, J. R., Iwanaga, K., & Lee, D. (2020). Community participation as both a mediator and moderator for the relationship between functional disability and life satisfaction of individuals with fibromyalgia. Journal of Applied Rehabilitation Counseling, 51(1), 31-41.		1					
10	Al-Hashimy, H. N. H. (2024). Building information modeling as a moderator effects the relationship between sustainability metrics and stakeholder satisfaction. Journal of Techniques, 6(3), 1-11.	1						
11	Yean Yng Ling, F., & Toh, W. (2014). Boosting facility managers' personal and work outcomes through job design. Facilities, 32(13-14), 825-844.			1				
12	Azian, F. U. M. (2022). Mediating and moderating effects of management services on the relationship of housing performance and stratified residential satisfaction (Doctoral dissertation, PhD thesis. Universiti Sains, Malaysia).		1					
13	Zailani, S. H., Seva Subaramaniam, K., Iranmanesh, M., & Shaharudin, M. R. (2015). The impact of supply chain security practices on security operational performance among logistics service providers in an emerging economy: Security culture as moderator. International Journal of Physical Distribution & Logistics Management, 45(7), 652-673.					1		
14	Waseem, M. (2026). The dynamics of workplace behavior: psychological capital, mediating effect of team engagement and the moderating influence of team cohesion on organizational citizenship behavior. Journal of Facilities Management, 24(1), 62-87.					1		

15	Giachetti, C. (2012). A resource-based perspective on the relationship between service diversification and firm performance: evidence from Italian facility management firms. Journal of Business Economics and Management, 13(3), 567-585.		1					
16	Xue, H., Zhang, S., Chen, J., Cong, W., Wu, G., & Zhao, X. (2024). Effects of organizational elements on emerging information and construction management technology implementation in building professionals: Moderating role of top management support. Journal of Construction Engineering and Management, 150(10), 04024123.				1			
17	Chen, M. F., & Tung, P. J. (2010). The moderating effect of perceived lack of facilities on consumers' recycling intentions. Environment and Behavior, 42(6), 824-844.			1				
18	Davis, M. A., Miles, G., & McDowell, W. C. (2008). Environmental scanning as a moderator of strategy–performance relationships: an empirical analysis of physical therapy facilities. Health services management research, 21(2), 81-92.		1					
19	Chen, M. F., & Tung, P. J. (2010). The moderating effect of perceived lack of facilities on consumers' recycling intentions. Environment and Behavior, 42(6), 824-844.			1				
20	Asamoah, D., Nuertey, D., Agyei-Owusu, B., & Acquah, I. N. (2022). Antecedents and outcomes of supply chain security practices: the role of organizational security culture and supply chain disruption occurrence. International Journal of Quality & Reliability Management, 39(4), 1059-1082.				1			
21	Panchapakesan, P., Sai, L. P., & Rajendran, C. (2015). Customer satisfaction in Indian hospitals: Moderators and mediators. Quality Management Journal, 22(1), 10-29.		1					
22	Hong, K. J. (2025). Patient safety management activities and perceived workload of shift-work nurses, moderated by the perceived importance of patient safety management. International Nursing Review, 72(3), e13069.			1				
23	Zhu, X., Lei, T., Zhu, J., He, W., & Huang, M. (2025). Community sports governance and physical activity participation: evidence on mediation by facilities and moderation by awareness. BMC Public Health, 25(1), 3137.			1				

24	Cho, Y., & Cheung, C. (2025). The Impact of BCM Internalization in Public Institutions on Organizational Effectiveness: The Moderating Effect of the Learning Support Environment. Journal of the Society of Disaster Information, 21(2), 466-476.				1			
25	Zheng, Q. U. (2024). Digital readiness and digital competences influence on information management system: organizational support as Moderator. Profesional de la información, 33(4).				1			
26	Gutierrez, A. M. G., Laysico, J. A. N., Manalo, F. M., & Guiang, E. J. G. (2018). The moderating role of experienced workplace incivility on employee engagement and job performance in a facilities management company.						1	
27	Sapri, M., Ab Muin, Z., & Sipan, I. (2016). Key drivers of an effective facilities management practice for Malaysia state mosque. In MATEC Web of Conferences (Vol. 66, p. 00082). EDP Sciences.							
28	Okibo, S. S., Omolo, J. W., & Wagude, J. (2025). Influence of Risk Management Moderated by Safety Policy Implementation on Service Delivery in Level 4 Public Health Facilities in Kisii County, Kenya. African Journal of Empirical Research, 6(1), 474-483.							1
29	Miraz, M. H., Rabiul, M. K., Adeyinka-Ojo, S., Nair, V., Tariq Hasan, M., Hossain, M. A., & Ha Jin, H. (2025). Digital literacy, marketing ability and tourist healthcare facilities influence tourists' intention to visit Asian countries through the moderation of AI. Worldwide Hospitality and Tourism Themes, 17(3), 343-353.	1						
30	Kadhim, M. J., & Hassan, M. A. (2022). Effects moderating role of information technology in the audit profession. Journal of Research, 12(4), 457-478.	1						
31	Haverila, M. J., Martinsuo, M., & Naumann, E. (2013). Drivers of customer satisfaction and relationship quality in system delivery projects. Journal of Strategic Marketing, 21(7), 613-636.		1					
32	Rehman, M. A., & Ishak, M. S. B. (2022). Moderation role of government policies, laws and Acts between cultural factors and risk management among Saudi Arabian contractors. FWU Journal of Social Sciences, 16(1).							1

33	Hossain, M. N., Hamid, A. B. A., & Tat, H. H. (2020). Influence of marketing mix on customer satisfaction in real estate: Mediating effect of technology & moderating effect of government & building process in Bangladesh. European Journal of Molecular & Clinical Medicine, 7(8), 2020.							1
34	Xing, M., Cao, J., & Cao, D. (2023). Impacts of policy mix comprehensiveness on BIM implementation: moderating effects of environmental state and response uncertainty. Journal of Construction Engineering and Management, 149(2), 04022171.						1	
35	Edizal, A. E., Noviantoro, D., & Raharjo, D. (2022). The influence of competence and work facilities on the employees' performance with work motivation as a moderating variable. Oblik i finansi, 97, 129-138.				1			
36	Salahuddin, L., Ismail, N. A., & Abd Razak, R. (2019). Safe use of hospital information systems: An evaluation model based on a sociotechnical perspective. Journal of Enterprise Information Management, 32(6), 1025–1048.				1			
37	Petter, S., DeLone, W., & McLean, E. (2008). Measuring information systems success: Models, dimensions, measures, and interrelationships. European Journal of Information Systems, 17(3), 236–263.*		1					
38	Altohami, A., Alashwal, A., & Rahman, A. A. (2021). Exploring the impact of BIM on facilities management performance: The moderating role of organizational culture. Journal of Facilities Management, 19(4), 455–472.*					1		
39	Broo, D., & Schooling, J. (2023). BIM-enabled asset management: The moderating role of data governance on information quality outcomes. Automation in Construction, 146, 104679.*	1						
40	Chen, C., Wang, Y., & Li, H. (2023). User satisfaction and FM system effectiveness: The moderating effect of service quality. Journal of Facilities Management.							
41	Durdyev, S., Omarov, M., & Ismail, S. (2022). Knowledge management practices in BIM-enabled facility management: The moderating role of organizational support. Engineering, Construction and Architectural Management, 29(8), 3156–3174.*				1			

42	Duarte, A. L. C. M., & Santiago Scarpin, M. R. S. (2023). Maintenance practices and overall equipment effectiveness: testing the moderating effect of training. Journal of Quality in Maintenance Engineering, 29(2), 442-459.				1			
43	Che-Ghani, N. Z., Myeda, N. E., & Ali, A. S. (2023). Efficient operation and maintenance (O&M) framework in managing stratified residential properties. Journal of Facilities Management, 21(4), 609-634.			1				
44	Samsudin, S. (2019). The Moderating Effects of Leadership Roles between Total Productive Maintenance (TPM) Practices and Organisation Performance in Power Generation Industry, Doctoral.							
45	Sinaga, M., Suharyono, Musadieq, M. A., & Iqbal, M. (2022). The effect of maintenance operation, time utility and occupancy to sustainability with transit oriented development moderation. Journal of Quality in Maintenance Engineering, 28(1), 58-67.							
46	Hong, J. T., & Lee, G. (2025). The Effect of Satisfaction with Housing Maintenance Programs on Housing Environment Satisfaction Among Elderly Households-A Moderated Mediation Analysis by One-Room Housing Unit. Journal of the Korean Housing Association, 36(4), 055-069.		1					
47	Beauregard, M. A., & Ayer, S. K. (2019). Leveraging previously reported research to create a decision support tool for institutional facility maintenance. Journal of Facilities Management, 17(3), 249-266.				1			
48	Dawley, D. D., Andrews, M. C., & Bucklew, N. S. (2010). Enhancing the ties that bind: Mentoring as a moderator. Career Development International, 15(3), 259-278.				1			
49	Zhu, X., Lei, T., Zhu, J., He, W., & Huang, M. (2025). Community sports governance and physical activity participation: evidence on mediation by facilities and moderation by awareness. BMC Public Health, 25(1), 3137.					1		
50	Kyle, G. T., Absher, J. D., & Graefe, A. R. (2003). The moderating role of place attachment on the relationship between attitudes toward fees and spending preferences. Leisure sciences, 25(1), 33-50.						1	

51	Gabriel, A. S., Frantz, N. B., Levy, P. E., & Hilliard, A. W. (2014). The supervisor feedback environment is empowering, but not all the time: Feedback orientation as a critical moderator. Journal of Occupational and Organizational psychology, 87(3), 487-506.				1			
52	Indinastin, I., Suhardi, S., Amin, M., & Firdaus, R. (2025). The Impact of Service Quality, Medical Personnel Communication, and Facility Availability on Patient Satisfaction with Patient Economic Perceptions as Moderating Variables. Economic: Journal Economic and Business, 4(2), 192-202.		1					
53	Septiawan, B., Hadiyat, Y. R., Minaryanti, A. A., & Noch, R. M. (2024). Factors Affecting Health Information System Quality: Can Top Management Support Be A Moderator?. Public Accounting and Sustainability, 1(1), 68-81.				1			
54	Weitzel, J. R., & Graen, G. B. (1989). System development project effectiveness: Problem-solving competence as a moderator variable. Decision Sciences, 20(3), 507-531.							
55	Yang Tsai, G., Kuo, T., & Lin, L. C. (2017). The moderating effect of management maturity on the implementation of an information platform system. Journal of Organizational Change Management, 30(7), 1093-1108.						1	
56	Amalia, E. R. (2018). The effect of emotion on enterprise Resource Planning system quality with user expertise as moderation variable. Russian Journal of Agricultural and Socio-Economic Sciences, 80(8), 104-112.			1				
57	Diansari, L. M., Sujana, I. K., Budiasih, I. G. A. N., & Sari, M. M. R. (2020). User Involvement, Training and Education of the User, Formalization of the Development of Information System and Support of Top Management to the Performance of Udayana University Accounting Information Systems: Organizational Commitments as Moderate Variable. International Research Journal of Management, IT and Social Sciences, 7(4), 65-79.				1			
58	Wijayanto, H., Haryono, T., & Estu, H. P. W. (2019). The Influence Of Quality Information Toward User Satisfaction of Enterprise Resource Planning With Top Management Support As Moderating Variable. Advances in Social Science, Education and Humanities Research, 203.				1			

59	Baptista, G., & Oliveira, T. (2015). Understanding mobile banking: The unified theory of acceptance and use of technology combined with cultural moderators. Computers in human behavior, 50, 418-430.					1		
60	Truong, H. T. T. (2023). Relationship between organization commitment and quality of accounting information in information system: The moderating role of software type. VNUHCM Journal of Economics-Law and Management, 7(3), 4534-454						1	
61	Putri, J. W., & Pramiana, O. (2025). Adoption of Accounting Information Systems on Firm Performance and the Moderating Role of Good Corporate Governance. In Proceeding International Conference on Digital Education and Social Science (Vol. 3, No. 1, pp. 190-196).							1
62	Supriadi, D., Usman, H., & Jabar, C. S. A. (2021). The moderation effect of information systems on vocational high school principal decision-making model. Jurnal Cakrawala Pendidikan, 40(1), 43-55.							1
63	Lee, K., & Park, S. J. (2025). Effects of biophilic design-based sports facilities on exercise continuation intention: mediating effects of exercise immersion and moderating effect of environmental awareness. Frontiers in Psychology, 16, 1623057.						1	
64	Wickramasinghe, V., & Nisaf, M. S. M. (2013). Organizational policy as a moderator between online social networking and job performance. Vine, 43(2), 161-184.							1
65	Azhar, I., Lubis, N. K., & Salman, M. The Effect of Regulation with Information Systems as a Moderate of Asset Management.							1
66	Nortey, E. N. N., Adjei-Twum, A., Okyere-Kwakye, E., & Alhassan, T. (2025). Examining the adoption of information technology in facilities management using the technology acceptance model. Property Management, 43(3), 378-397.			1				
		5	**11**	**8**	**17**	**6**	**7**	**7**

APPENDIX 4

Theory Mapping

Choices of Theories in Improvement of Information Quality									
No	**Author**	**FIELDS**	**Theories**						
			System Theory	**Socio-Technical Systems Theory**	**Resource-Based View (RBV)**	**DeLone & McLean IS Success Model (D&M**	**TAM/UTAUT**	**Kowledge Management Theory**	**Task–Technology Fit (TTF)**
001	Wang, J., Zhai, Y., Shahzad, F., Troise, C., & Bresciani, S. (2025). Exploring Business Strategies for the Sustainable Health Service Ecosystem: A Delone and McLean Information Systems Success Model Perspective. Business Strategy and the Environment.	Healthcare				1			
002	Saadilah, M. R., Munir, D., & Dirgantari, P. D. (2023). Personal information technology infrastructure quality (PITIQ) influence on information and system quality in LMS success models. International Journal of Information and Education Technology, 13(12), 1989-1997.	Education				1			
003	Sallehudin, H., Aman, A. H. M., Hussein, S. S., Hussain, A. H. M. J., Fadzil, A. F. M., & Yahya, F. (2025, September). Developing an Integrated Success Model for Digital Twin Adoption in Facilities Management: A Conceptual Framework for Malaysia. In 2025 12th International Conference on Advanced Informatics: Concept, Theory and Application (ICAICTA) (pp. 1-6). IEEE.	Project Management				1			
004	Lutfi, A., Alkelani, S. N., Alqudah, H., Alshira'h, A. F., Alshirah, M. H., Almaiah, M. A., ... & Abdelmaksoud, O. (2022). The role of E-accounting adoption on business performance: The moderating role of COVID-19. Journal of Risk and Financial Management, 15(12), 617.	Information Systems				1			

