# Understanding Construction FM Handover Failure: Why Information Loses Meaning and Digital Tools Fail

A Directed Research Project

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# ABSTRACT

Building Information Modelling (BIM) has the potential to improve facility management (FM) by enabling structured information delivery across the asset lifecycle. However, in practice, BIM-FM handover remains inefficient, with facility managers often receiving large volumes of data that are incomplete, poorly structured, or unusable. This study investigates the underlying causes of information meaning loss during construction-FM handover and examines how these challenges can be addressed.

A qualitative research approach was adopted, combining literature-based document analysis with industry interviews to identify recurring information meaning loss. The findings reveal that information breakdown is not confined to the handover stage but occurs progressively across lifecycle phases, originating from unclear FM requirements, lack of standardisation, fragmented data production, and absence of validation mechanisms. These issues result in poor information usability, requiring FM teams to manually reconstruct data for operational use.

To address these challenges, the study proposes a BIM-FM Information Continuity Framework that introduces structured interventions across lifecycle stages, including early definition of information requirements, standardisation, interoperability, validation, and integration into FM systems. The framework shifts the focus from document-based delivery to information-centric lifecycle management.

The study concludes that BIM-FM handover challenges are fundamentally information management issues rather than technological limitations. Ensuring effective FM outcomes requires continuous alignment between information production and operational needs, supported by structured and standardised information practices.

# UNDERTAKING

I declare hereby that the work presented in this Directed Research Project document Understanding Construction FM Handover Failure: Why Information Loses Meaning and Digital tools Fail ? by me, Aditya Parihar, PCM24016 submitted towards partial fulfilment of the requirements for the award of the degree M.TECH. IN CONSTRUCTION ENGINEERING AND MANAGEMENT at the Faculty of Technology, CEPT University, Ahmedabad is an authentic record of my own work carried out during the period of Spring 2026, under the supervision of Sh Siddharth Panjwani and Dr. Amarnath CB. Neither the data, nor any other content of this report have been copied. This work has not been previously submitted to any other institution for the award of any degree/diploma. I understand that my result and grades can be revoked if later it is found to be plagiarised or previous work resubmitted.

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*This document describes work undertaken as part of the Master of Technology in Construction Engineering and Management program at the Faculty of Technology, CEPT University. Author is solely responsible for all views and opinions expressed therein, and do not necessarily represent those of the institute.*

# CERTIFICATE

Title of the DRP : Understanding Construction FM Handover Failure: Why Information Loses Meaning and Digital tools Fail?

Name of the Student : Aditya Parihar

Code No. : PCM24016

The above titled study by the student is approved as a creditable work on the subject carried out and presented in a manner sufficiently satisfactory to warrant its acceptance as a pre-requisite for the degree of Master of Technology (Construction Engineering & Management) for which it has been submitted.

It is to be understood that by this approval, the undersigned do not endorse or approve the statements made, opinions expressed or conclusion drawn therein but approves the study only for the purpose for which it has been submitted by him/her and satisfies the requirements laid down in the academic programme.

Signature of the Guide : ……………………
Signed on 30 April 2026

# ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to my research guides, Sh. Siddharth Panjwani and Dr. Amarnath C.B., for their invaluable guidance, intellectual rigor, and continuous encouragement throughout the development of this Dissertation Research Project. Their critical insights, constructive feedback, and emphasis on analytical clarity have been instrumental in shaping the direction, depth, and academic quality of this study.

I am also sincerely thankful to CEPT University (Centre for Environmental Planning and Technology) for providing an intellectually enriching academic environment that fosters critical inquiry, interdisciplinary engagement, and research excellence. The institutional support and academic resources have played a significant role in enabling the successful completion of this work.

This research is grounded in an extensive body of scholarly literature on Building Information Modelling (BIM), facilities management, and information management practices. Prior studies highlighting the fragmentation of information across the building lifecycle and the consequent loss of data usability have been particularly influential in informing the conceptual framework of this study.

I would also like to acknowledge the contributions of researchers and practitioners in the field of Facility Management, whose work has significantly informed the theoretical and analytical foundations of this research.

# ABBREVIATIONS

AIM : Asset Information Model
AIR : Asset Information Requirements
AI : Artificial Intelligence
BIM : Building Information Modelling
CAFM : Computer-Aided Facility Management
CMMS : Computerized Maintenance Management System
COBie : Construction to Operations Building Information Exchange
DRP : Directed Research Project
EIR : Exchange Information Requirements
FM : Facility Management
IFC : Industry Foundation Classes
ISO : International Organization for Standardization
LOD : Level of Development
O&M : Operation and Maintenance
OIR : Organizational Information Requirements
PIM : Project Information Model

# TABLE OF CONTENTS

# LIST OF FIGURES

# LIST OF TABLES

# CHAPTER-1: INTRODUCTION

Despite rapid digitalisation in the construction industry, the transition of information from construction to facility management continues to face significant challenges. Large volumes of data such as BIM models, asset registers, drawings, and O&M manuals are routinely delivered at project completion. However, in practice, this information often lacks continuity, clarity, and usability for facility management teams, leading to heavy reliance on manual interpretation, rework, and parallel documentation systems (Matarneh et al., 2022; Pärn et al., 2017).

This problem becomes more critical in complex projects involving multiple stakeholders and long asset lifecycles, where effective information continuity is essential for operations and maintenance. While digital tools and BIM-based systems are increasingly introduced to improve handover processes, they frequently fail to deliver the expected value. This is not necessarily due to limitations of the tools themselves, but because the information they rely on is often incomplete, inconsistent, and poorly structured at the point of handover (Tsay et al., 2023).

Existing literature highlights that BIM has strong potential to support facility management; however, persistent issues such as fragmented data, lack of interoperability, and absence of clearly defined information requirements continue to limit its effectiveness (Pärn et al., 2017; Matarneh et al., 2022). Structured formats such as COBie attempt to address these challenges, yet information meaning loss remain in how information is interpreted and used in real operational contexts.

In response to this information meaning loss, this research focuses on understanding why information loses meaning during construction FM handover and why digital tools struggle to compensate for this loss. By analysing handover documents and practitioner experiences, the study aims to identify where breakdowns occur in information structure, context, and usability. The research ultimately seeks to shift the focus from simply delivering data to ensuring that information is meaningful, structured, and aligned with facility management needs.

## 1.1 Background

Construction-FM handover represents a critical transition within the building lifecycle, where responsibility shifts from project delivery teams to facility management (FM) teams responsible for long-term operation and maintenance. Facility management is understood as an integrated process of managing assets, systems, and services to ensure functionality, safety, and operational efficiency throughout the asset lifecycle (Pärn, Edwards, & Sing, 2017). The effectiveness of FM is therefore highly dependent on the quality, structure, and usability of information received at handover.

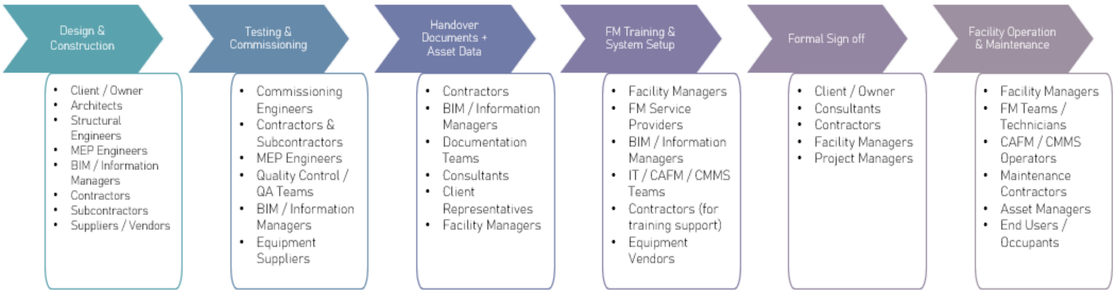


**Figure 1:FM Process**

The handover process is not a single event but a multi-stage lifecycle involving a sequence of interconnected phases: design and construction, testing and commissioning, handover of documents and asset data, FM training and system setup, formal signoff, and finally facility operation and maintenance. As illustrated in Figure 1, each stage involves distinct stakeholders including designers, contractors, BIM/information managers, and facility managers who contribute to the generation, transformation, and transfer of information across the project lifecycle.

Crucially, the nature and role of stakeholders evolve across these stages. While design and construction phases are dominated by architects, engineers, contractors, and suppliers, the later stages progressively introduce FM teams, system operators, and asset managers. However, in conventional project delivery, facility managers are often engaged only during the later stages of handover and system setup. This delayed involvement creates a disconnect between the information produced during earlier phases and the information required for effective facility operations.

Handover extends beyond the transfer of a physical asset and involves the delivery of complex and multi-format information, including BIM models, asset registers, operation and maintenance (O&M) manuals, commissioning data, and system-specific documentation. Ideally, this information should be structured, validated, and aligned with FM requirements to ensure seamless continuity from construction to operation.

However, the involvement of multiple stakeholders across fragmented stages, combined with diverse tools, standards, and data formats, introduces significant challenges in maintaining information consistency and usability. As information moves across lifecycle stages, it is often transformed, reinterpreted, or lost, leading to information meaning loss in asset data, poor standardisation, and reduced operational relevance.

Understanding how these information breakdowns emerge across stakeholder interactions and lifecycle stages is therefore essential. This study examines the FM handover process as an information continuity problem, focusing on how information is generated, transferred, and ultimately utilised by FM teams, and where its meaning and usability degrade within this transition.

# CHAPTER-2: RESEARCH METHODOLOGY

This study adopts a qualitative exploratory research approach to investigate information meaning loss during the transition from construction to facility management (FM). The research focuses on understanding how informational meaning degrades across lifecycle stages and how this impacts the usability of information in FM operations.

## 2.1 Research Design

The study integrates two complementary qualitative methods:
- Literature-Based Analysis
- Semi-Structured Interviews with FM Professionals

This combined approach enables triangulation, strengthening the reliability of findings by linking theoretical insights with practical industry experience. While literature establishes the conceptual understanding of BIM-FM challenges, interviews validate these issues in real-world contexts.

## 2.2 Literature Based Analysis

Due to the absence of access to project-specific handover datasets, this study adopts a literature-driven document analysis approach. Academic publications, industry reports, and international standards are treated as proxy datasets representing typical handover practices. The following sources were analysed:
- Peer-reviewed research on BIM-FM integration
- Industry standards and guidelines
- Published case studies on construction-FM handover

The analysis focused on identifying:
- Recurring information management challenges
- Causes of data fragmentation and interoperability issues
- Misalignment between information production and FM requirements

This approach enables the study to establish a robust theoretical foundation, supported by consistent evidence across multiple sources. Existing literature highlights persistent issues related to data quality, interoperability, and lifecycle information continuity, which directly inform this research.

## 2.3 Semi-Structured Interviews

To complement and validate literature findings, semi-structured interviews were conducted with FM professionals.
- Participants: 10 professionals with a minimum of 5 years' experience in Facility Management
- Objective: To contextualise and validate literature-identified information meaning loss within real operational environments

The interviews focused on the following themes:
- Usability of handover information
- Completeness and quality of asset data
- Challenges in interpreting documentation
- Extent of manual data reconstruction
- Impact of information issues on FM operations

This method provides context-rich insights, capturing practical challenges that are often not fully represented in literature.

### 2.4 Data Analysis Approach

The study employs thematic analysis to systematically interpret both literature and interview data.
- Data from both sources were coded and categorised
- Recurring patterns were identified and grouped into key themes
- These themes were synthesised into structured categories of information meaning loss.

A central analytical concept used in this study is "meaning-loss mapping", which refers to identifying points where information loses:
- Clarity
- Structure
- Context
- Operational relevance

This includes:
- Missing or incomplete asset data
- Lack of structured relationships between information elements
- Poor standardisation and naming conventions
- Disconnect between design/construction data and FM requirements

This analytical approach enables a process-oriented understanding of how information degradation occurs across lifecycle stages.

### 2.5 Research Assumptions

This study is based on the following key assumptions:
- Information meaning loss is a lifecycle issue: Information degradation occurs progressively across design, construction, and handover phases, rather than at a single point.
- FM performance depends on information usability: Effective facility management relies on structured, meaningful, and accessible information—not just the presence of data.
- BIM implementation is inconsistent in practice: Although BIM is intended to enable seamless information flow, its real-world application often fails to meet FM requirements.

## 2.6 Scope Definition Using Handover Model

To ensure analytical clarity, the study is scoped within the **traditional construction-to-FM handover model (Model 1)**, as illustrated in Figure 2.


**Figure 2:FM handover model**

While alternative models such as FM led and integrated delivery approaches exist, this research focuses on the traditional model, where:

- Information is delivered at project completion
- FM teams receive and interpret information post-handover

This model is selected for three key reasons:

1. It reflects the most common industry practice, particularly in conventional procurement systems
2. It provides a distinct transition point, enabling clear analysis of information degradation
3. It exposes maximum information meaning loss, due to limited early FM involvement

This defined scope ensures that the study remains focused, consistent, and grounded in real-world practice.

## 2.7 Research Question

How does informational meaning loss occur during construction FM handover, and how does this meaning loss affect FM usability of delivered information?

## 2.8 Scope and Limitations

This study focuses on information usability and information continuity in BIM FM handover.

**Key limitations include:**

- Absence of direct project-based document analysis
- Dependence on secondary (literature-based) data
- Limited sample size of interview participants

Despite these limitations, the use of triangulated qualitative methods ensures that the findings are robust, consistent, and grounded in both theory and practice.

# CHAPTER-3: LITERATURE REVIEW FOUNDATION

This section establishes the key concepts, standards, and frameworks that underpin Building Information Modelling (BIM) and its application in facility management (FM). These definitions provide the conceptual foundation necessary to understand how information is generated, structured, and transferred across the building lifecycle.

## 3.1 Building Information Modelling (BIM)

Building Information Modelling (BIM) is defined as a process and technology for creating, managing, and exchanging digital representations of physical and functional characteristics of a facility across its lifecycle (Eastman et al., 2008).
BIM integrates both geometric (3D) and non-geometric data, allowing building components to be represented as intelligent objects with attributes such as material properties, performance data, and relationships with other elements. This enables a coordinated digital model that supports multiple stakeholders throughout design, construction, and operation.

## 3.2 BIM for Facilities Management (BIM-FM)

BIM-FM refers to the application of BIM-generated information to support operations and maintenance (O&M) activities. It facilitates access to structured data related to:

- Building assets
- Systems and components
- Spatial information
- Maintenance and operational parameters

This information supports planning, monitoring, and management of facilities during the operational phase (Pärn et al., 2017).

## 3.3 BIM Maturity Levels

BIM maturity levels describe the progressive stages of digital collaboration and information integration within construction projects. The commonly referenced framework (Levels 0–3) illustrates the evolution from fragmented documentation to fully integrated, model-based collaboration.

- Level 0 - represents traditional 2D documentation with no structured collaboration.
- Level 1 - introduces managed CAD environments and partial digital coordination through a Common Data Environment (CDE).
- Level 2 - enables federated 3D models developed by different disciplines and exchanged through standardized formats (e.g., IFC), improving coordination and interoperability.
- Level 3 - represents full integration, where stakeholders operate within a shared, centrally managed model environment supporting real-time collaboration and extended lifecycle applications.

As maturity increases, information becomes more structured, interoperable, and collaboratively managed. Higher maturity levels align with lifecycle-oriented information governance frameworks such as ISO 19650, particularly in their emphasis on shared environments and standardized data exchange.

However, BIM maturity primarily measures the sophistication of collaboration and digital integration. It does not inherently assess semantic continuity or operational interpretability. A project may operate at Level 2 or Level 3 and still experience informational meaning degradation at the construction–FM interface. Thus, while BIM maturity enhances structural coordination, it does not guarantee that delivered asset information will be usable in facility management contexts.

## 3.4 Information Requirements: OIR, AIR, and EIR

Information Requirements define the type, level, and purpose of information needed at different stages of the building lifecycle.

- Organisational Information Requirements (OIR): Define strategic information needs aligned with organisational objectives.
- Asset Information Requirements (AIR): Specify the information required to manage assets during their operational life.
- Exchange Information Requirements (EIR): Define the information to be delivered by project stakeholders at various project stages.

These requirements ensure that information production aligns with the intended use of data.

## 3.5 ISO 19650 Framework

ISO 19650 is an international standard that provides a framework for managing information over the whole lifecycle of a built asset using BIM .
It establishes principles for:

- Information planning and management
- Data structuring and naming conventions
- Information exchange processes
- Use of a Common Data Environment (CDE)

The framework ensures that information is consistently created, managed, and shared among stakeholders.

## 3.6 Project Information Model (PIM) and Asset Information Model (AIM)

BIM information is structured into two key models:

- Project Information Model (PIM):Developed during the design and construction phases, containing project-specific information.
- Asset Information Model (AIM):The final dataset used during the operational phase for managing the facility.

The AIM is derived from the PIM at the point of handover and serves as the primary information source for FM activities.

## 3.7 buildingSMART Standards and Open Exchange Formats

buildingSMART International develops open standards to enable interoperability and data exchange in BIM environments.
Key standards include:

- Industry Foundation Classes (IFC): A standardised data schema that enables the exchange of building information between different software platforms.

- Construction Operations Building Information Exchange (COBie): A structured format for capturing and delivering asset data for facility management.
- BIM Collaboration Format (BCF): A format used for communicating issues and coordination data between project stakeholders.

These standards support a vendor-neutral approach to information exchange (buildingSMART International, 2020).

## 3.8 COBie (Construction Operations Building Information Exchange)

COBie is a data specification used to capture and deliver non-geometric information related to building assets (East, 2012).
It typically includes:

- Equipment and component data
- Manufacturer information
- Maintenance schedules
- Documentation references

COBie is commonly delivered in spreadsheet format and is designed to support the transfer of information from construction to FM systems.

## 3.9 Level of Development (LOD) Framework

The Level of Development (LOD) framework, developed by the American Institute of Architects (AIA), defines the degree of detail and reliability of BIM elements at different stages of project development (AIA, 2013).
Typical levels include:

- LOD 100: Conceptual representation
- LOD 200: Approximate geometry
- LOD 300: Accurate geometry and location
- LOD 350: Includes interfaces and connections between building systems
- LOD 400: Fabrication-level detail
- LOD 500: As-built representation

LOD provides a structured approach for developing and communicating model detail across project stages.