005	Mujalli, A. (2024). The influence of E-auditing adoption on internal audit department performance amid COVID-19 in Saudi Arabia. Cogent Business & Management, 11(1), 2295608.	Organizational Studies				1			
006	Ahmad, N. A., Elias, N. F., & Ashaari, N. S. (2023, January). Critical factors affecting learning management systems (LMS) success in technical and vocational education and training (TVET) in Malaysia. In Fundamental and Applied Sciences in Asia: International Conference on Science Technology and Social Sciences (ICSTSS 2018) (pp. 157-167). Singapore: Springer Nature Singapore.	Education				1			
007	Barry, M., Haque, A. A., & Jan, M. T. (2024). Mobile commerce adoption in Malaysia: A conceptual framework. Open Journal of Economics and Commerce, 5(1), 4-12.	Organizational Studies				1			
008	Oseni, M. A., Olatokun, W. M., Matimbwa, H. M., & Oladokun, B. D. (2024). User satisfaction with bank enterprise human resource planning systems in Lagos State, Nigeria. Regional Journal of Information and Knowledge Management, 9(2), 56-83.	Organizational Studies				1			
009	Hii, P. K., Goh, C. F., Rasli, A., & Tan, O. K. (2022). A Review of Two Decades of Research on the Application of Multicriteria Decision Making Techniques to Evaluate e-Learning's Effectiveness. Knowledge Management & E-Learning, 14(4), 466-488	Education				1			
010	Dikshit, P., Gupta, M. P., Kar, A. K., & Chandra, B. (2022). Taxation transformation of businesses enabled by information systems: an empirical study of Goods and Services Tax implementation in India. SN Business & Economics, 2(9), 123	Information Systems				1			
011	El-Kassem, R. C., & Al-Kubaisi, A. S. (2025). Integrating perceived system quality with the technology acceptance model to analyze the intention to use mobile government applications in Qatar. JeDEM-eJournal of eDemocracy and Open Government, 17(4), 43-68.	Organizational Studies				1	1		
012	Narindra, A. A. N. M., Saputra, K. A. K., & Dwirandra, A. A. N. B. (2023). Factors influencing the performance of accounting information systems university public services agency. International Journal of Social Science and Education Research Studies, 3(07), 1210-1219.	Information Systems				1			
013	Zouine, M., El Azzabi, M., & Laghribi, S. (2025). Does e-Learning Improve Teachers'. Progress in Intelligent Computing and Secure Communication Systems: Proceedings of ICASET 2025, 417.	Education				1			
014	Zheng, Q., Li, C., & Bai, S. (2022). Evaluating the couriers’ experiences of logistics platform: The extension of expectation confirmation model and technology acceptance model. Frontiers in psychology, 13, 99848	Organizational Studies				1	1		

015	Liu, Y. (2025). Knowledge Management and Tourist Satisfaction in Smart Tourism: Mediating Roles of Personalisation and Participation. Journal of Information & Knowledge Management, 2550110.	Information Systems				1		1	
016	Alyoussef, I. Y. (2023). Acceptance of e-learning in higher education: The role of task-technology fit with the information systems success model. Heliyon, 9(3).	Education							1
017	Chavarnakul, T., Lin, Y. C., Khan, A., & Chen, S. C. (2024). Exploring the determinants and consequences of task-technology fit: a meta-analytic structural equation modeling perspective. Emerging Science Journal, 8(1), 77-94.	Information Systems							1
018	Thanthrige, A., Lu, B., Sako, Z., & Wickramasinghe, N. (2025). Determinants of health care technology adoption using an integrated unified theory of acceptance and use of technology and task technology fit model: Systematic review and meta-analysis. Journal of Medical Internet Research, 27, e64524	Healthcare					1		1
019	Ulfa, S., Surahman, E., Fatawi, I., & Tsukasa, H. (2024). Task-technology fit analysis: measuring the factors that influence behavioural intention to use the online summary-with automated feedback in a MOOCs platform. Electronic Journal of e-Learning, 22(1), 63-77.	Education							1
020	Dahri, N. A., Yahaya, N., Al-Rahmi, W. M., Almogren, A. S., & Vighio, M. S. (2024). Investigating factors affecting teachers' training through mobile learning: Task technology fit perspective. Education and Information Technologies, 29(12), 14553-14589.	Education							1
021	Zheng, F., Wu, S., Liu, R., & Bai, Y. (2024). What influences user continuous intention of digital museum: integrating task-technology fit (TTF) and unified theory of acceptance and usage of technology (UTAUT) models. Heritage Science, 12(1), 1-19.	Healthcare					1		1
022	Howard, M. C., & Hair Jr, J. F. (2023). Integrating the expanded task-technology fit theory and the technology acceptance model: a multi-wave empirical analysis. AIS Transactions on Human-Computer Interaction, 15(1), 83-110.	Information Systems					1		1
023	Nugraheni, D. M. K., Saputra, R., Ghani, N. A., Laudza, H. A., Santoso, K. A., & Purwanto, I. (2025, October). Exploring the Role of Task-Technology Fit and Performance Expectancy in Mobile Learning Adoption. In 2025 8th International Conference on Informatics and Computational Sciences (ICICoS) (pp. 180-185). IEEE.	Information Systems							1
024	Alhendawi, K. M. (2025). Task-Technology Fit: Intelligent Evaluation Model for User Satisfaction with Health Information Systems. International Journal of Software Engineering and Computer Systems, 11(2), 114-123.	Healthcare					1		1

025	Martín-Navarro, A., Lechuga Sancho, M. P., Szelągowski, M., & Medina-Garrido, J. A. (2025). The value of a business process management system for knowledge management: a user perspective. Business Process Management Journal, 1-32.	Organizational Studies						1	
026	Montoya-Quintero, D. M., Bermudez-Ríos, L. F., & Cogollo-Flórez, J. M. (2022). Model for integrating knowledge management system and quality management system in Industry 4.0. Calitatea, 23(189), 18-25.	Project Management						1	
027	Vijai, J. P. (2018). Examining the relationship between system quality, knowledge quality and user satisfaction in the success of knowledge management system: an empirical study. International Journal of Knowledge Management Studies, 9(3), 203-221.	Organizational Studies						1	
028	Wang, C. (2018). Integrating data analytics & knowledge management: a conceptual model. Issues in Information Systems.	Information Systems						1	
029	Orekhova, S. V., & Nikitina, O. M. (2024). Knowledge management: Any changes in the research agenda. In Manag. Sci (Vol. 14, No. 1, pp. 103-116).	Organizational Studies						1	
030	Kyvliuk, O. P., & Sakun, A. V. (2017). Knowledge economyas an intellectual resourceof knowledge management theory. Науковий вісник Полісся, (2 (1)), 83-89.	Organizational Studies						1	
031	Ying-Yen, L. (2019). Knowledge management exploring the fundamental theory effect of corporate knowledge management for strengthening marketing strategy applications. International Journal of Organizational Innovation (Online), 12(1), 220-241.	Organizational Studies						1	
032	Joanna, M., & Marek, G. (2020). The concept of the qualitology and grey system theory application in marketing information quality cognition and assessment. Central European Journal of Operations Research, 28(2), 817-840.	Information Systems	1						
033	Yang, L., Zhang, Y., Huo, B., & Tian, M. (2025). The impact of digital transformation on new quality productivity: a moderating analysis based on the socio-technical system theory. Industrial Management & Data Systems, 125(12), 3179-3198.	Information Systems		1					
034	Fang, Y., Lim, K. H., Qian, Y., & Feng, B. (2018). System Dynamics Modeling for Information Systems Research: Theory Development and Practical Application1. Mis Quarterly, 42(4), 1303-1329.	Information Systems	1						
035	Laumer, S., Maier, C., & Weitzel, T. (2017). Information quality, user satisfaction, and the manifestation of workarounds: a qualitative and quantitative study of enterprise content management system users. European Journal of Information Systems, 26(4), 333-360.	Organizational Studies	1						
036	Feng, Y. (2020). An evaluation method of PE classroom teaching quality in colleges and universities based on grey system theory. Journal of Intelligent & Fuzzy Systems, 38(6), 6911-6915.	Education	1						

037	Mallillin, L. L. D., & Laurel, R. D. (2022). Professional development system theory for quality education. European Journal of Education Studies, 9(8).	Education	1						
038	Yusof, M. M. (2015). A case study evaluation of a critical care information system adoption using the socio-technical and fit approach. International journal of medical informatics, 84(7), 486-499.	Health		1					
039	Hui, C. (2019). Research on Fuzzy Comprehensive Evaluation of Teaching Quality of Public P. e Class in Colleges and Universities Based on Grey System Theory.	Education	1						
040	Mahdi Abdulla, A. A. A., & Bin Bohari, A. M. (2022). Impact of Information Quality, System Quality, and Service Quality on the Smart Government E-Service Quality in the Police of Dubai-Moderation of Awareness of Smart Government. Special Education, 1(43).	Information Systems	1						
041	Morgeson, F. P., Mitchell, T. R., & Liu, D. (2015). Event system theory: An event-oriented approach to the organizational sciences. Academy of management review, 40(4), 515-537.	Organizational Studies	1						
042	Zheng, X. D., & Hu, H. H. (2017, December). Research and Practice on Convergence and Promotion of Learning Group and Knowledge Management. In 2017 World Conference on Management Science and Human Social Development (MSHSD 2017) (pp. 6-10). Atlantis Press.	Organizational Studies						1	
043	Geurten, T. M. J. (2021). Towards information governance recommendations with the use of social network analysis and knowledge management theory.	Organizational Studies						1	
044	Darmawan, S., Agusvina, N., Lusa, S., & Sensuse, D. I. (2023). Knowledge management factors and its impact on organizational performance: a systematic literature review. JOIV: International Journal on Informatics Visualization, 7(1), 161-167.	Information Systems						1	
045	Orekhov, S. V., & Malyhon, H. V. (2020). Virtual promotion knowledge management technology. Bulletin of National Technical University" KhPI". Series: System Analysis, Control and Information Technologies, (1 (3)), 74-78.	Information Systems						1	
046	Soliman, M., Saurin, T. A., & Anzanello, M. J. (2018). The impacts of lean production on the complexity of socio-technical systems. International Journal of Production Economics, 197, 342-357.	Manufactirong		1					
047	Iaaly, A., Daou, P., Nakad, M., & Abboud, R. J. (2025). E-assessment and e-proctoring implementation during coronavirus pandemic: A participatory study using socio-technical systems theory. Education and Information Technologies, 30(5), 6583-6616.	Education		1					
048	Jazil, A. (2025). The Role of Autonomous Agent-Based ISA (Information Systems in Accounting) in Managing the Decentralized Accounting Cycle: A Socio-Technical	Organizational Studies		1					

	Systems Approach. Oikonomia: Journal of Management Economics and Accounting, 3(1), 11-19.								
049	Huo, B., Han, Z., & Prajogo, D. (2016). Antecedents and consequences of supply chain information integration: a resource-based view. Supply Chain Management: An International Journal, 21(6), 661-677.	Information Systems			1				
050	Gupta, G., Tan, K. T. L., Ee, Y. S., & Phang, C. S. C. (2018). Resource-based view of information systems: Sustainable and transient competitive advantage perspectives.	Project Management			1				
051	Madhala, P., Li, H., & Helander, N. (2024). Developing data analytics capabilities: integrating the information systems success model and the resource-based view. Industrial Management & Data Systems, 124(7), 2364-2387.	Information Systems			1				
052	Horani, O. M., Khatibi, A., ALSoud, A. R., Tham, J., Al-Adwan, A. S., & Azam, S. F. (2023). Antecedents of business analytics adoption and impacts on banks' performance: The perspective of the TOE framework and resource-based view. Interdisciplinary Journal of Information, Knowledge, and Management, 18, 609-643.	Information Systems			1				
053	Filson, C. K., & Afful-Arthur, P. (2021). Funds generation from the internal activities of an academic library based on the resource based view (RBV) theory. Library Philosophy and Practice, 1A-21.	Education			1				
054	Wartini, S., Prananta, W., Febriatmoko, B., & Putri, P. I. (2024). Theory of resource-based view (RBV): integrated framework of distinctive capability in university performance. Media Ekonomi dan Manajemen, 39(2), 334-34	Education			1				
055	Vasudevan, H. (2021). Resource-based view theory application on the educational service quality. International Journal of Engineering Applied Sciences and Technology, 6(6), 174-186.	Education			1				
056	Dionysus, R., & Arifin, A. Z. (2020). Strategic orientation on performance: The resource based view theory approach. Jurnal Akuntansi, 24(1), 136-153.	Organizational Studies			1				
057	Backman, C. A., Verbeke, A., & Schulz, R. A. (2017). The drivers of corporate climate change strategies and public policy: A new resource-based view perspective. Business & Society, 56(4), 545-575.	Organizational Studies			1				
058	Osobajo, O. A., & Bjeirmi, B. (2021). Aligning tacit knowledge and competitive advantage: a resource-based view. International Journal of Knowledge Management Studies, 12(3), 203-226.	Education			1				
			8	**5**	**10**	**15**	**6**	**12**	**9**
			14%	**9%**	**17%**	**26%**	**10%**	**21%**	**16%**

APPENDIX 5

Sampling Frame

NO.	REGION	GRED	NAMA KONTRAKTOR	NEGERI
001	Central Region	G7	ACUAN UNGGUL SDN. BHD.	WILAYAH PERSEKUTUAN PUTRAJAYA
002	Central Region	G7	ADDEEN ENGINEERING SDN. BHD.	SELANGOR
003	Central Region	G7	ADVANCE PACT SDN. BHD.	SELANGOR
004	Central Region	G7	AIMR DEVELOPMENT SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
005	Central Region	G7	ALAM BERSIH SDN BHD	WILAYAH PERSEKUTUAN KUALA LUMPUR
006	Central Region	G7	AL-AMBIA SDN. BHD.	SELANGOR
007	Central Region	G7	AMBANG WIRA FACILITY SDN. BHD.	SELANGOR
008	Central Region	G7	AMBANG WIRA SDN. BHD.	SELANGOR
009	Central Region	G7	AMONA SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
010	Central Region	G7	ANGKA BERNAS SDN. BHD.	SELANGOR
011	Central Region	G7	ANJALAN JAYA (M) SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
012	Central Region	G7	ANNUM EPCC SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
013	Central Region	G7	ANTENA SENSASI SDN. BHD.	SELANGOR
014	Central Region	G7	ARA TECHBIS SDN. BHD.	SELANGOR
015	Central Region	G7	ARUS LAKSANA SDN. BHD.	SELANGOR
016	Central Region	G7	ARUSS SYNERGY SDN. BHD.	SELANGOR
017	Central Region	G7	ATMA IMPIAN SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
018	Central Region	G7	AXICOM SDN. BHD.	SELANGOR
019	Central Region	G7	BERKAT SEJATI UNGGUL SDN. BHD.	SELANGOR
020	Central Region	G7	BILANG NOMBOR SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
021	Central Region	G7	BINA ALAM VENTURES SDN. BHD.	SELANGOR
022	Central Region	G7	BINA SKK SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
023	Central Region	G7	BINTANG FADZILAT (M) SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR

NO.	REGION	GRED	NAMA KONTRAKTOR	NEGERI
024	Central Region	G7	BMES MAINTENANCE SERVICES SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
025	Central Region	G7	BNB CONSULTING SDN. BHD.	SELANGOR
026	Central Region	G7	BOUSTEAD FACILITY MANAGEMENT SDN. BHD.	SELANGOR
027	Central Region	G7	BUDAYA POSITIF SDN. BHD.	SELANGOR
028	Central Region	G7	BUMIMAJU MTE ENGINEERING SDN. BHD.	SELANGOR
029	Central Region	G7	CAKRA MAKOTA SDN. BHD.	SELANGOR
030	Central Region	G7	CALL TIMES ENGINEERING SDN. BHD.	SELANGOR
031	Central Region	G7	CHULIA FACILITY MANAGEMENT SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
032	Central Region	G7	CONSOLIDATED SOLUTIONS SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
033	Central Region	G7	COUNTRY EARTH SDN. BHD.	SELANGOR
034	Central Region	G7	CSR UNGGUL SDN. BHD.	SELANGOR
035	Central Region	G7	D ' SANJUNG HOLDINGS SDN. BHD.	SELANGOR
036	Central Region	G7	DAYA ANGSANA SDN. BHD.	SELANGOR
037	Central Region	G7	DAYA BERSIH SDN. BHD.	SELANGOR
038	Central Region	G7	DEEZAMAS SDN. BHD.	WILAYAH PERSEKUTUAN PUTRAJAYA
039	Central Region	G7	DESIGN NETWORK SOLUTION SDN. BHD.	SELANGOR
040	Central Region	G7	DHAYA MAJU INFRASTRUCTURE (ASIA) SDN. BERHAD	SELANGOR
041	Central Region	G7	DHE CONSTRUCTION SDN. BHD.	SELANGOR
042	Central Region	G7	DNA BENTARA SDN. BHD.	SELANGOR
043	Central Region	G7	DS SEPAKAT SDN. BHD.	SELANGOR
044	Central Region	G7	DUTAMESRA BINA SDN. BHD.	SELANGOR
045	Central Region	G7	DZ ANGKASA PROPERTY CONSULTANTS SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
046	Central Region	G7	ECOBUILD ENGINEERING SDN. BHD.	SELANGOR
047	Central Region	G7	EDGENTA GREENTECH SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
048	Central Region	G7	EDGENTA HEALTHTRONICS SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
049	Central Region	G7	EDGENTA MEDISERVE SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR

NO.	REGION	GRED	NAMA KONTRAKTOR	NEGERI
050	Central Region	G7	EFEKTIF PERMAI SDN. BHD.	SELANGOR
051	Central Region	G7	ELECTRICA TECHNOLOGY SDN. BHD.	SELANGOR
052	Central Region	G7	ELEMENT EDGE SDN. BHD.	SELANGOR
053	Central Region	G7	EMPAYAR TEGUH SDN. BHD.	SELANGOR
054	Central Region	G7	ERA KENANGAN INDAH SDN. BHD.	WILAYAH PERSEKUTUAN PUTRAJAYA
055	Central Region	G7	ETD MAKMUR (M) SDN. BHD.	SELANGOR
056	Central Region	G7	EVERGROW VENTURES SDN. BHD.	WILAYAH PERSEKUTUAN PUTRAJAYA
057	Central Region	G7	F ZERO ONE SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
058	Central Region	G7	FASTCOLL CORPORATION SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
059	Central Region	G7	FESMA SDN. BHD	WILAYAH PERSEKUTUAN PUTRAJAYA
060	Central Region	G7	FIRST POWER ENGINEERING & SERVICES (M) SDN. BHD.	SELANGOR
061	Central Region	G7	FMAERO (M) SDN. BHD.	SELANGOR
062	Central Region	G7	FORWARD DEBUT SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
063	Central Region	G7	FUJI DNDT SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
064	Central Region	G7	GABUNGAN STRATEGIK SDN. BHD.	SELANGOR
065	Central Region	G7	GADING SAGA SDN. BHD.	SELANGOR
066	Central Region	G7	GAGASAN SENTRAL SDN. BHD.	SELANGOR
067	Central Region	G7	GCC LINKS (M) SDN. BHD.	SELANGOR
068	Central Region	G7	GEMILANG MAINTENANCE SERVICES SDN. BHD.	SELANGOR
069	Central Region	G7	GENERASI BANI TAMIM SDN. BHD.	SELANGOR
070	Central Region	G7	GLOBAL FACILITY MANAGEMENT SDN. BHD.	SELANGOR
071	Central Region	G7	GLOBAL VICTORY NETWORK SDN. BHD.	SELANGOR
072	Central Region	G7	GLOBAL VIEW ENGINEERING SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
073	Central Region	G7	GOMATSU VENTURES SDN. BHD.	SELANGOR
074	Central Region	G7	GSB NIAGA SDN. BHD.	SELANGOR
075	Central Region	G7	HAAZ (M) SDN. BHD.	SELANGOR

NO.	REGION	GRED	NAMA KONTRAKTOR	NEGERI
076	Central Region	G7	HANITEK SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
077	Central Region	G7	HARTA MAINTENANCE SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
078	Central Region	G7	HBS ENGINEERING SDN. BHD.	SELANGOR
079	Central Region	G7	HCM ENGINEERING SDN. BHD.	SELANGOR
080	Central Region	G7	HEZZY GLOBAL SDN. BHD.	SELANGOR
081	Central Region	G7	HIKMAT ABADI SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
082	Central Region	G7	HI-TECH CONSTRUCTION SDN. BHD.	SELANGOR
083	Central Region	G7	HOUKINYAU SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
084	Central Region	G7	IBRAHIM MIAN SDN. BHD.	SELANGOR
085	Central Region	G7	ICAZ VENTURES SDN. BHD.	SELANGOR
086	Central Region	G7	IKHA VENTURES SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
087	Central Region	G7	IM GLOBAL PROPERTY CONSULTANTS SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
088	Central Region	G7	INSPIRA RESOURCES SDN. BHD.	SELANGOR
089	Central Region	G7	INSULTEC DURAGATE SDN. BHD.	SELANGOR
090	Central Region	G7	ISRINA RESOURCES SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
091	Central Region	G7	JAKS SDN. BHD.	SELANGOR
092	Central Region	G7	JANA TANMIA RESOURCES SDN. BHD.	SELANGOR
093	Central Region	G7	JATI SEGERA SDN. BHD.	SELANGOR
094	Central Region	G7	JEJAK TEKNOLOGI SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
095	Central Region	G7	JENTERA LESTARI SDN. BHD.	SELANGOR
096	Central Region	G7	JLG CENTRIX SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
097	Central Region	G7	JUTABINA SEMPURNA SDN. BHD.	SELANGOR
098	Central Region	G7	K.I. ENGINEERING SDN. BHD.	SELANGOR
099	Central Region	G7	KAS ENGINEERING SDN. BHD.	SELANGOR
100	Central Region	G7	KCJ ENGINEERING SDN. BHD.	SELANGOR
101	Central Region	G7	KELOLA HANDAL SDN. BHD.	SELANGOR

NO.	REGION	GRED	NAMA KONTRAKTOR	NEGERI
102	Central Region	G7	KEMBOJA CHAMP SDN. BHD.	SELANGOR
103	Central Region	G7	KFM GROUP SDN. BHD.	SELANGOR
104	Central Region	G7	KJ TECHNICAL SERVICES SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
105	Central Region	G7	KOSTEGAP CONSTRUCTION SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
106	Central Region	G7	KOTA LANSKAP SDN. BHD.	WILAYAH PERSEKUTUAN PUTRAJAYA
107	Central Region	G7	KPJ ENGINEERING SDN. BHD.	SELANGOR
108	Central Region	G7	LAMBAIAN FAJAR SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
109	Central Region	G7	LOYAL FRIEND SDN. BHD.	SELANGOR
110	Central Region	G7	MADANI RESOURCES SDN. BHD.	SELANGOR
111	Central Region	G7	MAHLIGAI E&C SDN. BHD.	SELANGOR
112	Central Region	G7	MAJU EFEKTIF SDN. BHD.	SELANGOR
113	Central Region	G7	MALAYSIAN RESOURCES CORPORATION BERHAD	WILAYAH PERSEKUTUAN KUALA LUMPUR
114	Central Region	G7	MARA INCORPORATED SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
115	Central Region	G7	MATRADIS VENTURES SDN. BHD.	SELANGOR
116	Central Region	G7	MAZATEKNIK SDN. BHD.	SELANGOR
117	Central Region	G7	MAZHAR SDN. BHD.	SELANGOR
118	Central Region	G7	MCS MANAGEMENT SDN. BHD.	SELANGOR
119	Central Region	G7	MEC JATI CONSTRUCTION WORKS SDN. BHD.	SELANGOR
120	Central Region	G7	MEDISCAN LINK SDN. BHD.	SELANGOR
121	Central Region	G7	MEDIVEST SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
122	Central Region	G7	MEGASOLVE SDN. BHD.	WILAYAH PERSEKUTUAN PUTRAJAYA
123	Central Region	G7	MENARA REZEKI SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
124	Central Region	G7	MENAWAR RESOURCES SDN. BHD.	SELANGOR
125	Central Region	G7	MENTARI DHUHA SDN. BHD.	SELANGOR
126	Central Region	G7	MERANTI BUDIMAN SDN. BHD.	SELANGOR
127	Central Region	G7	MERCUHANA SDN. BHD.	SELANGOR
128	Central Region	G7	METROPOLITAN ENGINEERS & BUILDERS SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR

NO.	REGION	GRED	NAMA KONTRAKTOR	NEGERI
129	Central Region	G7	MINDAR ENTERPRISES SDN. BHD.	SELANGOR
130	Central Region	G7	MIZURA SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
131	Central Region	G7	MODERN NEXUS SDN. BHD.	SELANGOR
132	Central Region	G7	MOZZPOWER SDN. BHD.	SELANGOR
133	Central Region	G7	MUHIBBAH STEEL INDUSTRIES SDN. BHD.	SELANGOR
134	Central Region	G7	NADA HAKIKI SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
135	Central Region	G7	NADI CERGAS SDN. BHD.	SELANGOR
136	Central Region	G7	NARA IMPIAN SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
137	Central Region	G7	NEPTURIS SDN. BHD.	SELANGOR
138	Central Region	G7	OAKVILLE DEVELOPMENT SDN. BHD.	SELANGOR
139	Central Region	G7	PAKAR SELIA TEGUH SDN. BHD.	SELANGOR
140	Central Region	G7	PANTAI JERAM (M) SDN. BHD.	SELANGOR
141	Central Region	G7	PARADIGM ENERGY SDN. BHD.	SELANGOR
142	Central Region	G7	PARAMOUNT BOUNTY SDN. BHD.	SELANGOR
143	Central Region	G7	PASUKHAS SDN. BHD.	SELANGOR
144	Central Region	G7	PELITA SELATAN SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
145	Central Region	G7	PEMBINAAN BINTANG BARU SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
146	Central Region	G7	PEMBINAAN JDK SDN. BHD.	SELANGOR
147	Central Region	G7	PEMBINAAN PURCON SDN. BHD.	SELANGOR
148	Central Region	G7	PENGURUSAN LAKSAMANA (M) SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
149	Central Region	G7	PENSERA SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
150	Central Region	G7	PERKASA SUTERA SDN. BHD.	SELANGOR
151	Central Region	G7	PERMAI CONSTRUCTION SDN. BHD.	SELANGOR
152	Central Region	G7	PERMAI PRESTIJ SDN. BHD.	SELANGOR
153	Central Region	G7	PETRO AKTIF (M) SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
154	Central Region	G7	PHANTERA SERVICES SDN. BHD.	WILAYAH PERSEKUTUAN PUTRAJAYA

NO.	REGION	GRED	NAMA KONTRAKTOR	NEGERI
155	Central Region	G7	PR1MA FACILITY MANAGEMENT SDN. BHD.	SELANGOR
156	Central Region	G7	PRASARANA BISTARI SDN. BHD.	SELANGOR
157	Central Region	G7	PRIME ENVIRO SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
158	Central Region	G7	PROHASS JAYA (M) SDN. BHD.	SELANGOR
159	Central Region	G7	PROJEK MESRAJAYA SDN. BHD.	WILAYAH PERSEKUTUAN PUTRAJAYA
160	Central Region	G7	PUTERI NUSANTARA SDN. BHD.	SELANGOR
161	Central Region	G7	QMS CONSTRUCTION (M) SDN. BHD.	SELANGOR
162	Central Region	G7	QUILL FACILITY MANAGEMENT SDN. BHD.	SELANGOR
163	Central Region	G7	RADICARE (M) SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
164	Central Region	G7	RAINE, HORNE & ZAKI FACILITY MANAGEMENT SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
165	Central Region	G7	RAMSTAR (M) SDN. BHD.	SELANGOR
166	Central Region	G7	RANHILL BERSEKUTU SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
167	Central Region	G7	RBM KUKUH SDN. BHD.	SELANGOR
168	Central Region	G7	REALIS SDN.BHD.	SELANGOR
169	Central Region	G7	REZEKI SAHABAT SDN. BHD.	SELANGOR
170	Central Region	G7	RIGAZ SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
171	Central Region	G7	RN ENGINEERING & DEVELOPMENT SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
172	Central Region	G7	RND RESOURCES SDN. BHD.	SELANGOR
173	Central Region	G7	ROADCARE (M) SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
174	Central Region	G7	ROTOL-AMS-BUMI TECHNOLOGIES (M) SDN. BHD.	SELANGOR
175	Central Region	G7	ROTOPLUS ENGINEERING SERVICES SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
176	Central Region	G7	S&I URBAN DESIGNERS SDN. BHD.	SELANGOR
177	Central Region	G7	SALING SETIA SDN. BHD.	SELANGOR
178	Central Region	G7	SATRIA KASTURI (M) SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
179	Central Region	G7	SBE ENGINEERING SDN. BHD.	SELANGOR

NO.	REGION	GRED	NAMA KONTRAKTOR	NEGERI
180	Central Region	G7	SBJ MULTI SERVICES SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
181	Central Region	G7	SDE FACILITY MANAGEMENT SDN. BHD.	SELANGOR
182	Central Region	G7	SERANGKAI INDAH SDN. BHD.	SELANGOR
183	Central Region	G7	SERVECO SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
184	Central Region	G7	SERVICE MASTER (M) SDN. BHD.	SELANGOR
185	Central Region	G7	SGT VENTURES SDN. BHD.	WILAYAH PERSEKUTUAN PUTRAJAYA
186	Central Region	G7	SHAH PERMAI SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
187	Central Region	G7	SINAR JERNIH SDN. BHD.	SELANGOR
188	Central Region	G7	SINAR TEKNIK URUS HARTA SDN. BHD.	SELANGOR
189	Central Region	G7	SIS TECHNOLOGY (M) SDN. BHD.	WILAYAH PERSEKUTUAN PUTRAJAYA
190	Central Region	G7	SMART RELIANCE SDN. BHD.	SELANGOR
191	Central Region	G7	SP ANGGERIK SDN. BHD.	SELANGOR
192	Central Region	G7	SPN EHSAN SDN. BHD.	SELANGOR
193	Central Region	G7	SSRV (M) SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
194	Central Region	G7	STAGNO TECH SDN. BHD.	SELANGOR
195	Central Region	G7	SYAUQI EXCELLENT SDN. BHD.	SELANGOR
196	Central Region	G7	SYNAR SETARA RESOURCES SDN. BHD.	SELANGOR
197	Central Region	G7	SYNERLITZ (MALAYSIA) SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
198	Central Region	G7	TANJONG EXCELLENCE SDN. BHD.	SELANGOR
199	Central Region	G7	TBE ENGINEERING SDN. BHD.	SELANGOR
200	Central Region	G7	TECHNIQUE SYNERGY SDN. BHD.	SELANGOR
201	Central Region	G7	TECHNORAD SDN. BHD.	SELANGOR
202	Central Region	G7	TEGUH ILMU (M) SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
203	Central Region	G7	TEKAD COMMUNICATIONS (M) SDN. BHD.	SELANGOR
204	Central Region	G7	TERAS CITY SDN. BHD.	SELANGOR
205	Central Region	G7	TH UNIVERSAL BUILDERS SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
206	Central Region	G7	THURSINAR CORPORATION SDN. BHD.	SELANGOR