## 3.10 Relationship Between LOD and COBie

LOD and COBie represent two complementary aspects of BIM information:

- LOD: Defines the level of geometric and graphical detail of model elements
- COBie: Defines the structured non-geometric data required for asset management

Together, they contribute to the overall completeness of building information by combining physical representation and associated asset data.

## 3.11 Data Drops

Data Drops refer to defined points in the project lifecycle where information is formally delivered and exchanged between stakeholders.
These typically occur at key project stages such as:

- Concept design
- Detailed design

- Construction completion
- Handover

Each Data Drop ensures that information is progressively developed and transferred in a structured manner.

### 3.12 Soft Landings Framework

Soft Landings is a framework that promotes ongoing collaboration between project teams and facility management throughout the building lifecycle (BSI, 2014).
It focuses on:

- Early involvement of FM teams
- Continuous feedback during design and construction
- Post-occupancy evaluation

This approach supports the alignment of design intent with operational performance.

### 3.13 Common Data Environment (CDE)

A Common Data Environment (CDE) is a centralised digital platform used to collect, manage, and disseminate project information (ISO, 2018).
It enables:

- Version control
- Collaboration among stakeholders
- Structured information storage

The CDE ensures that all project participants access and work with the same information source.

### 3.14 Facility Management Systems (CAFM / CMMS)

Facility management operations are supported by digital systems such as:

- CAFM (Computer-Aided Facility Management): Used for managing space, assets, and services
- CMMS (Computerised Maintenance Management Systems): Used for managing maintenance activities and asset performance

These systems rely on structured data inputs to support operational workflows (Autodesk & IFMA, 2013).

The concepts discussed above collectively illustrate that BIM-enabled information management is structured across the building lifecycle through a series of interconnected frameworks, standards, and data models. Each term contributes to defining how information is specified, created, coordinated, and transferred from design to facility management. To consolidate this understanding, the following table maps these key concepts in relation to their roles and stages within the building lifecycle.

**Table 1: Relationship of Key BIM–FM Concepts Across the Building Lifecycle, illustrating their roles in information definition, development, coordination, and transfer from design to facility management.**

| Lifecycle Stage | Key Concepts | Role in Lifecycle | Relationship |
|---|---|---|---|
| **Project - Initiation** | OIR | Defines organisational goals | Drives AIR and EIR |
| | ISO 19650 | Sets information management principles | Governs entire lifecycle |
| | CDE | Platform for data management | Used across all stages |
| **Design Phase** | EIR | Defines what information is needed | Guides designers |
| | LOD (100–300) | Defines level of model detail | Controls model development |
| | IFC | Enables data exchange | Supports interoperability |
| | PIM (initial) | Central design information model | Stores all project data |
| | Data Drops (early) | Structured information submissions | Formal checkpoints |
| **Coordination Phase** | LOD 350 | Defines system relationships | Enables interdisciplinary coordination |
| | BCF | Issue tracking and coordination | Supports collaboration |
| **Construction Phase** | LOD 400 | Fabrication-level detail | Supports construction execution |
| | COBie (data capture) | Captures asset information | Prepares FM dataset |
| | Data Drops (mid/late) | Verified information exchange | Ensures structured delivery |

| | | | |
|---|---|---|---|
| | PIM (final) | Completed project information | Basis for AIM |
| **Handover Phase** | COBie (final) | Structured asset data delivery | Input for FM systems |
| | AIM creation | Transformation of PIM - AIM | Critical transition stage |
| | Soft Landings | Ensures FM involvement | Supports knowledge transfer |
| **Operation (FM) Phase** | AIM | Operational information model | Used for FM activities |
| | CAFM / CMMS | Facility management systems | Use AIM data |
| | Information Quality (IQ) | Ensures usability of data | Supports decision-making |
| | Knowledge Management | Enables learning and optimisation | Enhances FM performance |

# CHAPTER-4: LITERATURE REVIEW

This section focuses on understanding why information meaning loss occurs during the Construction FM handover process and how it affects the usability of data in facility management operations.

Although the handover process is designed to be structured and systematic, research shows that the information delivered at this stage is often difficult to use in practice. Information created during design and construction does not always translate into meaningful or usable knowledge for FM teams. Instead, facility managers frequently receive data that is incomplete, poorly organized, or lacking the level of detail required for day-to-day operations (Autodesk & IFMA, 2023; Mohanraj, 2021). In many cases, this information is scattered across different formats and systems, making it difficult to access, interpret, and integrate into FM workflows (Mohanraj, 2021).

To better understand these challenges, studies have grouped the causes of information meaning loss into five key domains: People, Process, Information, Digital Tools, and Governance. As illustrated in Figure 3, these domains show that the issue is not only technical but also shaped by how people work, how processes are managed, and how decisions are made within projects (Mohanraj, 2021).

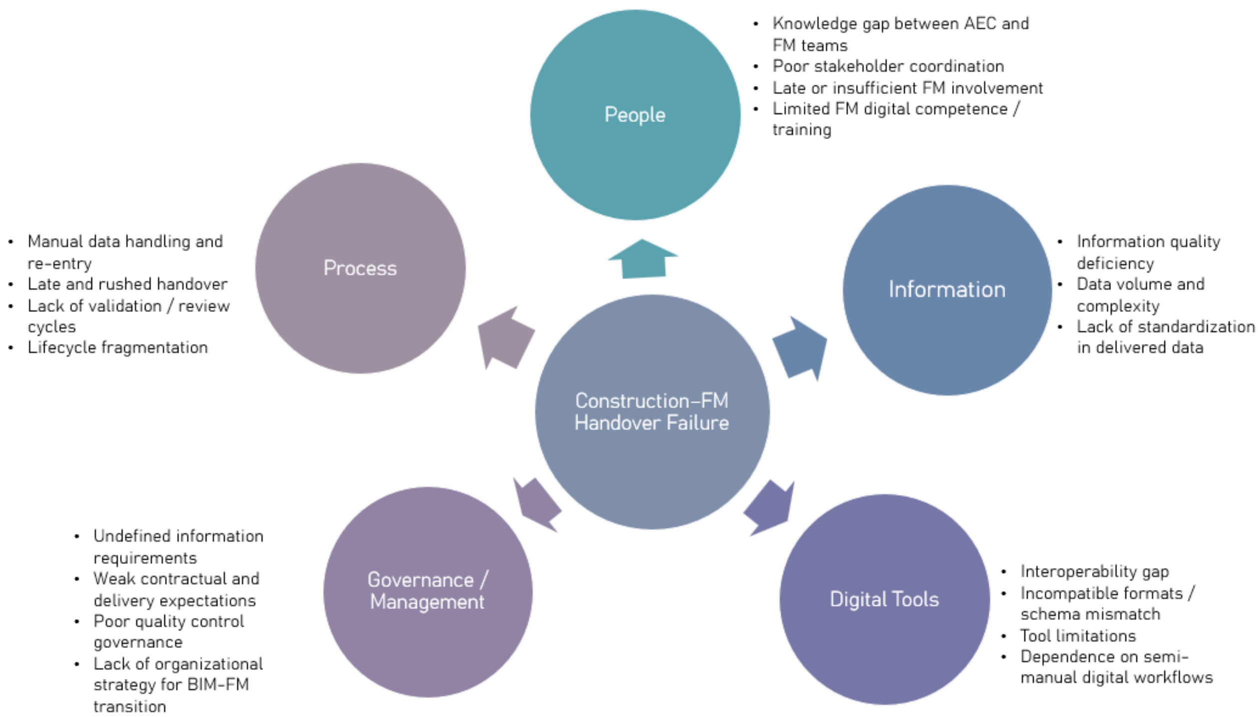


**Figure 3: Information meaning loss categories**

For example, poor coordination between stakeholders can lead to information meaning loss in communication and missing information. Similarly, the absence of clearly defined information requirements means that the data produced during earlier stages may not match what FM teams actually need. In addition, reliance on manual data handling and unstructured workflows increases the risk of errors, duplication, and inconsistencies.

Technical challenges, such as lack of interoperability between systems and incompatible data formats, further limit the usability of information. Weak governance and lack of quality control mechanisms also contribute to the problem by allowing incomplete or incorrect information to pass through the handover stage (Becerik-Gerber et al., 2012; East, 2013; Mohanraj, 2021; Volk et al., 2014).

Overall, these issues demonstrate that information meaning loss in FM handover is not caused by a single factor but emerges from a combination of interconnected problems across the project lifecycle. Understanding these underlying causes is essential for improving how information is managed and delivered. The following sections explore each of these domains in more detail to identify the root causes of information meaning loss and their impact on FM practice.

## 4.1 Definition of Informational Meaning Loss

Informational Meaning Loss refers to the degradation of the usability, interpretability, and contextual relevance of information as it moves across lifecycle stages, such that the receiving stakeholder (FM) cannot effectively use it for decision making or operations.

## 4.2 Informational Meaning Loss in Handover Data

Information quality is a critical factor influencing the effectiveness of construction FM handover. Although large volumes of data are transferred at project completion, this information is often incomplete, poorly structured, or misaligned with the operational needs of facility managers. As a result, FM teams frequently struggle to use handover information effectively for maintenance and asset management (East, 2012; Mohanraj, 2021).

A key contributor to poor information quality is the late involvement of FM stakeholders in the project lifecycle. When FM teams are not engaged during the design and construction phases, the information generated tends to reflect construction priorities rather than operational requirements. This disconnects leads to the delivery of data that lacks relevance, context, and usability for FM purposes. As illustrated in Figure 4, early FM engagement throughout the project lifecycle results in higher-quality and more complete information at handover, whereas late involvement leads to significant information meaning loss and reduced usability.

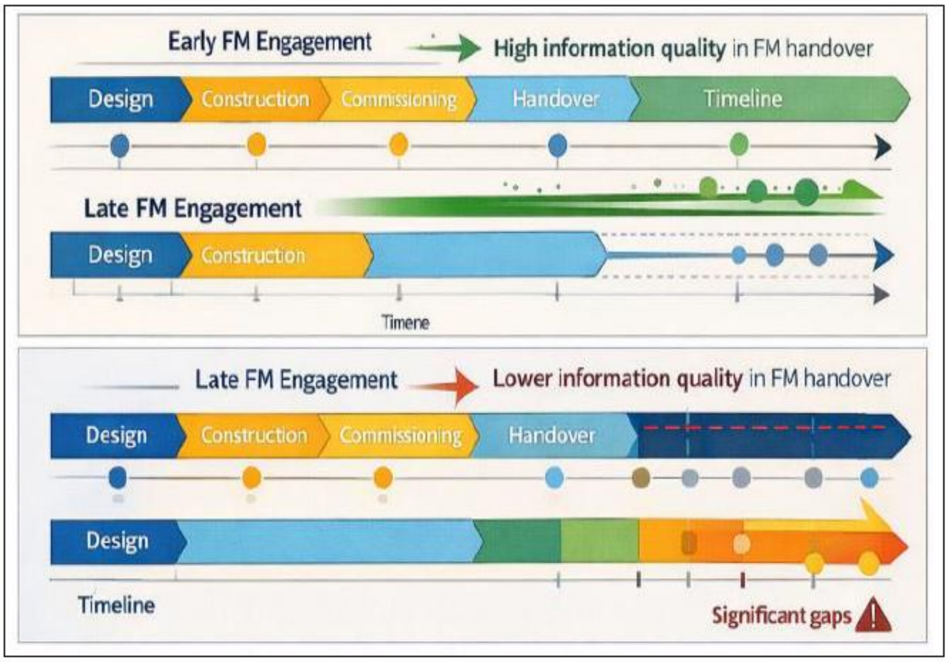


**Figure 4: Comparison of early and late FM engagement and its impact on information quality at handover. (Mohanraj, 2021)**

The issue of information quality is also influenced by the nature and volume of data transferred. Studies indicate that handover processes often result in an overwhelming amount of information, much of which lacks direct operational value. Facility managers are therefore required to filter, interpret, and reorganize large datasets to extract useful insights. As shown in Figure 5, this "tsunami of information" includes both valuable and non-valuable data, placing a significant burden on FM personnel to identify and reconstruct meaningful information (Thabet and Lucas, 2017).

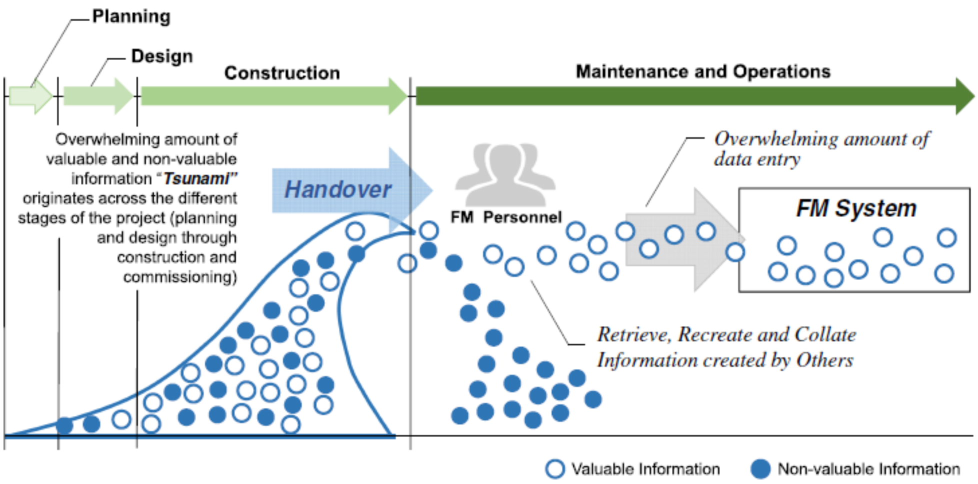


**Figure 5: Illustration of information overload during construction FM handover ("tsunami of information") highlighting the presence of both valuable and non-valuable data. (Thabet and Lucas, 2017)**

## 4.3 Meaning Loss from Poorly Defined Information Requirements

A critical meaning loss underpinning many handover issues is the lack of clearly defined FM specific information requirements. Frameworks such as Asset Information Requirements (AIR) and Employer's Information Requirements (EIR), as emphasized in ISO 19650, are intended to guide structured information delivery however, their implementation remains inconsistent in practice (ISO, 2018; Mohanraj, 2021). As illustrated in Figure 6, information requirements are expected to follow a structured hierarchy from Organizational Information Requirements (OIR) to AIR, PIR, and EIR ensuring that high level organizational needs are translated into detailed, project specific information deliverables.

However, in practice, facility owners often lack the expertise to define precise requirements, resulting in generic or poorly structured specifications that fail to align with operational needs (Mohanraj, 2021). Consequently, the information generated during design and construction does not effectively support FM activities, reinforcing the disconnect between data production and operational use. This information meaning loss highlights the absence of a clearly defined "information demand side" in many projects, despite the existence of structured frameworks.

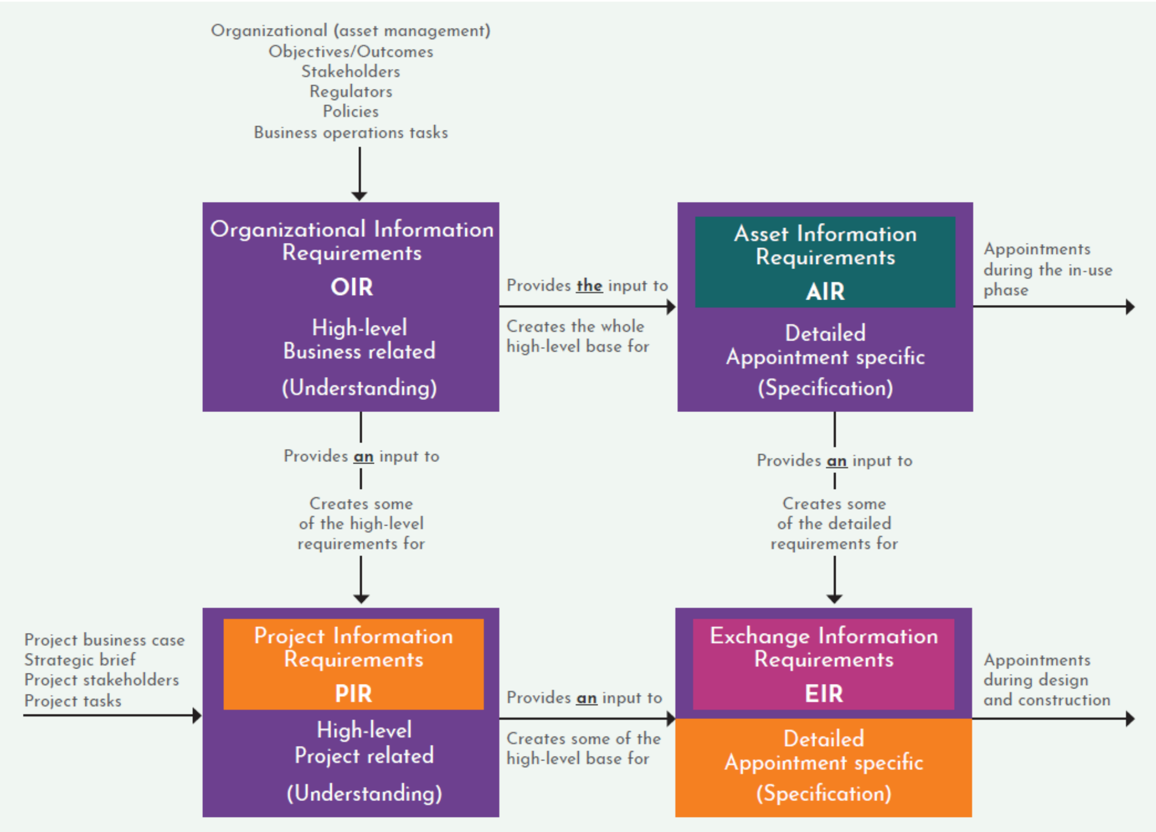


**Figure 6: Information requirements hierarchy (OIR-AIR-EIR-AIM). Source: International Organization for Standardization. ISO 19650-1: Organization and Digitization of Information about Buildings and Civil Engineering Works. 2018.**

## 4.4 Impact of Data Structure and Standardization on Informational Meaning

Even when information is available, its structure and format often limit its usability. Standardized data exchange formats such as COBie and IFC have been developed to facilitate interoperability however, their practical implementation presents significant challenges. Research shows that inconsistent interpretation of data schemas, incomplete data population, and insufficient validation processes result in fragmented and unreliable datasets (East, 2012; Mohanraj, 2021). While COBie provides a simplified structure for data exchange, it often fails to capture complex relationships between building systems, leading to partial information meaning loss during translation. Similarly, IFC, although comprehensive, is often too complex and inconsistently implemented across platforms, limiting its practical application in FM (Pärn et al., 2017; Automated and Interconnected FM System, 2017).
These challenges are further compounded by inconsistencies in asset classification and naming within BIM environments. As illustrated in Figure 7, the same asset can be categorized differently across models, resulting in ambiguity and reduced usability of data for FM systems. Such inconsistencies highlight the lack of standardized data structuring practices, even when digital models are available.