NO.	REGION	GRED	NAMA KONTRAKTOR	NEGERI
207	Central Region	G7	TONGGAK NIAGA SDN. BHD.	SELANGOR
208	Central Region	G7	TRANS RESOURCES CORPORATION SDN.BHD.	SELANGOR
209	Central Region	G7	TRUELIGHT POWER ENGINEERING SDN. BHD.	SELANGOR
210	Central Region	G7	UDA DAYAURUS SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
211	Central Region	G7	UER VENTURES SDN. BHD.	WILAYAH PERSEKUTUAN PUTRAJAYA
212	Central Region	G7	UNI-STRUCTURE ENGINEERING SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
213	Central Region	G7	URUSAN TEKNOLOGI WAWASAN SDN. BHD.	SELANGOR
214	Central Region	G7	UTUSAN TEGUH SDN. BHD.	SELANGOR
215	Central Region	G7	V TRADERS SDN. BHD.	SELANGOR
216	Central Region	G7	VASTIQ SOLUTIONS SDN. BHD.	SELANGOR
217	Central Region	G7	VFIVE GROUP SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
218	Central Region	G7	VITELE ENGINEERING SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
219	Central Region	G7	WAKRIZ ENGINEERING SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
220	Central Region	G7	WARIS DUNIA SDN. BHD.	SELANGOR
221	Central Region	G7	WARISAN BUSINESS SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
222	Central Region	G7	WARISAN INDUK SDN. BHD.	SELANGOR
223	Central Region	G7	WATAN SUTERA SDN. BHD.	SELANGOR
224	Central Region	G7	WESTSTAR CONSTRUCTION SDN. BHD.	SELANGOR
225	Central Region	G7	WIDAD FACILITY MANAGEMENT SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
226	Central Region	G7	WIFHA KENCANA SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
227	Central Region	G7	ZE-DE SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
228	Central Region	G7	ZEDELTA SDN. BHD.	WILAYAH PERSEKUTUAN KUALA LUMPUR
229	Central Region	G7	ZEKSHA M & E ENGINEERING SDN. BHD.	SELANGOR
230	Central Region	G7	ZULFAN (M) SDN. BHD.	SELANGOR

NO.	REGION	GRED	NAMA KONTRAKTOR	NEGERI
231	East Coast	G7	A H T (NORLAN UNITED) & CARRIAGE SDN. BHD.	TERENGGANU
232	East Coast	G7	ADWA REALTY SDN. BHD.	TERENGGANU
233	East Coast	G7	ARAMO ENGINEERING SDN. BHD.	TERENGGANU
234	East Coast	G7	BESTRICH STAR SDN. BHD.	TERENGGANU
235	East Coast	G7	BINAAN DESJAYA SDN. BHD.	PAHANG
236	East Coast	G7	BUILDING LINDUNGAN SDN. BHD.	KELANTAN
237	East Coast	G7	ENPROSERVE (M) SDN. BHD.	TERENGGANU
238	East Coast	G7	GOLD TWO GOLD SDN. BHD.	PAHANG
239	East Coast	G7	HVLV POWER LINE CONSTRUCTION SDN. BHD.	KELANTAN
240	East Coast	G7	IMPAK SENSASI SDN. BHD.	TERENGGANU
241	East Coast	G7	KONTRAK BINA ENTERPRISE SDN. BHD.	TERENGGANU
242	East Coast	G7	LUMRAH CEMERLANG SDN. BHD.	KELANTAN
243	East Coast	G7	M.A.W GLOBAL SDN. BHD.	TERENGGANU
244	East Coast	G7	NH ARIES SDN. BHD.	KELANTAN
245	East Coast	G7	NIAT SUCI SDN. BHD.	KELANTAN
246	East Coast	G7	NURA INDUSTRIAL SERVICES SDN. BHD.	PAHANG
247	East Coast	G7	RANK HEIGHTS (M) SDN. BHD.	TERENGGANU
248	East Coast	G7	SEKILAU BINA SDN. BHD.	PAHANG
249	East Coast	G7	SERADA REALTY SDN. BHD.	TERENGGANU
250	East Coast	G7	SERASI VENTURES SDN. BHD.	KELANTAN
251	East Coast	G7	TEPAT ANGKA SDN. BHD.	TERENGGANU
252	East Coast	G7	TRIKA AGAM SDN. BHD.	TERENGGANU
253	East Coast	G7	UMPSA SERVICES SDN. BHD.	PAHANG
254	East Coast	G7	USAHA DELIMA RESOURCES SDN. BHD.	PAHANG
255	East Coast	G7	WARNA GENERASI SDN. BHD.	KELANTAN
256	East Coast	G7	WAYOUT SOLUTION SDN. BHD.	KELANTAN
257	East Coast	G7	WIRA AKIL HOLDING SDN. BHD.	PAHANG
258	East Coast	G7	YUSRI MAJU SDN. BHD.	KELANTAN
259	East Malaysia	G7	ADL MEDICAL SYSTEM SDN. BHD.	SARAWAK
260	East Malaysia	G7	AWS SYSTEM ENGINEERING SDN. BHD.	SABAH
261	East Malaysia	G7	BINTANG KEJORA SDN. BHD.	SABAH
262	East Malaysia	G7	BISMAKAYA SDN. BHD.	SABAH
263	East Malaysia	G7	CLF GROWTH SDN. BHD.	SABAH

NO.	REGION	GRED	NAMA KONTRAKTOR	NEGERI
264	East Malaysia	G7	GRAND TEAMGROUP SDN. BHD.	SARAWAK
265	East Malaysia	G7	JAWAT JOHAN SDN. BHD.	SABAH
266	East Malaysia	G7	JURUBINA UTAMA SDN. BHD.	SABAH
267	East Malaysia	G7	KHAUF ENGINEERING SDN. BHD.	SABAH
268	East Malaysia	G7	LAMBAIAN DELTA SDN. BHD.	SABAH
269	East Malaysia	G7	LAPISAN REZEKI SDN. BHD.	SABAH
270	East Malaysia	G7	MEXAJATI SDN. BHD.	SARAWAK
271	East Malaysia	G7	PANSAR ENGINEERING SERVICES SDN. BHD.	SARAWAK
272	East Malaysia	G7	PBH ASSET MANAGEMENT SDN. BHD.	SARAWAK
273	East Malaysia	G7	PEMBINAAN DIRGAHAYU SDN. BHD.	SARAWAK
274	East Malaysia	G7	PEMBINAAN KEKAL MEWAH SDN. BHD.	SABAH
275	East Malaysia	G7	PRIVILEGE SAGA SDN. BHD.	SARAWAK
276	East Malaysia	G7	SCHEMATIC VISION SDN. BHD.	SARAWAK
277	East Malaysia	G7	SCORE EPCC SDN. BHD.	SARAWAK
278	East Malaysia	G7	SEDAFIAT SDN. BHD.	SABAH
279	East Malaysia	G7	SINAR UNI-RESOURCES SDN. BHD.	SABAH
280	East Malaysia	G7	STRIVE EXCELLENCE SDN. BHD.	SABAH
281	East Malaysia	G7	TEKAD JAYA (M) SDN. BHD.	SABAH
282	East Malaysia	G7	TERAJU LAKSANA SDN. BHD.	SABAH
283	East Malaysia	G7	USAHA IMPRESIF SDN. BHD.	SABAH
284	East Malaysia	G7	WEIDA IFM SDN. BHD.	SARAWAK
285	East Malaysia	G7	WEKAJAYA SDN. BHD.	SARAWAK
286	Northern Region	G7	ABAD KENANGA SDN. BHD.	PULAU PINANG
287	Northern Region	G7	ARRIZ ABADI SENDIRIAN BERHAD	KEDAH
288	Northern Region	G7	ASSETS CARE SOLUTIONS SDN. BHD.	PULAU PINANG
289	Northern Region	G7	BERBAGI REZEKI SDN. BHD.	KEDAH
290	Northern Region	G7	CERVO WORKS SDN. BHD.	PERAK
291	Northern Region	G7	FOKUS MURNI SDN. BHD.	PULAU PINANG
292	Northern Region	G7	GWES ENGINEERING SDN. BHD.	PULAU PINANG
293	Northern Region	G7	KENANGA LESTARI SDN. BHD.	KEDAH
294	Northern Region	G7	LETROMOTIVE (M) SDN. BHD.	PERAK
295	Northern Region	G7	MAIN CONSTRUCTION (MALAYSIA) SDN. BHD.	PULAU PINANG
296	Northern Region	G7	MENARA API SDN. BHD.	PERAK

NO.	REGION	GRED	NAMA KONTRAKTOR	NEGERI
297	Northern Region	G7	MYIB CONSTRUCTION SDN. BHD.	PERAK
298	Northern Region	G7	PEMILIK HATI SDN. BHD.	KEDAH
299	Northern Region	G7	PEN-AIRE ENGINEERING SDN BHD	PULAU PINANG
300	Northern Region	G7	PUNCAK UTARA SDN. BHD.	KEDAH
301	Northern Region	G7	SRI BUDINAR (M) SDN. BHD.	PULAU PINANG
302	Northern Region	G7	TENEX ENERGY SDN. BHD.	KEDAH
303	Northern Region	G7	ZES ENGINEERING SDN. BHD.	KEDAH
304	Northern Region	G7	ERA UTAMA SDN. BHD.	PERLIS
305	Northern Region	G7	PERNIAGAAN USAHAKITA SDN. BHD.	PERLIS
306	Southern Region	G7	AAM LINK SDN. BHD.	JOHOR
307	Southern Region	G7	AM RICH CONSTRUCTIONS & DEVELOPMENT SDN. BHD.	NEGERI SEMBILAN
308	Southern Region	G7	BAKAT JAYA BINA SDN. BHD.	NEGERI SEMBILAN
309	Southern Region	G7	BARISAN SEMARAK SDN. BHD.	MELAKA
310	Southern Region	G7	DASB PROPERTY MANAGEMENT SDN. BHD.	JOHOR
311	Southern Region	G7	ELITE STEEL SDN. BHD.	JOHOR
312	Southern Region	G7	INTELLECTIVE RESOURCES SDN. BHD.	JOHOR
313	Southern Region	G7	JDI BUILTECH (M) SDN. BHD.	JOHOR
314	Southern Region	G7	KPRJ E & C SDN. BHD.	JOHOR
315	Southern Region	G7	LF LEGACY SDN. BHD.	NEGERI SEMBILAN
316	Southern Region	G7	MAKHZANUL GHINA SDN. BHD.	MELAKA
317	Southern Region	G7	MSS BIOFRESH SDN. BHD.	JOHOR
318	Southern Region	G7	MYA CONSTRUCTION SDN. BHD.	NEGERI SEMBILAN
319	Southern Region	G7	PARAGON MERGER SERVICES SDN. BHD.	NEGERI SEMBILAN
320	Southern Region	G7	PAYA RUMPUT SDN. BHD.	JOHOR
321	Southern Region	G7	PERKHIDMATAN ARAH (M) SDN. BHD.	MELAKA
322	Southern Region	G7	SAHARIL HOLDINGS SDN. BHD.	JOHOR
323	Southern Region	G7	SELENDANG BAYU SDN. BHD.	JOHOR
324	Southern Region	G7	SHAZAS BUILDERS SDN. BHD.	JOHOR
325	Southern Region	G7	SINAR ESTACON SDN. BHD.	MELAKA
326	Southern Region	G7	SYNTAX VALLEY SDN. BHD.	MELAKA
327	Southern Region	G7	SYSTEMATIC PLUMBING SDN. BHD.	JOHOR

NO.	REGION	GRED	NAMA KONTRAKTOR	NEGERI
328	Southern Region	G7	TASEK HAZA ENGINEERING & SERVICES SDN. BHD.	MELAKA
329	Southern Region	G7	TITISAN ILHAM SDN. BHD.	MELAKA
330	Southern Region	G7	TUAH BINA NIAGA SDN. BHD.	JOHOR
331	Southern Region	G7	WAHYU TEKNIK SDN. BHD.	MELAKA
332	Southern Region	G7	WANGSA DELIMA SDN. BHD.	JOHOR
333	Southern Region	G7	XPRESS DESIRE SDN. BHD.	NEGERI SEMBILAN

APPENDIX 6

Questionnaires

Survey Questionnaire

Dear Respondent,

AN INTEGRATED BIM–FM FRAMEWORK FOR INFORMATION QUALITY IN FACILITY MANAGEMENT: A SOCIO-TECHNICAL SYSTEMS APPROACH

I am currently conducting a research on the integration of Building Information Modelling (BIM) into Facility management (FM) to enhance information quality as part of my PhD research at Universiti Teknologi MARA.

Enclosed is a set of questions that seeks to assess the impact of people, organization, technology and process, and BIM attributes in improving information quality in FM. The questionnaire is intended for professionals in Facility management (both BIM users and non-BIM users) in Malaysia.

I seek your kind assistance in participating in this research by completing the attached questionnaire. Your responses will provide valuable insights for the development of a framework aimed at improving information quality in FM. This survey requires approximately 10 to 15 minutes of your time.

Participation in this research is entirely voluntary, and you may discontinue at any time if you wish to do so. The information obtained from this survey will be kept strictly confidential and will only be used for academic purposes. Should you have any questions or wish to receive a summary of the research's findings, please feel free to contact me at (or via email at 2021420606@student.uitm.edu.my.

Thank you in advance for your valuable time and assistance in completing this questionnaire.

Warm regards,
[NurAisyah Azmi]
PhD Candidate
Kolej Alam Bina
Universiti Teknologi MARA
40450 Shah Alam, Selangor

SECTION 1

PART A: Respondents' Demographics (*Demografi Responden*)

Please tick (/) in the box or highlight or write your response in the space provided.

Sila tandakan (/) di dalam kotak atau "highlight" atau tulis jawapan anda di ruangan yan disediakan.