These findings suggest that the existence of standards alone does not guarantee effective data exchange; rather, consistent implementation and validation are essential.

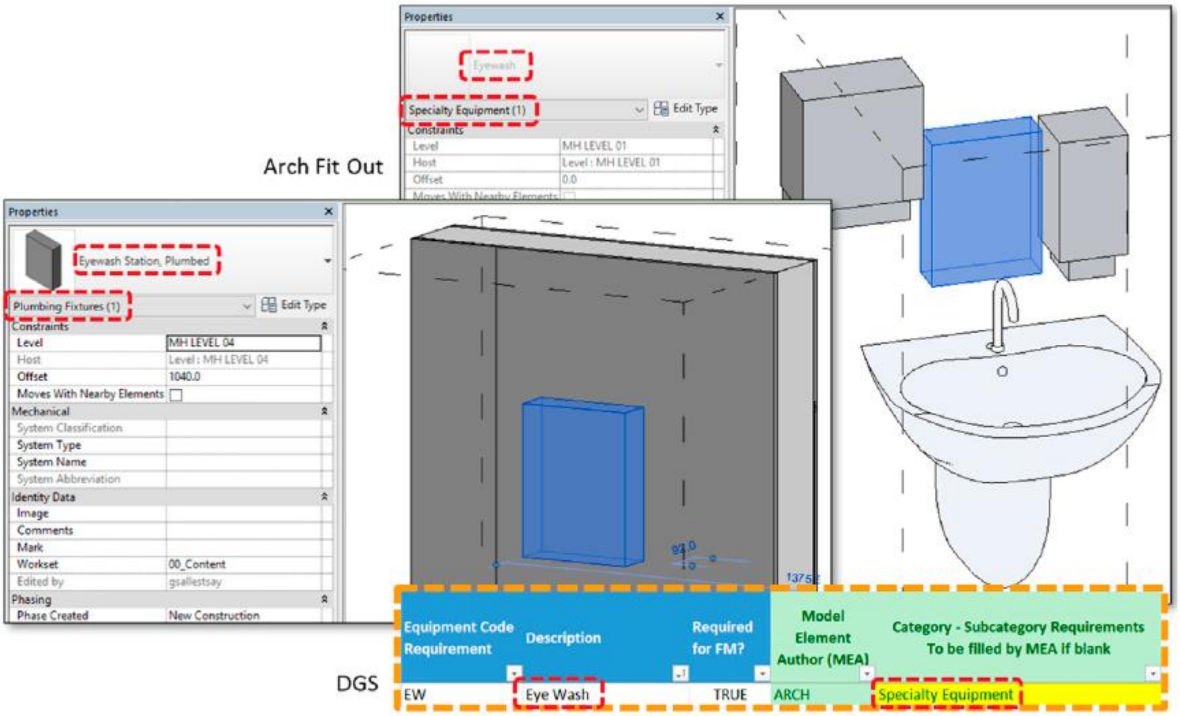


**Figure 7: Example of inconsistent asset classification and naming in BIM models affecting FM data usability. Source: BIM-FM Consortium, BIM for FM Guide v2.1, 2012**

## 4.5 Meaning Loss from Poor Interoperability and System Integration

The integration of BIM with FM systems remains a major challenge, even when standardized data formats are used. Differences in data schemas, classification systems, and software capabilities often lead to difficulties in transferring information between BIM platforms and FM systems such as CMMS or CAFM. As illustrated in Figure 8, the asset information delivery process involves multiple stages from BIM requirements and model development to external databases and final integration into FM systems each requiring data transformation and validation. These multiple transitions increase the likelihood of information meaning loss, inconsistency, and misinterpretation across systems.

Studies indicate that data exchange frequently results in issues such as duplication, data loss, and incompatibility, requiring additional interventions such as middleware platforms or custom programming solutions (Mohanraj, 2021; Thabet and Lucas, 2017). These workarounds increase both cost and complexity while reducing the efficiency of digital workflows. Additionally, research on semantic web technologies highlights that the lack of unified data models and semantic consistency further limits interoperability across AEC systems (Pauwels et al., 2017).

This information meaning loss demonstrates that technological fragmentation, rather than the absence of tools, remains a key barrier to achieving seamless information continuity between BIM and FM systems.

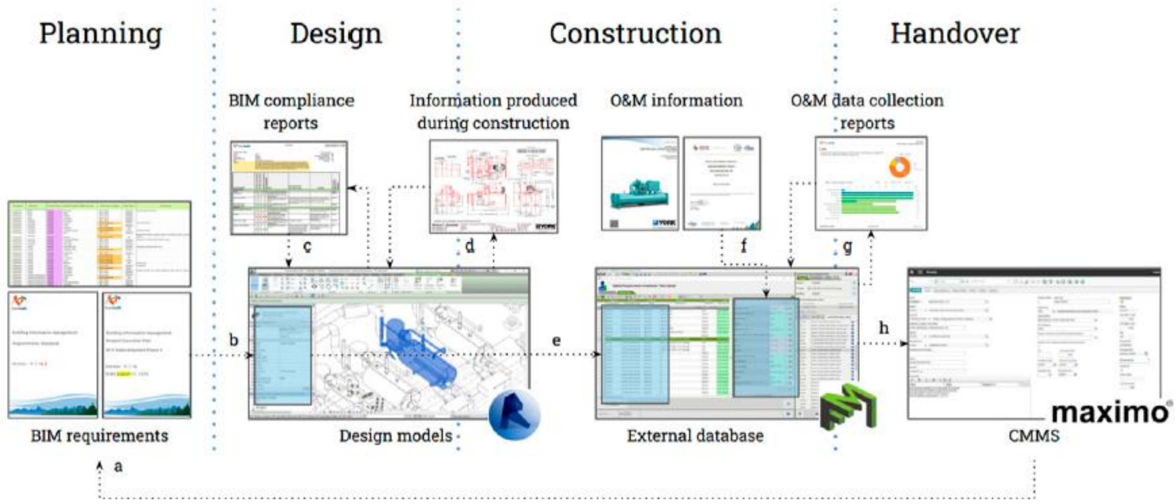


**Figure 8: Schematic representation of the asset information delivery process in BIM, illustrating data transformation from BIM models to external databases and integration into FM systems. (Tsay et al., 2022).**

## 4.6 Meaning Loss from Fragmented Project Processes

The fragmented nature of project delivery processes significantly contributes to information meaning loss. Design, construction, and operations are often treated as discrete phases, with limited integration and continuity of information across the lifecycle (Autodesk & IFMA, 2023).

Handover is typically approached as a final-stage activity, rather than a continuous and integrated process, resulting in rushed workflows and incomplete data transfer. Studies indicate that only a fraction of the information generated during design and construction is effectively transferred to FM teams, with substantial losses occurring during this transition

(Mohanraj, 2021).This fragmentation disrupts the flow of information and undermines the potential of BIM as a lifecycle information management tool.

## 4.7 Meaning Loss from Manual Data Handling

Closely linked to process inefficiencies is the continued reliance on manual data handling practices. In many projects, information is extracted from drawings, reports, and BIM models and manually entered into FM systems, introducing errors and inconsistencies. As illustrated in Figure 9, asset data is typically collected from multiple sources, manually transferred into spreadsheets, verified through site walkthroughs, and then re-entered to create asset records. This fragmented workflow highlights the dependence on manual intervention despite the availability of digital models.

Manual data transfer processes are not only time-consuming but also highly prone to inaccuracies, resulting in reduced data reliability and increased operational inefficiencies (Mohanraj, 2021; Eastman et al., 2018). This information loss reflects a disconnect between digital information generation and its practical application in FM systems.

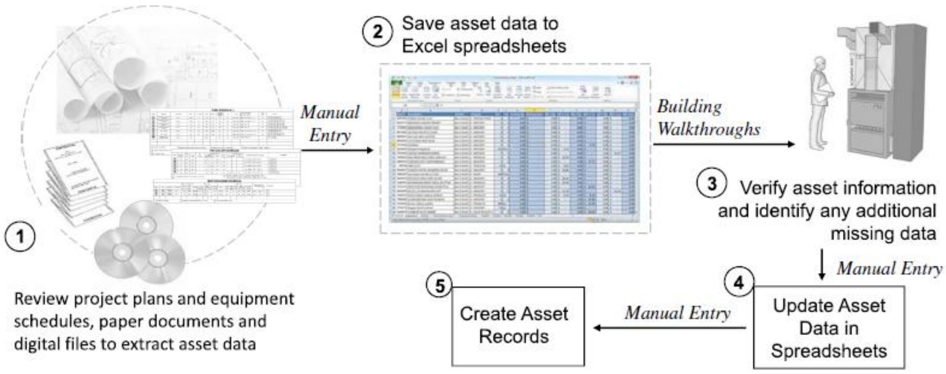


**Figure 9: Current asset data collection and manual entry practices in BIM–FM workflows, highlighting reliance on spreadsheets and manual verification processes. (Thabet and Lucas, 2017)**

## 4.8 Meaning Loss from Stakeholder knowledge and coordination

The literature consistently identifies a significant information loss in knowledge and coordination between AEC and FM stakeholders. Design and construction teams typically possess strong expertise in BIM technologies but have limited understanding of FM operational requirements, while facility managers often lack familiarity with BIM processes and digital tools (Mohanraj, 2021; Pärn et al., 2017).