1. How long have you been involved in operation and maintenance? / *Berapa lama anda telah terlibat dalam operasi dan penyelenggaraan?*	
1 - 5 years / *tahun*	
6 - 10 years / *tahun*	
11 - 20 years / *tahun*	
more than 20 years / *lebih dari 20 tahun*	

2. Location of company * (select only one) ***Lokasi syarikat * (pilih satu sahaja)***	
Northern / *Utara* (Perlis, Kedah, Penang, Perak)	
East Coast / *Pantai Timur* (Kelantan, Terengganu, Pahang)	
Central / *Tengah* (Selangor, Kuala Lumpur, Putrajaya)	
Southern / *Selatan* (Negeri Sembilan, Melaka, Johor)	
East Malaysia / *Malaysia Timur* (Sabah, Sarawak)	

3. What is the nature of your current organization business? / *Apakah jenis perniagaan organisasi anda sekarang?* Can choose more than 1 / *Boleh pilih dari satu*	
Residential / Kediaman	
Health Facility / Fasiliti Kesihatan	
Airport / Lapangan Terbang	
Educational Building / Bangunan Pendidikan	
Government Building / Bangunan Kerajaan	
Commercial Building / Bangunan Komersial	

4. How would you rate your awareness of BIM usage in the facility management? / *Bagaimana anda menilai tahap kesedaran anda mengenai penggunaan BIM dalam pengurusan fasiliti?*						
Not Aware at all *(Tidak Menyedari langsung)*	**1**	**2**	**3**	**4**	**5**	**Very Aware *(Sangat Menyedari)***

5. How would you rate your knowledge of Building Information Modelling (BIM) in Facility Management (FM)? / *Bagaimana anda menilai pengetahuan anda mengenai Building Information Modelling (BIM) dalam Pengurusan Fasiliti (FM)?*						
Not knowledgeable at all (Tidak berpengetahuan langsung)	1	2	3	4	5	Very knowledgeable (Sangat berpengetahuan)

6. Are your organization a BIM user in FM? / *Adakah organisasi anda menggunakan BIM dalam Pengurusan Fasiliti (FM)?*	
Yes / *Ya*	
No /*Tidak*	

7. How long have your organization been using BIM in FM? / *Berapa lama anda telah menggunakan BIM dalam Pengurusan Fasiliti (FM)?*	
1 - 5 years / *tahun*	
6 - 10 years / *tahun*	
more than 10 years / *lebih dari 10 tahun*	
Never use BIM / *Tidak pernah guna*	

Please read each statement carefully. Please tick at the appropriate box as per appropriate scale indicated in each section that represents your best evaluation of each statement.

PART B: Social

People refers to the characteristics or conditions of a single or group of practitioners performing their related tasks (Salahuddin et al., 2020). *Orang merujuk kepada ciri atau keadaan satu atau sekumpulan pengamal menjalankan tugas yang berkaitan (Salahuddin et al., 2020).*

Organisational condition of the work system in which the practitioners perform their tasks (Salahuddin et al., 2020).*Keadaan organisasi sistem kerja di mana para pekerja melaksanakan tugas mereka (Salahuddin et al., 2020).*

1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)
1 = sangat tidak setuju, 2 = tidak bersetuju, 3 = neutral, 4 = setuju, 5 = sangat setuju

No	People	Strongly Disagree				Strongly Agree
PEO 1.	Employees in our organization clearly understand all the functions provided in the FM Information System. *Kakitangan dalam organisasi kami memahami dengan jelas semua fungsi ada dalam Sistem Maklumat FM.*	**1**	**2**	**3**	**4**	**5**
PEO 2.	Employees in our organization effectively utilize all available functions in the FM Information System to carry out their assigned work tasks. *Kakitangan dalam organisasi kami menggunakan semua fungsi yang ada dalam Sistem Maklumat FM dengan berkesan untuk melaksanakan tugas kerja yang diberikan kepada mereka.*	**1**	**2**	**3**	**4**	**5**
PEO 3.	Employees in our organization possess sufficient knowledge to appropriately use our FM Information System, ensuring high-quality information. *Pekerja dalam organisasi kami mempunyai pengetahuan yang mencukupi untuk menggunakan Sistem Maklumat FM dengan sewajarnya bagi memastikan maklumat berkualiti tinggi.*	**1**	**2**	**3**	**4**	**5**

NO	Organization	Strongly Disagree				Strongly Agree
OR G1	ORG1. The organization facilitates effective communication regarding FM information management queries. *Organisasi menggalakkan komunikasi berkesan mengenai pengurusan maklumat FM.*	**1**	**2**	**3**	**4**	**5**
OR G 2.	ORG2. Clear instructions and guidelines for managing FM information are provided by our organization. *Arahan dan garis panduan yang jelas untuk mengurus maklumat FM disediakan oleh organisasi kami.*	**1**	**2**	**3**	**4**	**5**
OR G 3.	ORG3. Departments within our organization coordinate effectively concerning FM information systems. *Jabtan dalam organisasi kami menyelaras dengan berkesan berkenaan sistem maklumat FM.`*	**1**	**2**	**3**	**4**	**5**
OR G 4.	ORG4. There is strong inter-departmental collaboration regarding FM information handling within our organization. *Terdapat kerjasama kukuh antara jabatan dalam mengendali maklumat FM dalam organisasi kami.*	**1**	**2**	**3**	**4**	**5**
OR G5.	ORG5. Our organization provides adequate training on utilizing FM information systems. *Organisasi kami menyediakan latihan yang mencukupi untuk menggunakan sistem maklumat FM.*	**1**	**2**	**3**	**4**	**5**
OR G 6.	ORG6. Regular and scheduled training sessions are provided by our organization to update	**1**	**2**	**3**	**4**	**5**

	knowledge on digital FM systems. *Sesi latihan tetap dan berjadual disediakan oleh organisasi kami untuk mengemas kini pengetahuan tentang sistem FM digital.*					
ORG 7.	ORG7. Our organization conducts specific training whenever new FM procedures or system improvements are introduced *Organisasi kami menjalankan latihan khusus apabila prosedur/FM baharu atau penambahbaikan sistem diperkenalkan..*	**1**	**2**	**3**	**4**	**5**
ORG8.	ORG8. Training provided by our organization effectively equips with necessary skills to manage FM information systems. *Latihan yang disediakan oleh organisasi kami dengan berkesan melengkapkan kemahiran yang diperlukan untuk mengurus sistem maklumat FM.*	**1**	**2**	**3**	**4**	**5**
ORG9.	ORG9. Our organization ensures staff are trained to handle situations involving information system downtime or malfunction. *Organisasi kami memastikan kakitangan dilatih untuk mengendalikan situasi yang melibatkan masa henti atau kerosakan sistem maklumat.*	**1**	**2**	**3**	**4**	**5**
ORG10	ORG10. Our FM department has sufficient staff to manage operations and maintain information systems effectively. *Jabatan FM kami mempunyai kakitangan yang mencukupi untuk mengurus operasi dan*	**1**	**2**	**3**	**4**	**5**

	menyelenggara sistem maklumat dengan berkesan.					
ORG11	ORG11. Our FM organisation is equipped with adequate and functional digital devices (e.g., desktops, laptops, tablets) to support FM information management *Organisasi FM kami dilengkapi dengan peranti digital yang mencukupi dan berfungsi (cth., desktop, komputer riba, tablet) untuk menyokong pengurusan maklumat FM*	**1**	**2**	**3**	**4**	**5**
ORG12	ORG12. The digital equipment in our organisation (e.g., computers, tablets) have sufficient speed and performance to support information management *Peralatan digital dalam organisasi kami (cth., komputer, tablet) mempunyai kelajuan dan prestasi yang mencukupi untuk menyokong pengurusan maklumat*	**1**	**2**	**3**	**4**	**5**
ORG13	ORG13. Our FM staff have sufficient time and resources to complete facility management information tasks safely and effectively *Kakitangan FM kami mempunyai masa dan sumber yang mencukupi untuk menyelesaikan tugas maklumat pengurusan kemudahan dengan selamat dan berkesan*	**1**	**2**	**3**	**4**	**5**

PART C: Technical

Technology used by practitioners to support their services (Salahuddin et al., 2020).

Teknologi *yang digunakan oleh pengamal untuk menyokong perkhidmatan mereka (Salahuddin et al., 2020).*

Process refers to the activities that support the accomplishment of work goals (Kashif Ali and Abdul Waheed 2024.

Proses *merujuk kepada aktiviti yang menyokong pencapaian matlamat kerja (Kashif Ali dan Abdul Waheed 2024.*

Please indicate your agreement or disagreement on the following statements by indicating your appropriate response based on the following scale.

1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)

1 = sangat tidak setuju, 2 = tidak bersetuju, 3 = neutral, 4 = setuju, 5 = sangat setuju

NO	Technology	Strongly Disagree				Strongly Agree
TEC1	TEC1. The FM information system of my organization is easy to use *Sistem maklumat FM organisasi saya mudah digunakan*	**1**	**2**	**3**	**4**	**5**
TEC 2	TEC2. The FM information system of my organization displays information in a manner easy to read. *Sistem maklumat FM organisasi saya memaparkan maklumat dengan cara yang mudah dibaca.*	**1**	**2**	**3**	**4**	**5**
TEC 3	TEC3. Routine tasks can be performed in a straightforward manner using the FM information system. *Tugas rutin boleh dilakukan dengan cara yang mudah menggunakan sistem maklumat FM*	**1**	**2**	**3**	**4**	**5**

TEC 4	TEC4. The FM information system of my organization is well designed to allows me to enter comprehensive information *Sistem maklumat FM organisasi saya direka bentuk dengan baik untuk membolehkan saya memasukkan maklumat yang komprehensif*	**1**	**2**	**3**	**4**	**5**
TEC 5	TEC 5. The FM information system of my organization uses terms that are clear and easy to understand *Sistem maklumat FM organisasi saya menggunakan istilah yang jelas dan mudah difahami*	**1**	**2**	**3**	**4**	**5**
TEC 6	TEC 6. The FM information system of my organization uses consistent words, terminology, and sequences of action *Sistem maklumat FM organisasi saya menggunakan perkataan, istilah dan urutan tindakan yang konsisten*	**1**	**2**	**3**	**4**	**5**
TEC 7	TEC 7. The FM information system of my organization fit my actual work practice and workflow *Sistem maklumat FM organisasi saya sesuai dengan amalan kerja dan aliran kerja sebenar saya*	**1**	**2**	**3**	**4**	**5**
TEC8	TEC 8. The FM information system of my organization provides adequate functions to support my work. *Sistem maklumat FM organisasi saya menyediakan fungsi yang mencukupi untuk menyokong kerja saya.*	**1**	**2**	**3**	**4**	**5**

TEC9	TEC 9. Technical supports are always willing to help resolving FM information system issues. *Sokongan teknikal sentiasa bersedia membantu menyelesaikan isu sistem maklumat FM*	**1**	**2**	**3**	**4**	**5**
TEC10	TEC10. Adequate technical support is available for resolving FM information system issues promptly. *Sokongan teknikal yang mencukupi tersedia untuk menyelesaikan isu sistem maklumat FM dengan segera.*	**1**	**2**	**3**	**4**	**5**
TEC11	TEC11. Technical support have the knowledge to resolve FM information system issues. *Sokongan teknikal mempunyai pengetahuan untuk menyelesaikan isu sistem maklumat FM.*	**1**	**2**	**3**	**4**	**5**
TEC12	TEC12. Technical supports in my organization perform continuous updates and maintenance of the FM information system *Sokongan teknikal dalam organisasi saya melaksanakan kemas kini berterusan dan penyelenggaraan sistem maklumat FM*	**1**	**2**	**3**	**4**	**5**
TEC13	TEC13. Technical supports in my organization perform continuous maintenance of hardware related to the FM information system *Sokongan teknikal dalam organisasi saya melaksanakan penyelenggaraan berterusan yang berkaitan dengan sistem maklumat FM*	**1**	**2**	**3**	**4**	**5**

NO	PROCESS	Strongly Disagree				Strongly Agree
PRO1	PRO1. Our FM organization has standardized operational processes that are clearly understood by staff and relevant stakeholders. *Organisasi FM kami telah menyeragamkan proses operasi yang difahami dengan jelas oleh kakitangan dan pihak berkepentingan yang berkaitan.*	**1**	**2**	**3**	**4**	**5**
PRO 2	PEO2. Most FM processes in our organization are automated or systematized to minimize the risk of human error. *Kebanyakan proses FM dalam organisasi kami adalah automatik atau sistematik untuk meminimumkan risiko kesilapan manusia.*	**1**	**2**	**3**	**4**	**5**
PRO 3	PEO3. Our FM organization utilizes the latest technology and tools to perform maintenance and operations more effectively. *Organisasi FM kami menggunakan teknologi dan alatan terkini untuk melaksanakan penyelenggaraan dan operasi dengan lebih berkesan.*	**1**	**2**	**3**	**4**	**5**
PRO 4	PEO4. The FM systems used in our organization allow us to monitor and track FM information. *Sistem FM yang digunakan dalam organisasi kami membolehkan kami memantau dan menjejaki proses berkaitan maklumat FM*	**1**	**2**	**3**	**4**	**5**

PRO 5	PEO5. Our FM organization regularly reviews and improves its operational processes to maintain information quality. *Organisasi FM kami sentiasa menyemak dan menambah baik proses operasinya untuk mengekalkan kualiti maklumat*	**1**	**2**	**3**	**4**	**5**

PART D: BIM Attributes

BIM Attributes refer to application areas of Facility management BIM could be implemented and beneficial (Becerik-Gerber et al., 2012).

Atribut BIM merujuk kepada bidang aplikasi pengurusan kemudahan BIM boleh dilaksanakan dan bermanfaat (Becerik-Gerber et al., 2012).

Please indicate your agreement or disagreement on the following statements by indicating your appropriate response based on the following scale.

1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)

1 = sangat tidak setuju, 2 = tidak bersetuju, 3 = neutral, 4 = setuju, 5 = sangat setuju

NO	BIM ATTRIBUTES	Strongly Disagree				Strongly Agree
BF1	BF1. The ability to integrate and exchange information seamlessly across different platforms and software environments can improve FM information quality *Keupayaan untuk menyepadukan dan bertukar maklumat dengan lancar merentas platform dan persekitaran perisian yang berbeza boleh meningkatkan kualiti maklumat FM*	**1**	**2**	**3**	**4**	**5**
BF 2	BF2. Accurate and timely information from a system would enhance FM information quality *Maklumat yang tepat dan tepat pada masanya daripada sistem akan meningkatkan kualiti maklumat FM*	**1**	**2**	**3**	**4**	**5**
BF 3	BF3. A system with clear visuals of FM data would help in enhance FM information quality. *Sistem dengan visual data FM yang jelas akan membantu dalam meningkatkan kualiti*	**1**	**2**	**3**	**4**	**5**

	maklumat FM.					
BF 4	BF4. Precise identification, tracking, and management of building assets throughout the entire lifecycle can improve FM information quality *Pengenalpastian tepat, penjejakan dan pengurusan aset bangunan sepanjang keseluruhan kitaran hayat boleh meningkatkan kualiti maklumat FM*	**1**	**2**	**3**	**4**	**5**
BF 5	BF5. Efficiently creating, updating, and managing electronic documents or databases related to assets can improve FM information quality *Mencipta, mengemas kini dan mengurus dokumen elektronik atau pangkalan data yang berkaitan dengan aset dengan cekap boleh meningkatkan kualiti maklumat FM*	**1**	**2**	**3**	**4**	**5**
BF 6	BF6. Visualize space and host space attributes for immediate access to facilitate identifying underutilized spaces, forecast space requirements, simplify space analysis, manage the move process, and compare actual with planned space utilization can enhance FM information quality *Visualisasikan atribut ruang untuk akses segera bagi memudahkan mengenal pasti ruang yang kurang digunakan, meramalkan keperluan ruang, memudahkan analisis ruang, mengurus proses pergerakan dan membandingkan penggunaan ruang yang sebenar dengan terancang boleh meningkatkan kualiti*	**1**	**2**	**3**	**4**	**5**

	maklumat FM					
BF 7	BF7. Assist in planning, designing, analyzing, and simulating remodel, renovation, or demolition work can enhance FM information quality *Membantu dalam merancang, mereka bentuk, menganalisis dan mensimulasikan kerja-kerja pengubahsuaian, pengubahsuaian atau perobohan boleh meningkatkan kualiti maklumat FM*	**1**	**2**	**3**	**4**	**5**
BF 8	BF8. Improving preparation, response, and recovery during emergencies such as fire, natural disasters, or security issues can improve FM information quality *Memperbaik persediaan, tindak balas dan pemulihan semasa kecemasan seperti kebakaran, bencana alam atau isu keselamatan boleh meningkatkan kualiti maklumat FM*	**1**	**2**	**3**	**4**	**5**
BF 9	BF9. Better tracking and managing of energy consumption for cost savings and sustainability can improve FM information quality. *Penjejakan dan pengurusan penggunaan tenaga yang lebih baik untuk penjimatan dan kemampanan kos boleh meningkatkan kualiti maklumat FM.*	**1**	**2**	**3**	**4**	**5**

PART E: Information Quality

Information quality is defined as the completeness, accuracy, format and currency of information produced by the FM information system. Completeness indicates the extent to which the user perceives that FM information system provide all the necessary information; accuracy focuses on the perceived correctness of information; format refers to the perception of how well the information is presented; and, finally, currency refers to the extent which the information is up to date (Akter et al., 2017).

Kualiti maklumat ditakrifkan sebagai kesempurnaan, ketepatan, format dan mata wang maklumat yang dihasilkan oleh sistem maklumat. Kelengkapan menunjukkan sejauh mana pengguna menganggap bahawa sistem maklumat FM menyediakan semua maklumat yang diperlukan; ketepatan memberi tumpuan kepada ketepatan maklumat yang dirasakan; format merujuk kepada persepsi sejauh mana maklumat disampaikan; dan, akhirnya, mata wang merujuk kepada sejauh mana maklumat adalah terkini (Akter et al., 2017).

1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)
1 = sangat tidak setuju, 2 = tidak bersetuju, 3 = neutral, 4 = setuju, 5 = sangat setuju

NO	Information Quality	Strongly Disagree				Strongly Agree
Completeness						
IQ1	IQ1. Our organization provide complete set of FM information for recent events *Organisasi kami menyediakan set lengkap maklumat FM untuk acara terkini*	**1**	**2**	**3**	**4**	**5**
IQ2	IQ2. FM information I receive contain all comprehensive information about recent events. *Maklumat FM yang saya terima mengandungi semua maklumat komprehensif tentang keadaan terkini*	**1**	**2**	**3**	**4**	**5**
IQ3	IQ3. I received all FM information I need about the recent events. *Saya menerima semua maklumat FM yang saya perlukan tentang peristiwa baru-baru ini.*	**1**	**2**	**3**	**4**	**5**
Accuracy						
IQ4	IQ4. I receive correct FM information	**1**	**2**	**3**	**4**	**5**

	Saya menerima maklumat FM yang betul					
IQ5	IQ5. The FM information I receive was error free *Maklumat FM yang saya terima adalah bebas ralat*	**1**	**2**	**3**	**4**	**5**
IQ6	IQ6. The FM information provided was accurate *Maklumat FM yang diberikan adalah tepat*	**1**	**2**	**3**	**4**	**5**
Format						
IQ7	IQ7. The FM information provided was well formatted *Maklumat FM yang diberikan telah diformat dengan baik*	**1**	**2**	**3**	**4**	**5**
IQ8	IQ8. The FM information was well laid out *Maklumat FM telah disusun dengan baik*	**1**	**2**	**3**	**4**	**5**
IQ9	IQ9. The FM information are clearly presented on the screen. *Maklumat FM dipaparkan dengan jelas pada skrin.*	**1**	**2**	**3**	**4**	**5**
Currency						
IQ10	IQ10. I received the most recent FM information *Saya menerima maklumat FM terkini*	**1**	**2**	**3**	**4**	**5**
IQ11	IQ11. My system produce the most current FM information	**1**	**2**	**3**	**4**	**5**
IQ12	IQ12The FM information from my system was always up to date	**1**	**2**	**3**	**4**	**5**

Suggestion / *Cadangan*:

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____

APPENDIX 7

Questionnaire Review Form

QUESTIONNAIRE REVIEW FORM

Dear Respondent,

AN INTEGRATED BIM–FM FRAMEWORK FOR INFORMATION QUALITY IN FACILITY MANAGEMENT: A SOCIO-TECHNICAL SYSTEMS APPROACH

I am currently conducting a research on the integration of Building Information Modelling (BIM) into Facility management (FM) to enhance information quality as part of my PhD research at Universiti Teknologi MARA.
Enclosed is a set of questionnaire review forms that seeks to assess the impact of people, organization, technology and process, and BIM attributes in improving information quality in FM. The questionnaire is intended for professionals in Facility management (both BIM users and non-BIM users) in Malaysia.
I seek your kind assistance in participating in this review by completing the attached questionnaire. Your responses will provide valuable insights for the development of a framework aimed at improving information quality in FM. This survey requires approximately 10 to 15 minutes of your time.
Participation in this research is entirely voluntary, and you may discontinue at any time if you wish to do so. The information obtained from this survey will be kept strictly confidential and will only be used for academic purposes. Should you have any questions or wish to receive a summary of the research's findings, please feel free to contact me at   or via email at 2021420606@student.uitm.edu.my.

Thank you in advance for your valuable time and assistance in completing this questionnaire.
Warm regards,
[NurAisyah Azmi]
PhD Candidate
Kolej Alam Bina
Universiti Teknologi MARA
40450 Shah Alam, Selangor

This questionnaire contains 3 parts and a total of 76 items related to information quality in FM.
We need your expert judgment on the degree of relevance of each item to the measured parts. Your review should be based on the definition and relevant terminologies that are provided to you. Please be as objective and constructive as possible in your review and use the following rating scale:

Degree of relevance:
1 = The item is not relevant to the measured variable
2 = The item is somewhat relevant to the measured variable
3 = The item is quite relevant to the measured variable
4 = The item is highly relevant to the measured variable

Social

People refers to the characteristics or conditions of a single or group of practitioners performing their related tasks (Salahuddin et al., 2020). *Orang merujuk kepada ciri atau keadaan satu atau sekumpulan pengamal menjalankan tugas yang berkaitan (Salahuddin et al., 2020).*

Organisational condition of the work system in which the practitioners perform their tasks (Salahuddin et al., 2020).*Keadaan organisasi sistem kerja di mana para pekerja melaksanakan tugas mereka (Salahuddin et al., 2020).*

NO	PEOPLE	RELEVANCE				REMARKS
PEO1.	Employees in our organization clearly understand all the functions provided in the FM Information System. *Kakitangan dalam organisasi kami memahami dengan jelas semua fungsi ada dalam Sistem Maklumat FM.*	**1**	**2**	**3**	**4**	
PEO2.	Employees in our organization effectively utilize all available functions in the FM Information System to carry out their assigned work tasks. *Kakitangan dalam organisasi kami menggunakan semua fungsi yang ada dalam Sistem Maklumat FM dengan berkesan untuk melaksanakan tugas*	**1**	**2**	**3**	**4**	

	kerja yang diberikan kepada mereka.					
PEO3.	Employees in our organization possess sufficient knowledge to appropriately use our FM Information System, ensuring high-quality information. *Pekerja dalam organisasi kami mempunyai pengetahuan yang mencukupi untuk menggunakan Sistem Maklumat FM dengan sewajarnya bagi memastikan maklumat berkualiti tinggi*.	**1**	**2**	**3**	**4**	
NO	**ORGANIZATION**	**RELEVANCE**				**REMARKS**
ORG 1	ORG1. The organization facilitates effective communication regarding FM information management queries. *Organisasi menggalakkan komunikasi berkesan mengenai pengurusan maklumat FM.*	**1**	**2**	**3**	**4**	
ORG 2.	ORG2. Clear instructions and guidelines for managing FM information are provided by our organization. *Arahan dan garis panduan yang jelas untuk mengurus maklumat FM disediakan oleh organisasi kami.*	**1**	**2**	**3**	**4**	
ORG 3.	ORG3. Departments within our organization coordinate effectively concerning FM information systems. *Jabtan dalam organisasi kami menyelaras dengan berkesan berkenaan sistem maklumat FM.`*	**1**	**2**	**3**	**4**	
ORG 4.	ORG4. There is strong inter-departmental collaboration regarding FM information handling within our organization. *Terdapat kerjasama kukuh antara*	**1**	**2**	**3**	**4**	

	jabatan dalam mengendali maklumat FM dalam organisasi kami.					
ORG 5.	ORG5. Our organization provides adequate training on utilizing FM information systems. *Organisasi kami menyediakan latihan yang mencukupi untuk menggunakan sistem maklumat FM.*	**1**	**2**	**3**	**4**	
ORG 6.	ORG6. Regular and scheduled training sessions are provided by our organization to update knowledge on digital FM systems. *Sesi latihan tetap dan berjadual disediakan oleh organisasi kami untuk mengemas kini pengetahuan tentang sistem FM digital.*	**1**	**2**	**3**	**4**	
ORG 7.	ORG7. Our organization conducts specific training whenever new FM procedures or system improvements are introduced *Organisasi kami menjalankan latihan khusus apabila prosedur/FM baharu atau penambahbaikan sistem diperkenalkan..*	**1**	**2**	**3**	**4**	
ORG 8.	ORG8. Training provided by our organization effectively equips with necessary skills to manage FM information systems. *Latihan yang disediakan oleh organisasi kami dengan berkesan melengkapkan kemahiran yang diperlukan untuk mengurus sistem maklumat FM.*	**1**	**2**	**3**	**4**	
ORG	ORG9. Our organization ensures staff are trained to handle situations	**1**	**2**	**3**	**4**	

9.	involving information system downtime or malfunction. *Organisasi kami memastikan kakitangan dilatih untuk mengendalikan situasi yang melibatkan masa henti atau kerosakan sistem maklumat.*					
ORG 10	ORG10. Our FM department has sufficient staff to manage operations and maintain information systems effectively. *Jabatan FM kami mempunyai kakitangan yang mencukupi untuk mengurus operasi dan menyelenggara sistem maklumat dengan berkesan.*	**1**	**2**	**3**	**4**	
ORG 11	ORG11. Our FM organisation is equipped with adequate and functional digital devices (e.g., desktops, laptops, tablets) to support FM information management *Organisasi FM kami dilengkapi dengan peranti digital yang mencukupi dan berfungsi (cth., desktop, komputer riba, tablet) untuk menyokong pengurusan maklumat FM*	**1**	**2**	**3**	**4**	
ORG 12	ORG12. The digital equipment in our organisation (e.g., computers, tablets) have sufficient speed and performance to support information management *Peralatan digital dalam organisasi kami (cth., komputer, tablet) mempunyai kelajuan dan prestasi yang mencukupi untuk menyokong pengurusan maklumat*	**1**	**2**	**3**	**4**	

ORG 13	ORG13. Our FM staff have sufficient time and resources to complete facility management information tasks safely and effectively *Kakitangan FM kami mempunyai masa dan sumber yang mencukupi untuk menyelesaikan tugas maklumat pengurusan kemudahan dengan selamat dan berkesan*	**1**	**2**	**3**	**4**	

PART C: Technical

Technology used by practitioners to support their services (Salahuddin et al., 2020).

Teknologi *yang digunakan oleh pengamal untuk menyokong perkhidmatan mereka (Salahuddin et al., 2020).*

Process refers to the activities that support the accomplishment of work goals (Kashif Ali and Abdul Waheed 2024.

Proses *merujuk kepada aktiviti yang menyokong pencapaian matlamat kerja (Kashif Ali dan Abdul Waheed 2024.*

NO	**TECHNOLOGY**	**RELEVANCE**				**REMARKS**
TEC1	TEC1. The FM information system of my organization is easy to use *Sistem maklumat FM organisasi saya mudah digunakan*	**1**	**2**	**3**	**4**	
TEC 2	TEC2. The FM information system of my organization displays information in a manner easy to read. *Sistem maklumat FM organisasi saya memaparkan maklumat dengan cara yang mudah dibaca.*	**1**	**2**	**3**	**4**	
TEC 3	TEC3. Routine tasks can be performed in a straightforward manner using the	**1**	**2**	**3**	**4**	

	FM information system. *Tugas rutin boleh dilakukan dengan cara yang mudah menggunakan sistem maklumat FM*					
TEC 4	TEC4. The FM information system of my organization is well designed to allows me to enter comprehensive information *Sistem maklumat FM organisasi saya direka bentuk dengan baik untuk membolehkan saya memasukkan maklumat yang komprehensif*	**1**	**2**	**3**	**4**	
TEC 5	TEC 5. The FM information system of my organization uses terms that are clear and easy to understand *Sistem maklumat FM organisasi saya menggunakan istilah yang jelas dan mudah difahami*	**1**	**2**	**3**	**4**	
TEC 6	TEC 6. The FM information system of my organization uses consistent words, terminology, and sequences of action *Sistem maklumat FM organisasi saya menggunakan perkataan, istilah dan urutan tindakan yang konsisten*	**1**	**2**	**3**	**4**	
TEC 7	TEC 7. The FM information system of my organization fit my actual work practice and workflow *Sistem maklumat FM organisasi saya sesuai dengan amalan kerja dan aliran kerja sebenar saya*	**1**	**2**	**3**	**4**	
TEC8	TEC 8. The FM information system of my organization provides adequate functions to support my work.	**1**	**2**	**3**	**4**	

	Sistem maklumat FM organisasi saya menyediakan fungsi yang mencukupi untuk menyokong kerja saya.					
TEC9	TEC 9. Technical supports are always willing to help resolving FM information system issues. *Sokongan teknikal sentiasa bersedia membantu menyelesaikan isu sistem maklumat FM*	**1**	**2**	**3**	**4**	
TEC10	TEC10. Adequate technical support is available for resolving FM information system issues promptly. *Sokongan teknikal yang mencukupi tersedia untuk menyelesaikan isu sistem maklumat FM dengan segera.*	**1**	**2**	**3**	**4**	
TEC11	TEC11. Technical support have the knowledge to resolve FM information system issues. *Sokongan teknikal mempunyai pengetahuan untuk menyelesaikan isu sistem maklumat FM.*	**1**	**2**	**3**	**4**	
TEC12	TEC12. Technical supports in my organization perform continuous updates and maintenance of the FM information system *Sokongan teknikal dalam organisasi saya melaksanakan kemas kini berterusan dan penyelenggaraan sistem maklumat FM*	**1**	**2**	**3**	**4**	
TEC13	TEC13. Technical supports in my organization perform continuous maintenance of hardware related to the FM information system *Sokongan teknikal dalam organisasi*	**1**	**2**	**3**	**4**	

	saya melaksanakan penyelenggaraan berterusan yang berkaitan dengan sistem maklumat FM					
NO	**PROCESS**	**RELEVANCE**				**REMARKS**
PRO1	PRO1. Our FM organization has standardized operational processes that are clearly understood by staff and relevant stakeholders. *Organisasi FM kami telah menyeragamkan proses operasi yang difahami dengan jelas oleh kakitangan dan pihak berkepentingan yang berkaitan.*	**1**	**2**	**3**	**4**	
PRO 2	PEO2. Most FM processes in our organization are automated or systematized to minimize the risk of human error. *Kebanyakan proses FM dalam organisasi kami adalah automatik atau sistematik untuk meminimumkan risiko kesilapan manusia.*	**1**	**2**	**3**	**4**	
PRO 3	PEO3. Our FM organization utilizes the latest technology and tools to perform maintenance and operations more effectively. *Organisasi FM kami menggunakan teknologi dan alatan terkini untuk melaksanakan penyelenggaraan dan operasi dengan lebih berkesan.*	**1**	**2**	**3**	**4**	
PRO 4	PEO4. The FM systems used in our organization allow us to monitor and track FM information. *Sistem FM yang digunakan dalam organisasi kami membolehkan kami memantau dan menjejaki proses*	**1**	**2**	**3**	**4**	

	berkaitan maklumat FM					
PRO 5	PEO5. Our FM organization regularly reviews and improves its operational processes to maintain information quality. *Organisasi FM kami sentiasa menyemak dan menambah baik proses operasinya untuk mengekalkan kualiti maklumat*	**1**	**2**	**3**	**4**	

PART D: BIM Attributes

BIM Attributes refer to application areas of Facility management BIM could be implemented and beneficial (Becerik-Gerber et al., 2012).