This disconnect leads to poor communication and misalignment of expectations, resulting in the delivery of information that does not meet FM needs. Furthermore, the late involvement of facility managers in the project lifecycle restricts their ability to influence information requirements and ensure relevant data is captured (Volk et al., 2014; Autodesk & IFMA, 2023).

## 4.9 Role of Governance in Information Meaning Loss

Governance-related issues underpin many of the challenges identified in FM handover. The absence of clear roles, responsibilities, and validation procedures leads to weak oversight of information quality throughout the project lifecycle.

Without structured governance frameworks, there is limited accountability for ensuring that information meets required standards. Additionally, contractual arrangements often fail to enforce the delivery of FM-ready information, allowing inconsistencies and omissions to persist (ISO, 2018; Mohanraj, 2021).

Research also indicates that organizations lacking a strategic approach to BIM-FM integration struggle to realize the full benefits of digital handover, highlighting the importance of governance in enabling effective information management (Autodesk & IFMA, 2023)

## 4.10 Synthesis of Literature Findings

The findings of this study indicate that information meaning loss in BIM-FM handover is primarily driven by poor structuring, inconsistency, and limited usability of data across key deliverables. Rather than occurring at a single stage, meaning loss accumulates progressively across the handover chain, as illustrated in Figure 9.

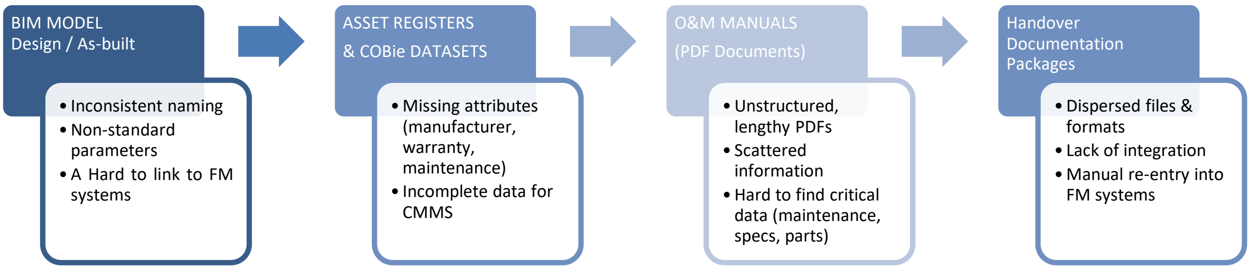


**Figure 10: Information meaning loss in BIM–FM handover datasets.**

Figure 10 demonstrates how information degradation begins within BIM models through inconsistent naming conventions and non-standard parameters, which limit their usability for FM systems (Tsay et al., 2023). This issue continues in asset registers and COBie datasets, where critical attributes such as maintenance and warranty information are often incomplete, reducing their effectiveness for asset management. The problem becomes more pronounced in O&M manuals, which are typically delivered as unstructured documents, making information difficult to access. Finally, handover documentation packages are often fragmented and require manual re-entry, increasing the likelihood of errors (Mattern et al., 2022).

However, the impact of this information loss extends beyond data quality and directly affects multiple stakeholders involved in facility operations, as illustrated in Figure 10.

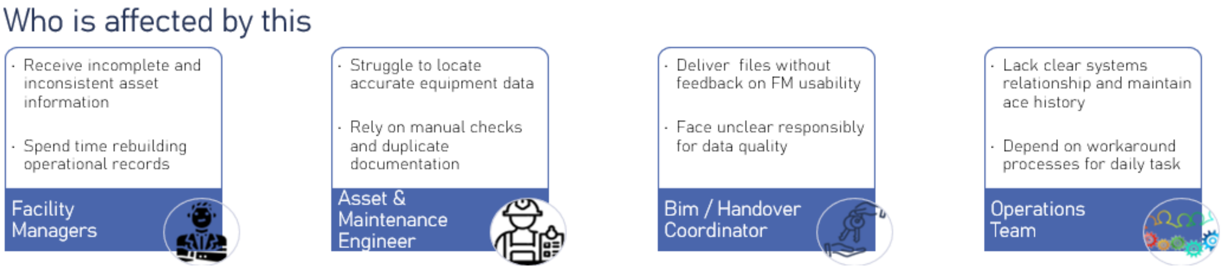


**Figure 11: Affected Stakeholders**

Figure 11 highlights that facility managers are required to rebuild incomplete asset information, while asset and maintenance engineers struggle to locate accurate technical data and often rely on manual verification processes. At the same time, BIM or handover coordinators face unclear responsibility for data quality, and operations teams depend on workaround processes due to lack of system integration. These challenges demonstrate that information meaning loss is not only a technical issue but a practical and operational problem that reduces efficiency, increases workload, and limits effective decision-making across the asset lifecycle.

Overall, the findings confirm that meaning loss is a cumulative issue arising from incompleteness, inconsistency, poor structuring, and lack of interoperability across information deliverables (Pärn et al., 2017). Addressing this requires a shift towards structured, standardized, and FM-aligned information practices, guided by frameworks such as Asset Information Requirements (AIR) and Employer's Information Requirements (EIR), to ensure that information retains its meaning and usability throughout the lifecycle.

# CHAPTER-5: FINDINGS AND ANALYSIS

The findings presented in this study are derived from a combination of literature analysis and semi-structured interviews with facility management (FM) professionals. While literature provides a theoretical understanding of BIM-FM handover challenges, interviews offer practical insights into how these issues manifest in real-world operations. The integration of both sources enables a comprehensive evaluation of information meaning loss across the project lifecycle.

## 5.1 Identification Criteria for Meaning Loss

Informational meaning loss types were identified using the following criteria:

1. Context Loss

Occurs when the intent behind information is not preserved.
For example, asset data may exist, but FM teams do not know why it was created or how it supports operations.
This is primarily caused by:

- weak or absent OIR/AIR definitions
- late involvement of FM stakeholders

2. Semantic Loss

Refers to the loss of interpretability of information, particularly by machines or non-design stakeholders.
For instance:

- BIM objects lack standardized naming or classification
- data is not aligned with FM systems

This reflects the broader issue that BIM models are often design-centric rather than operation-centric, limiting their usability for FM .

3. Completeness Loss

Occurs when critical asset information is missing at the point of handover.
Examples include:

- missing maintenance schedules
- absence of spare part data
- incomplete equipment specifications

This aligns with industry findings that significant portions of construction data are not transferred to operations, leading to inefficiencies .

4. Structure Loss

Refers to the loss of structured, machine-readable data formats.
Instead of structured datasets (e.g., COBie), information is delivered as:

- PDFs
- scattered manuals
- non-standard documents

As a result, FM teams must manually extract and recreate data, which introduces errors and inefficiencies.

5. Continuity Loss

Occurs when information is not consistently maintained across lifecycle stages.
This is caused by:

- lack of interoperability between systems
- absence of a continuous information management strategy

Consequently, FM teams receive disconnected datasets, requiring reconstruction of asset information.

## 5.2 Literature Based Analysis

The literature consistently identifies that BIM–FM handover challenges are not due to a lack of data, but due to deficiencies in information structure, quality, and usability.

**Literature-Based Identification of BIM–FM Information meaning Loss**

**Table 2: Summary of Literature on BIM–FM Information Meaning Loss**

| Informational Meaning Loss Type | Description | Literature Evidence | Impact on FM |
|---|---|---|---|
| **Context Loss** | Absence of clearly defined AIR/EIR and FM intent | Mohanraj (2021) | Misalignment between delivered data and FM needs |
| **Semantic Loss** | Inconsistent naming, classification, and metadata | Eastman et al. (2018); Pärn et al. (2017) | Data difficult to interpret and query |
| **Structure Loss** | Fragmented and unstructured documentation formats | BIM Handbook; Thabet & Lucas (2017) | Increased effort to locate and integrate data |
| **Completeness Loss** | Missing asset attributes and information | Tsay et al. (2023) | Limits operational decision-making |
| **Continuity Loss** | Data loss during transfer across systems and stages | East (2012); Tan et al. (2018) | Decline in reliability across lifecycle |

The analysis highlights recurring issues, including lack of defined FM requirements, poor standardisation, fragmented documentation, incomplete asset data, interoperability limitations, and absence of contextual relationships. Collectively, these issues indicate that although information is generated throughout the lifecycle, it often lacks the structure and context required to support FM operations

## 5.3 Semi- Structure Interview Analysis

The interview findings validate and extend the literature by demonstrating how these information meaning losses are experienced in practice.