Atribut BIM merujuk kepada bidang aplikasi pengurusan kemudahan BIM boleh dilaksanakan dan bermanfaat (Becerik-Gerber et al., 2012).

NO	BIM ATTRIBUTES	RELEVANCE				REMARKS
BF1	BF1. The ability to integrate and exchange information seamlessly across different platforms and software environments can improve FM information quality *Keupayaan untuk menyepadukan dan bertukar maklumat dengan lancar merentas platform dan persekitaran perisian yang berbeza boleh meningkatkan kualiti maklumat FM*	**1**	**2**	**3**	**4**	
BF 2	BF2. Accurate and timely information from a system would enhance FM information quality *Maklumat yang tepat dan tepat pada masanya daripada sistem akan*	**1**	**2**	**3**	**4**	

	meningkatkan kualiti maklumat FM					
BF 3	BF3. A system with clear visuals of FM data would help in enhance FM information quality. *Sistem dengan visual data FM yang jelas akan membantu dalam meningkatkan kualiti maklumat FM.*	**1**	**2**	**3**	**4**	
BF 4	BF4. Precise identification, tracking, and management of building assets throughout the entire lifecycle can improve FM information quality *Pengenalpastian tepat, penjejakan dan pengurusan aset bangunan sepanjang keseluruhan kitaran hayat boleh meningkatkan kualiti maklumat FM*	**1**	**2**	**3**	**4**	
BF 5	BF5. Efficiently creating, updating, and managing electronic documents or databases related to assets can improve FM information quality *Mencipta, mengemas kini dan mengurus dokumen elektronik atau pangkalan data yang berkaitan dengan aset dengan cekap boleh meningkatkan kualiti maklumat FM*	**1**	**2**	**3**	**4**	
BF 6	BF6. Visualize space and host space attributes for immediate access to facilitate identifying underutilized spaces, forecast space requirements, simplify space analysis, manage the move process, and compare actual with planned space utilization can enhance FM information quality *Visualisasikan atribut ruang untuk akses segera bagi memudahkan*	**1**	**2**	**3**	**4**	

	mengenal pasti ruang yang kurang digunakan, meramalkan keperluan ruang, memudahkan analisis ruang, mengurus proses pergerakan dan membandingkan penggunaan ruang yang sebenar dengan terancang boleh meningkatkan kualiti maklumat FM					
BF 7	BF7. Assist in planning, designing, analyzing, and simulating remodel, renovation, or demolition work can enhance FM information quality *Membantu dalam merancang, mereka bentuk, menganalisis dan mensimulasikan kerja-kerja pengubahsuaian, pengubahsuaian atau perobohan boleh meningkatkan kualiti maklumat FM*	**1**	**2**	**3**	**4**	
BF 8	BF8. Improving preparation, response, and recovery during emergencies such as fire, natural disasters, or security issues can improve FM information quality *Memperbaik persediaan, tindak balas dan pemulihan semasa kecemasan seperti kebakaran, bencana alam atau isu keselamatan boleh meningkatkan kualiti maklumat FM*	**1**	**2**	**3**	**4**	
BF 9	BF9. Better tracking and managing of energy consumption for cost savings and sustainability can improve FM information quality. *Penjejakan dan pengurusan penggunaan tenaga yang lebih baik untuk penjimatan dan kemampanan kos boleh meningkatkan kualiti maklumat FM.*	**1**	**2**	**3**	**4**	

PART E: Information Quality

Information quality is defined as the completeness, accuracy, format and currency of information produced by the FM information system. Completeness indicates the extent to which the user perceives that FM information system provide all the necessary information; accuracy focuses on the perceived correctness of information; format refers to the perception of how well the information is presented; and, finally, currency refers to the extent which the information is up to date (Akter et al., 2017).

Kualiti maklumat ditakrifkan sebagai kesempurnaan, ketepatan, format dan mata wang maklumat yang dihasilkan oleh sistem maklumat. Kelengkapan menunjukkan sejauh mana pengguna menganggap bahawa sistem maklumat FM menyediakan semua maklumat yang diperlukan; ketepatan memberi tumpuan kepada ketepatan maklumat yang dirasakan; format merujuk kepada persepsi sejauh mana maklumat disampaikan; dan, akhirnya, mata wang merujuk kepada sejauh mana maklumat adalah terkini (Akter et al., 2017).

NO	INFORMATION QUALITY	RELEVANCE				REMARKS
Completeness						
IQ1	IQ1. Our organization provide complete set of FM information for recent events *Organisasi kami menyediakan set lengkap maklumat FM untuk acara terkini*	**1**	**2**	**3**	**4**	
IQ2	IQ2. FM information I receive contain all comprehensive information about recent events. *Maklumat FM yang saya terima mengandungi semua maklumat komprehensif tentang keadaan terkini*	**1**	**2**	**3**	**4**	
IQ3	IQ3. I received all FM information I need about the recent events. *Saya menerima semua maklumat FM yang saya perlukan tentang peristiwa baru-baru ini.*	**1**	**2**	**3**	**4**	
Accuracy						
IQ4	IQ4. I receive correct FM information *Saya menerima maklumat FM yang betul*	**1**	**2**	**3**	**4**	
IQ5	IQ5. The FM information I receive was error free	**1**	**2**	**3**	**4**	

	Maklumat FM yang saya terima adalah bebas ralat					
IQ6	IQ6. The FM information provided was accurate *Maklumat FM yang diberikan adalah tepat*	**1**	**2**	**3**	**4**	
Format						
IQ7	IQ7. The FM information provided was well formatted *Maklumat FM yang diberikan telah diformat dengan baik*	**1**	**2**	**3**	**4**	
IQ8	IQ8. The FM information was well laid out *Maklumat FM telah disusun dengan baik*	**1**	**2**	**3**	**4**	
IQ9	IQ9. The FM information are clearly presented on the screen. *Maklumat FM dipaparkan dengan jelas pada skrin.*	**1**	**2**	**3**	**4**	
Currency						
IQ10	IQ10. I received the most recent FM information *Saya menerima maklumat FM terkini*	**1**	**2**	**3**	**4**	
IQ11	IQ11. My system produce the most current FM information					
IQ12	IQ12The FM information from my system was always up to date					

Suggestion / *Cadangan*:

APPENDIX 8

Sumamry of Expert Reviews (CVI)

The number of experts and its implication on the acceptable cut-off score of CVI

PART	VARIABLE	ITEM	PAKAR 1	PAKAR 2	PAKAR 3	PAKAR4	PAKAR5	PAKAR6	I-CVI
1	People	PEO1	1.00	1.00	0.00	1.00	1.00	1.00	0.83
		PEO2	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		PEO3	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	Organization	ORG1	0.00	1.00	1.00	1.00	1.00	1.00	0.83
		ORG2	0.00	1.00	1.00	1.00	1.00	1.00	0.83
		ORG3	0.00	1.00	1.00	1.00	1.00	1.00	0.83
		ORG4	0.00	1.00	1.00	1.00	1.00	1.00	0.83
		ORG5	0.00	1.00	1.00	1.00	1.00	1.00	0.83
		ORG6	1.00	1.00	1.00	1.00	1.00	0.00	0.83
		ORG7	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		ORG8	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		ORG9	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		ORG10	1.00	1.00	1.00	1.00	1.00	0.00	0.83
		ORG11	1.00	1.00	1.00	1.00	1.00	1.00	1.0
		ORG12	1.00	1.00	1.00	1.00	1.00	1.00	1.0
		ORG13	1.00	1.00	1.00	1.00	1.00	1.00	1.0
3	Technology	TEC1	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		TEC2	1.00	0.00	1.00	1.00	1.00	1.00	0.83
		TEC3	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		TEC4	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		TEC5	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		TEC6	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		TEC7	1.00	0.00	1.00	1.00	1.00	1.00	0.83
		TEC8	1.00	1.00	1.00	0.00	1.00	1.00	0.83
		TEC9	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4	Process	PRO1	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		PRO2	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		PRO3	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		PRO4	0.00	1.00	1.00	1.00	1.00	1.00	0.83
		PRO5	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	BIM Attributes	BA1	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		BA2	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		BA3	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		BA4	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		BA5	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		BA6	1.00	1.00	1.00	0.00	1.00	1.00	0.83
		BA7	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		BA8	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		BA9	0.00	1.00	1.00	1.00	1.00	1.00	0.83
6	Information Quality	IQ1	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		IQ2	0.00	1.00	1.00	1.00	1.00	1.00	0.83
		IQ3	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		IQ4	1.00	1.00	1.00	1.00	0.00	1.00	0.83
		IQ5	1.00	1.00	0.00	1.00	1.00	1.00	0.83
		IQ6	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		IQ7	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		IQ8	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		IQ9	1.00	0.00	1.00	1.00	1.00	1.00	0.83
		IQ10	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		IQ11	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		IQ12	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		IQ113	1.00	1.00	1.00	1.00	1.00	1.00	1.00
PURATA	PURATA	PURATA	0.87	0.95	0.95	0.95	0.97	0.97	

$\sum I - CVI$	0.94
S-CVI = $\frac{\text{AVE I-CVI}}{\text{AVE I (item)}}$	0.94

* ITEM YANG DIHIGHLIGHTKAN MERUPAKAN ITEM YANG DIGUGURKAN KERANA TIDAK MENCAPAI NILAI I-CVI YANG DITETAPKAN IAITU 0.78 (LYNN 1986)
Cut Off Point iCVI = 0.78 (Lynn, 1986)
Cut Off Point sCVI = 0.86 (Smith et.al, 2004)

APPENDIX 9

Summary of Expert Reviewers

No	Designation	Company	Years of Experience
1	Senior Lecturer	Universiti Kebangsaan Malaysia	13 years
2	Senior Lecturer	Universiti Pendidikan Sultan Idris	8 years
3	Senior Lecturer	Universiti Utara Malaysia	11 years
4	Facility Managers	Stagno Tech Sdn Bhd	8 years
5	Facility Managers	Urusan Teknologi Wawasan Sdn Bhd	6 years
6	Managing Director	Microcorp Sdn Bhd	15 years

APPENDIX 10

Pilot Research: Demographic Analysis

Demographics	**Frequency**	**Valid Percent**
Duration in Operation and Maintenance		
1 - 5 years	2	3.3
6 - 10 years	4	6.7
11 - 20 years	33	55
more than 20 years	21	35
States		
Northern	3	5
East Coast	0	0
Central	51	85
Southern	2	3.33
East Malaysia	4	6.67
Nature of Organization		
Residential	20	33.33
Health Facility	9	15
Airport	4	6.7
Educational Building	6	10
Government Building	9	15
Commercial Building	12	20
BIM User		
Yes	25	41.7
No	35	58.3
Duration of BIM User		
1 - 5 years	5	8.3
6 -10 years	8	13.3
11-20 years	12	20
Never use BIM in FM	35	58.33

Rate Your Awareness Of BIM Usage In The Facility Management		
Not Aware at all	2	3.3
Slightly Aware	6	10
Moderately Aware	14	23.3
Aware	13	21.7
Very Aware	25	41.7
Knowledge of Building Information Modelling (BIM) in Facility Management (FM)		
Not knowledgeable at all	2	3.3
Slightly knowledgeable	6	10
Moderately knowledgeable	14	23.3
Knowledgeable	13	21.7
Very knowledgeable	25	41.7

APPENDIX 11

Pilot Test

Construct	Item	Loading	AVE	CR	CA
People	PEO1	0.892	0.719	1.064	0.922
	PEO2	0.830			
	PEO3	0.881			
Organization	ORG1	0.903	0.703	0.575	0.960
	ORG2	0.905			
	ORG3	0.847			
	ORG4	0.731			
	ORG5	0.791			
	ORG6	0.800			
	ORG7	0.878			
	ORG8	0.731			
	ORG9	0.897			
	ORG10	0.805			
	ORG11	0.777			
	ORG12	0.789			
	ORG13	0.739			
Technology	TEC1	0.662	0.620	1.004	0.967
	TEC2	0.792			
	TEC3	0.783			
	TEC4	0.793			
	TEC5	0.866			
	TEC6	0.817			
	TEC7	0.806			
	TEC8	0.868			
	TEC9	0.795			
	TEC10	0.731			
	TEC11	0.723			
	TEC12	0.733			
	TEC13	0.796			
Process	PRO1	0.926	0.812	0.999	0.977
	PRO2	0.890			
	PRO3	0.945			
	PRO4	0.854			
	PRO5	0.883			

Information Quality	IQ1	0.743	0.603	0.957	0.940
	IQ2	0.842			
	IQ3	0.766			
	IQ4	0.731			
	IQ5	0.746			
	IQ6	0.834			
	IQ7	0.840			
	IQ8	0.692			
	IQ9	0.710			
	IQ10	0.819			
	IQ11	0.766			
	IQ12	0.809			
BIM Attributes	BA1	0.917	0.826	0.985	0.969
	BA2	0.923			
	BA3	0.938			
	BA4	0.915			
	BA5	0.717			
	BA6	0.957			
	BA7	0.889			
	BA8	0.988			
	BA9	0.887			

APPENDIX 12

Pilot Test HTMT

	BA	IQ	ORG	PEO	PRO	TEC
BA						
IQ	0.225					
ORG	0.175	0.110				
PEO	0.092	0.185	0.245			
PRO	0.149	0.154	0.145	0.104		
TEC	0.123	0.192	0.361	0.231	0.136	

Note: BA=BIM Attributes. IQ=Information Quality, ORG=Organization, PEO=People, PRO=Process, TEC=Technology

APPENDIX 13

Choosing between CB-SEM and PLS-SEM

No	Criteria for Evaluation	PLS-SEM	CB-SEM
1.	Research Goals	• To identify key drivers or predictions of key target constructs. • If the research is exploratory in nature or an expansion from an existing structural theory.	• If the goal is to test theories, confirm theories, or compare theories.
2.	Measurement Model Specification	• If a structural model has formative constructs.	• If the additional specification of error terms, such as covariation, is required.
3.	Structural Model	• If the structural model is intricate (many constructs and many indicators).	• If the non-recursive structural model.
4.	Data Characteristics and Algorithm	• If did not meet the distributional assumptions of data. • In the case of a small sample size. • If the data is non-normal in some way.	• If data meet the distributionas assumptions of data.
5.	Model Evaluation	• If subsequent analyses require the use of latent variable scores.	• If your research includes the implementation of a global goodness-of-fit criterion. • If you need to determine the invariance of a measurement model.