### Interview-Based Evidence of BIM–FM Information Challenges

**Table 3: Interview-Based Evidence of BIM–FM Information Challenges and Their Operational Impacts**

| Informational Meaning Loss Type | Observed Issue | Evidence from Interviews | Operational Impact |
|---|---|---|---|
| **Context Loss** | Late FM involvement | "We are not involved until handover" | Data does not align with operational needs |
| **Structure Loss** | Unstructured and scattered data | "We search across multiple files" | Inefficient workflows |
| **Semantic Loss** | Data not interpretable | "Data is there but not usable" | Requires manual interpretation |
| **Completeness Loss** | Missing or unreliable data | "No one verifies if data is complete" | Poor decision-making |
| **Continuity Loss** | System integration failures | "It doesn't fit our system" | Limits automation and usability |

The interviews reveal that FM teams frequently receive information that is available but not usable. Key challenges include late FM involvement, fragmented documentation, lack of validation, and difficulties in integrating data into FM systems. A consistent pattern across responses is the reliance on manual data reconstruction, indicating that digital deliverables fail to meet operational requirements.

These findings reinforce that BIM–FM handover failures are primarily usability issues, where the problem lies not in data availability but in its structure, relevance, and interpretability.

## 5.4 Integrated Analysis of Information loss

The combined analysis of literature and interviews indicates that information meaning loss are not isolated to the handover stage but emerge progressively across the lifecycle.

Three key patterns are identified:

1. Upstream Origin of Information meaning loss

Information meaning loss originate at the project initiation stage due to poorly defined FM requirements and limited stakeholder integration. Early-stage decisions significantly influence downstream information usability.

2. Progressive Degradation of Information

During design and construction, lack of standardisation and governance results in inconsistent data structures, fragmented documentation, and incomplete asset information.

3. Manifestation at Handover and FM Stage

At handover, accumulated deficiencies appear as poor information quality and lack of validation. In FM operations, this results in manual data handling, interoperability challenges, and reduced system efficiency.

This confirms that handover is not the origin of the problem, but the point where upstream failures become visible.

## 5.5 Existing Lifecycle-Based Analysis of Informational Meaning Loss

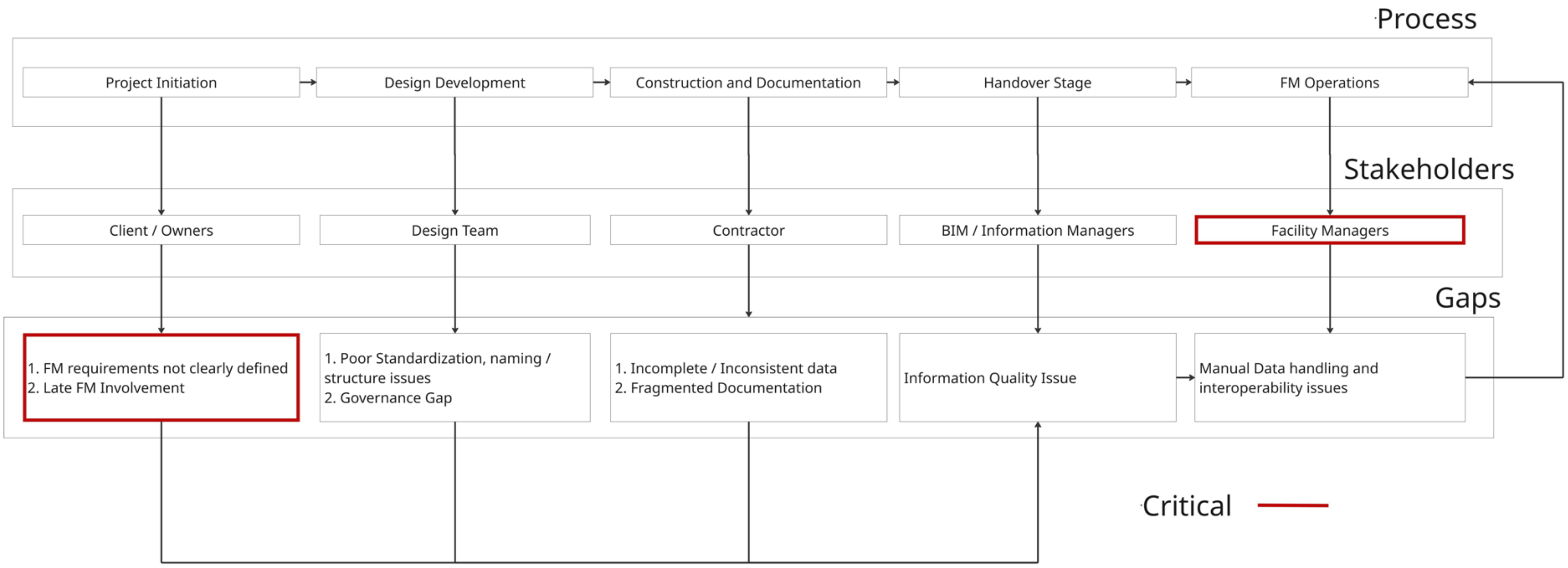


**Figure 12:Existing BIM–FM Information Discontinuity Framework**

Figure 12 illustrates the flow of information across five lifecycle stages project initiation, design development, construction, handover, and FM operations along with associated stakeholders and key information meaning loss.
The framework demonstrates that:

- Early-stage information meaning loss relate to undefined requirements
- Mid-stage information meaning loss relate to poor structuring and fragmentation
- Late-stage information meaning loss relate to validation and usability

This lifecycle perspective establishes that information meaning loss is cumulative and systemic, rather than stage specific.

## 5.6 Document Level Analysis of Information Meaning Loss Across Lifecycle

Building upon the lifecycle analysis, this section explicitly links project phases to the documents produced and examines how specific types of information meaning loss emerge within these deliverables.
FM teams rely on key handover documents such as asset registers, O&M manuals, BIM models, as-built drawings, commissioning reports, and COBie datasets. These documents are expected to deliver structured and usable information; however, they frequently exhibit significant information quality deficiencies

**Table 4:Phase Stakeholder Based Classification of Document Level Information Loss in Construction-FM Handover and Its Impact on FM Usability**

| Stage | Document | Issue (Not Just Gap) | Type of Meaning Loss | Why It Is Meaning Loss (Not Gap) | Who Suffers |
|---|---|---|---|---|---|
| **Project Initiation** | AIR / EIR | FM requirements not clearly defined | Context Loss | Data may exist, but its purpose and relevance for FM is not defined | FM Teams |
| **Design** | BIM Models / Drawings | Inconsistent naming, classification | Semantic Loss | Data exists but cannot be interpreted consistently across systems | FM Teams, BIM Managers |
| **Design** | BIM Models | Missing relationships (asset–system–space) | Context Loss | Information lacks meaning about how systems function together | FM Teams |
| **Construction** | Asset Registers / O&M Data | Missing attributes (maintenance, warranty) | Completeness Loss | Data is partially available but insufficient for operational use | FM Teams, Asset Engineers |
| **Construction** | O&M Manuals (PDFs) | Unstructured documentation | Structure Loss | Information exists but is not usable or machine-readable | FM Teams |
| **Construction** | As-built Drawings | Not updated to actual conditions | Accuracy Loss | Data exists but represents incorrect reality, leading to wrong interpretation | FM Teams |
| **Handover** | COBie / Asset Data | Missing fields, manual errors | Completeness + Structure Loss | Data is delivered but unreliable and inconsistent | FM Teams |
| **Handover** | Commissioning Reports | Not linked to assets/systems | Context Loss | Performance data exists but lacks meaning without system linkage | FM Teams |
| **Handover** | Handover Package | Fragmented across formats | Structure + Continuity Loss | Information exists but is scattered and disconnected | FM Teams |
| **FM Operations** | CAFM / CMMS | Data not compatible with systems | Continuity Loss | Data cannot transition into usable FM workflows | FM Teams |

**Explanation of Findings**

The analysis confirms that information meaning loss manifests in multiple forms across lifecycle documents, rather than as a single isolated issue:

- Missing Information: Incomplete asset data limits the creation of reliable FM databases
- Inaccurate Information: As-built data does not reflect actual site conditions
- Unstructured Information: Non-standard formats hinder usability and integration
- Loss of Context (Informational Meaning Loss): Absence of relationships (asset–system–space) reduces interpretability

Among these, loss of contextual relationships represents the most critical form of information loss, as it directly affects the ability of FM teams to interpret and operationalise data.

## 5.7 Synthesis: Identification of Critical Information meaning loss

The integrated findings reveal that BIM–FM handover failures are systemic and rooted in lifecycle-wide information management deficiencies.

Five critical information meaning loss are identified:

- **Undefined FM Requirements:** Lack of AIR/EIR leads to misalignment between data delivery and FM needs
- **Lack of Standardisation:** Inconsistent data structures reduce interoperability
- **Fragmented and Incomplete Information:** Dispersed and missing data limits usability
- **Absence of Validation at Handover:** Unverified data reduces reliability
- Interoperability and Usability Constraints: Poor system integration necessitates manual processes

## 5.8 Key Findings

- Information meaning loss is progressive: It originates early and accumulates across lifecycle stages
- The core issue is loss of informational meaning: Data lacks structure and contextual relationships
- FM involvement is limited: Late engagement results in a supply-driven approach to information delivery
- Manual data reconstruction is prevalent: FM teams routinely rebuild datasets due to poor data quality
- Technology is not the primary failure: BIM limitations stem from weak processes, not capability information loss.