APPENDIX 14

Missing Data Analysis

NO	Valid	Missing	Minimum	Maximum
Q1	238	0	1	4
Q2	238	0	1	7
Q3	238	0	1	7
Q4	238	0	2	5
Q5	238	0	2	5
Q6	238	0	0	1
Q7	238	0	2	5
PEO1	238	0	1	5
PEO2	238	0	1	5
PEO3	238	0	1	5
ORG1	238	0	1	5
ORG2	238	0	1	5
ORG3	238	0	1	5
ORG4	238	0	1	5
ORG5	238	0	1	5
ORG6	238	0	1	5
ORG7	238	0	1	5
ORG8	238	0	1	5
ORG9	238	0	1	5
ORG10	238	0	1	5
ORG11	238	0	1	5
ORG12	238	0	1	5
ORG13	238	0	1	5
TEC1	238	0	1	5
TEC2	238	0	1	5
TEC3	238	0	1	5
TEC4	238	0	1	5
TEC5	238	0	1	5
TEC6	238	0	1	5
TEC7	238	0	1	5
TEC8	238	0	1	5
TEC9	238	0	1	5
TEC10	238	0	1	5
TEC11	238	0	1	5
TEC12	238	0	1	5
TEC13	238	0	1	5
PRO1	238	0	1	5
PRO2	238	0	1	5
PRO3	238	0	1	5
PRO4	238	0	1	5
PRO5	238	0	1	5
BA1	238	0	1	5
BA2	238	0	1	5
BA3	238	0	1	5
BA4	238	0	1	5
BA5	238	0	1	5
BA6	238	0	1	5
BA7	238	0	1	5
BA8	238	0	1	5
BA9	238	0	1	5
IQ1	238	0	1	5
IQ2	238	0	1	5

IQ3	238	0	1	5
IQ4	238	0	1	5
IQ5	238	0	1	5
IQ6	238	0	1	5
IQ7	238	0	1	5
IQ8	238	0	1	5
IQ9	238	0	1	5
IQ10	238	0	1	5
IQ11	238	0	1	5
IQ12	238	0	1	5

APPENDIX 15

Harman Single-Factor Test: Total Variance Explained

Total Variance Explained						
Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.841	16.075	16.075	8.130	14.782	14.782
2	7.248	13.177	29.252			
3	6.123	11.132	40.384			
4	4.580	8.327	48.711			
5	3.854	7.007	55.718			
6	3.280	5.963	61.682			
7	3.066	5.574	67.256			
8	2.405	4.372	71.628			
9	1.825	3.319	74.946			
10	1.202	2.186	77.132			
11	.897	1.631	78.764			
12	.843	1.533	80.297			
13	.671	1.221	81.517			
14	.605	1.100	82.617			
15	.563	1.023	83.640			
16	.541	.984	84.624			
17	.436	.792	85.416			
18	.427	.776	86.192			
19	.400	.727	86.919			
20	.382	.695	87.614			
21	.350	.635	88.250			
22	.346	.629	88.879			
23	.336	.612	89.490			
24	.333	.605	90.095			
25	.310	.563	90.658			
26	.306	.556	91.214			
27	.282	.513	91.727			
28	.272	.495	92.221			
29	.259	.471	92.692			
30	.256	.466	93.159			
31	.249	.453	93.612			
32	.236	.429	94.041			
33	.223	.405	94.447			
34	.213	.387	94.834			
35	.212	.385	95.219			
36	.195	.355	95.574			
37	.187	.340	95.914			
38	.178	.323	96.237			
39	.174	.316	96.553			
40	.169	.308	96.861			
41	.158	.288	97.148			
42	.153	.278	97.426			
43	.152	.276	97.702			
44	.149	.270	97.972			
45	.135	.246	98.218			
46	.129	.235	98.453			
47	.121	.220	98.673			
48	.120	.217	98.890			
49	.108	.196	99.087			

50	.098	.178	99.265			
51	.095	.173	99.438			
52	.089	.162	99.600			
53	.086	.157	99.757			
54	.074	.134	99.891			
55	.060	.109	100.000			
Extraction Method: Principal Axis Factoring.						

APPENDIX 16

Descriptive Analysis of Each Indicator

Constructs	Indicators	N	Min	Max	Sum	Mean	Std. Deviation
People	PE01	238	2	4	1016	3.27	.577
(PEO)	PEO2	238	2	5	1002	3.32	.573
Mean: 3.289, Std Dev: 0.515	PEO3	238	2	5	1023	3.28	.589
Organization	ORG1	238	1	4	667	2.8	0.629
(ORG)	ORG2	238	1	5	665	2.79	0.646
Mean:2.978 Std Dev:0.280	ORG3	238	1	5	670	2.82	0.643
	ORG4	238	1	4	668	2.81	0.633
	ORG5	238	1	4	674	2.83	0.614
	ORG6	238	2	5	664	2.79	0.572
	ORG7	238	1	4	657	2.76	0.571
	ORG8	238	2	4	668	2.81	0.540
	ORG9	238	2	4	662	2.78	0.569
	ORG10	238	2	5	808	3.39	0.598
	ORG11	238	2	5	807	3.39	0.625
	ORG12	238	2	5	805	3.38	0.574
	ORG13	238	2	5	800	3.36	0.590
Technology (TEC)	TEC1	238	2	4	691	2.9	0.546
Mean:3.045 Std Dev:0.342	TEC2	238	1	4	674	2.83	0.556
	TEC3	238	2	4	675	2.84	0.522
	TEC4	238	1	4	681	2.86	0.56
	TEC5	238	1	4	683	2.87	0.562
	TEC6	238	1	4	682	2.87	0.542
	TEC7	238	1	4	679	2.85	0.58
	TEC8	238	1	5	682	2.87	0.587
	TEC9	238	2	5	835	3.51	0.594
	TEC10	238	2	5	830	3.49	0.572
	TEC11	238	2	5	769	3.23	0.603
	TEC12	238	2	5	770	3.24	0.619
	TEC13	238	1	5	769	3.23	0.617

Process (PRO)	PRO1	238	1	4	716	3.01	0.566
Mean:3.042 Std Dev:0.507	PRO2	238	1	4	729	3.06	0.574
	PRO3	238	2	5	719	3.02	0.57
	PRO4	238	2	5	728	3.06	0.548
	PRO5	238	2	4	728	3.06	0.563
BIM Attributes (BA)	BA1	238	1	4	623	2.62	0.624
Mean:2.619 Std Dev: 0.577	BA2	238	1	4	622	2.61	0.651
	BA3	238	1	4	618	2.6	0.634
	BA4	238	1	4	627	2.63	0.653
	BA5	238	1	4	622	2.61	0.638
	BA6	238	1	4	620	2.61	0.612
	BA7	238	1	4	630	2.65	0.617
	BA8	238	1	4	621	2.61	0.645
	BA9	238	1	4	627	2.63	0.627
Information Quality (IQ)	IQ1	238	2	4	727	3.05	0.246
Mean: 3.073 Std Dev: 0.196	IQ2	238	3	4	729	3.06	0.244
	IQ3	238	3	4	733	3.08	0.272
	IQ4	238	3	4	735	3.09	0.284
	IQ5	238	3	4	732	3.08	0.265
	IQ6	238	2	4	736	3.09	0.304
	IQ7	238	3	4	731	3.07	0.258
	IQ8	238	3	4	728	3.06	0.236
	IQ9	238	2	4	729	3.06	0.26
	IQ10	238	2	4	729	3.06	0.26
	IQ11	238	3	4	733	3.08	0.272
	IQ12	238	3	4	733	3.08	0.272

APPENDIX 17

Validation Feedback Form

VALIDATION FEEDBACK FORM

BIM FM INTEGRATED FRAMEWORK FOR FACILITY MANAGEMENT INFORMATION QUALITY

A. Background

Building Information Modelling (BIM) is gaining recognition in Malaysia as a key enabler of digital transformation, yet its integration into Facility Management (FM) remains limited, especially beyond design and construction stages. This research addresses that gap by examining how socio-technical factor specifically, People, Organization, Technology, and Process affect FM Information Quality (FMIQ). Guided by Socio-Technical Systems (STS) theory, the research further explores the moderating role of BIM Attributes (BA), such as real-time data access, asset visualization, and space management, in strengthening these relationships. Using PLS-SEM, the research analyses data from BIM and non-BIM FM organizations at the firm level in Malaysia, offering a data-driven framework for improving FM information quality through BIM integration.

1. Distributed structured questionnaires to **238 respondents** from facility management organizations across Malaysia.

2. Respondents included both **BIM users and non-BIM users**, representing various firm-level FM operations.

3. **People**, **Organization**, **Technology**, **Process** (independent variables)

4. **BIM Functional Attributes (BFA)** (moderator)

5. **FM Information Quality (FMIQ)** (dependent variable)

6. Used **Partial Least Squares Structural Equation Modelling (PLS-SEM)** to assess the relationships and test moderation effects

B. Purpose

The BIM-FM Integrated Framework developed in this research plays a crucial role in supporting the adoption and integration of BIM within the Facility Management (FM) environment. It is designed to facilitate effective information quality across multi-disciplinary FM stakeholders throughout the post-construction lifecycle. By aligning social (people and organization) and technical (technology and process) components with BIM attributes, the framework enhances collaboration, communication, and coordination across different roles and departments. The framework provides structured guidance on how socio-technical readiness and BIM attributes can be strategically combined to improve the quality, accuracy, and accessibility of FM information, ultimately enabling better-informed decision-making.

C. Components of the BIM-FM Integrated Framework

This framework has 3 major parts

<u>Part 1: Socio-Technical Factor</u>

This includes the social (People and Organization) and technical (Technology and Process) dimensions, derived from Socio-Technical Systems (STS) theory. These components reflect the foundational conditions that influence how FM information is created, shared, and maintained within organizations.

<u>Part 2: BIM Attributes (BA)</u>

BIM is positioned as a **moderating factor,** enhancing the effect of socio-technical factor on information quality.

<u>Part 3: Outcomes</u>

This is the main outcome of the framework. The focus is on improving key aspects of FM information quality such as accuracy, completeness, format, and currency usability essential for efficient decision-making and long-term asset performance.

D. Validation Framework

As part of the validation process for this research, we kindly request your professional feedback on the usefulness and relevance of the BIM-FM Integrated Framework developed to enhance information quality in Facility Management (FM) through BIM integration. Please provide your views by ticking (✓) one option on the five-point Likert scale for each item below:

1 = Poor, 2 = Satisfactory, 3 = Good, 4 = Very Good, 5 = Excellent

Your responses will help evaluate the framework's clarity, applicability, and practicality in real FM contexts.

Ql: How do you rate the appropriateness of the component in the proposed framework in terms of:

Item	Questions	Scale					Comment
		1	2	3	4	5	
1.1	Correct identification of social factors: People						
1.2	Correct identification of social factors: Organization						
1.3	Correct identification of technical factors: Technology						
1.4	Correct identification of technical factors: Process						
1.5 Correct identification of BIM attributes?							
	Lifecycle Data Integration: Enables precise identification, tracking, and management of building assets.						
	Facilitating Real-Time Data Access: Instantaneous access to accurate and updated facility information.						
	Visualization; Graphical tools aiding clearer communication and decision-making.						
	Data interoperability: the ability to integrate data across platforms.						
	Creating Digital Assets: Comprehensive and accurate digital records for improved information management.						
	Space Management: Effective and efficient management and						

	optimization of physical spaces.						
	Planning and Feasibility Studies: Supports informed decisions for both capital and non-capital facility projects.						
	Emergency Management: Preparedness and efficient response to emergencies using BIM data.						
	Controlling and Monitoring Energy: Enhanced energy management practices through continuous monitoring and analysis						

Q2: How do you rate the appropriateness of the component in the proposed framework in terms of :

Item	Questions	Scale					Comment
		1	2	3	4	5	
2.1	Ease of understanding.						
2.2	Ease of use the framework						
2.3	Beneficial use of the framework.						
2.4	Relevance and applicability of the framework						

Q3: Please provide additional comments or suggestions on the applicability of the framework

All information will be treated as confidential and used solely for this research. We would appreciate if you could provide the following information:

Name: ____

Position: ____

Experience: years: __________________________________

Name of organisation: _______________________________

Thank you very much for your valuable contribution to this research.

AUTHOR'S PROFILE

Nur Aisyah Azmi is a PhD candidate at Universiti Teknologi MARA (UiTM), Malaysia. She is currently an assistant director at the Department of Polytechnic and Community College Education (JPPKK), Ministry of Higher Education Malaysia. She previously served as a Lecturer at UTM SPACE, Universiti Teknologi Malaysia and later as a Lecturer at Politeknik Sultan Abdul Halim Mu'adzam Shah (POLIMAS). She holds a Bachelor of Quantity Surveying (Honours) and a Master's degree integrated project management discipline. Nur Aisyah has extensive experience in academic coordination, digital learning development, and national-level educational initiatives, particularly within the Polytechnic and Community College (PolyCC) ecosystem. She has actively contributed to curriculum enhancement, industry collaboration programmes, and institutional digital transformation aligned with national agendas such as the Malaysia Plans and Industry 4.0 initiatives. She has published seven (7) academic papers in indexed journals and conference proceedings, primarily in the areas of Building Information Modelling, Facility Management, socio-technical systems, information delivery, and construction management. Her scholarly works include studies on BIM–FM integration, barriers to BIM adoption, information quality in Facility management, and contractual and organisational challenges in BIM implementation.

LIST OF PUBLICATION: JOURNAL

Azmi, N. A., Ismail, N. A. A., & Rosman, A. F. (2024). The adoption and impact of Building Information Modelling (BIM) towards Facility Management (FM) in Malaysia. *Malaysian Journal of Sustainable Environment*, 11(3), 241–266.

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Azmi, N. A., Ismail, N. A. A., & Rosman, A. F. (2023). A systematic review on barriers in integrating Building Information Modelling (BIM) in Facility Management. *Malaysian Construction Research Journal (MCRJ)*, 20(3), 1–12.

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Azmi, N. A., Brahim, J., & Ismail, Z. (2024). Issues in the design and build (D&B) contract of Building Information Modelling (BIM) project implementation. *Malaysian Construction Research Journal (MCRJ)*, 42(1), 13–26.

LIST OF CONFERENCE ATTENDED

1. International Conference on Built Environment in Developing Countries ICBEDC2024
2. 2ND International Conference on Green & Safe Cities 2024 (Iegresafe).
3. International Conference on Research Methodology for Built Environment and Engineering 2023. (ICRMBEE)
4. International TVET Academic & Research Symposium 2026 (ITARS 5.0)