## 5.9 Key Insight

The study establishes that BIM-FM handover failures are fundamentally information management failures, where unstructured, unvalidated, and context-poor data leads to a loss of informational meaning and reduced usability in FM operations

# CHAPTER-6: DISCUSSION

## 6.1 Interpreting the Nature of BIM-FM Information meaning Breakdown

The findings confirm that BIM–FM handover failures are not isolated technical issues but represent a systemic breakdown in information continuity across the project lifecycle. Rather than occurring at the handover stage, these issues originate in early project phases and progressively intensify, ultimately affecting FM operations.

A key insight is that the problem is not the absence of data, but the lack of usable, structured, and contextually aligned information. Information generated during design and construction frequently fails to support FM needs due to poor standardisation, fragmentation, and absence of relational context between assets, systems, and spaces.

The findings further establish that meaning degradation is progressive and cumulative. Early-stage deficiencies particularly undefined FM requirements and limited stakeholder integration propagate across lifecycle stages, leading to downstream usability challenges. This reinforces that handover is not the origin of failure, but the point at which accumulated information deficiencies become operationally visible.

## 6.2 Role of BIM Concepts in Preventing Meaning Loss

| Concept | Prevents Which Meaning Loss | How |
|---|---|---|
| **OIR/AIR** | Context Loss | Defines purpose of data |
| **EIR** | Continuity Loss | Ensures structured exchange |
| **COBie** | Structure + Completeness Loss | Provides structured dataset |
| **IFC** | Semantic Loss | Enables interoperability |
| **Validation** | Completeness Loss | Ensures accuracy |

## 6.3 Limitations of Existing BIM-FM Handover Structure

The lifecycle-based framework (Figure 12) highlights that the existing BIM–FM handover process is inherently fragmented and reactive, characterised by delayed stakeholder involvement, lack of structured information requirements, and absence of validation mechanisms.

A critical limitation is the late involvement of FM teams, who are typically engaged only at the final stage despite being the primary users of the information. This results in a supply-driven approach, where data is produced based on project delivery outputs rather than operational needs.

The current structure lacks:

- Early definition of FM-specific information requirements
- Standardised data governance across lifecycle stages
- Mechanisms for validating completeness and usability of information

As a result, information degrades across the lifecycle, leading to inefficiencies in FM operations. This demonstrates that the existing approach is document-centric rather than information-centric, limiting its ability to support lifecycle management effectively.

## 6.4 Interpreting Information Loss as Loss of Informational Meaning

A central contribution of this study is the interpretation of information breakdown as a loss of informational meaning. The findings show that information does not merely become incomplete; rather, it loses its ability to be interpreted and applied in operational contexts.
This loss occurs through:

- Structural degradation (inconsistent formats and standards)
- Accuracy loss (unupdated or incorrect data)
- Contextual disconnection (missing relationships between assets, systems, and spaces)

Among these, loss of contextual relationships is the most critical, as it directly affects the interpretability and usability of information in FM operations. Without these relationships, data cannot be translated into actionable knowledge, reinforcing the information loss between data availability and operational use.

## 6.5 Framework Development

The proposed BIM–FM Information Continuity Framework is developed through the integration of insights from both literature and interview findings.
The literature identifies recurring information meaning loss related to standardisation, fragmentation, and interoperability, while the interviews highlight practical consequences such as manual data reconstruction, unusable information, and lack of trust in delivered data.
By mapping these insights across lifecycle stages, key breakdown points were identified at:

- Project initiation (lack of FM requirements)
- Design stage (lack of standardisation)
- Construction stage (fragmentation and incompleteness)
- Handover stage (lack of validation)
- FM stage (manual data handling and integration challenges)

These breakdown points directly inform the framework interventions, ensuring that the proposed solution is evidence-based and grounded in both theory and practice.

## 6.6 Proposed BIM-FM Information Continuity Framework

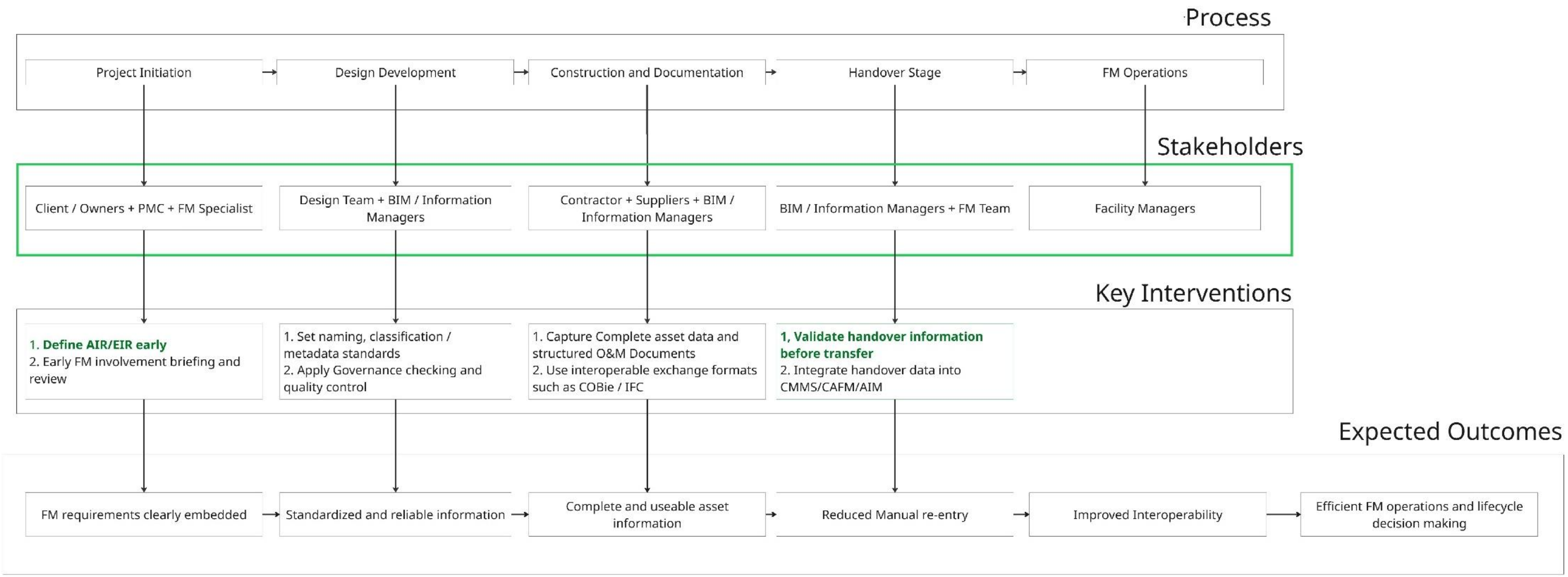


**Figure 13:Proposed BIM–FM Information Continuity Framework**

The proposed framework shifts from a fragmented, document-based process to a **structured, lifecycle-oriented information management approach**. It integrates phases, stakeholders, targeted interventions, and expected outcomes to address the root causes of information meaning loss.

The proposed framework directly responds to the identified informational meaning loss types. Each intervention is designed to prevent a specific form of meaning degradation:

- Context loss: addressed through OIR/AIR definition
- Semantic loss: addressed through standardisation
- Structure loss: addressed through structured data formats
- Completeness loss: addressed through validation
- Continuity loss: addressed through system integration

## 6.7 Key Interventions Across Lifecycle Stages

- **Project Initiation:** Early definition of OIR, AIR, and EIR with FM involvement ensures alignment between information production and operational needs.
- **Design Development:** Implementation of naming conventions, classification systems, and metadata standards ensures consistency and interoperability.
- **Construction Stage:** Structured capture of asset data using interoperable formats (COBie, IFC) reduces fragmentation and supports system integration.
- **Handover Stage:** Validation mechanisms ensure completeness, accuracy, and usability of information before transfer.
- **FM Operations:** Direct integration into CAFM/CMMS systems reduces manual data entry and improves operational efficiency.

The framework demonstrates that information continuity depends on coordinated processes, stakeholder alignment, and structured data management, rather than technology alone.

## 6.8 Interpreting Information Continuity Through Lifecycle Interventions

The analysis of information production across lifecycle stages highlights that information continuity must be actively managed through targeted interventions, rather than assumed as an inherent outcome of BIM processes.

While information is continuously generated by different stakeholders, its usability declines due to the absence of mechanisms to preserve its structure, consistency, and contextual relationships. This reinforces that the issue is not the volume of data, but the lack of structured processes to maintain its meaning.

The proposed framework addresses this by introducing lifecycle-specific interventions that ensure information is defined, standardised, validated, and integrated. These interventions collectively enable the preservation of informational meaning across the lifecycle.

## 6.9 Linking Framework Interventions to Identified Information meaning loss

**Table 5:Information breakdown and intervention strategies across the BIM–FM lifecycle.**

| Phase | Stakeholders | Nature of Information Breakdown | Root Cause | Framework Intervention | How It Preserves Informational Meaning | Expected FM Outcome |
|---|---|---|---|---|---|---|
| **Project Initiation** | Client / Owner + FM Team | Misalignment between produced data and FM needs | Undefined or weak AIR/EIR; late FM involvement | Define OIR/AIR/EIR with early FM participation | Establishes clear data requirements and purpose from the outset | Information aligned with operational needs |
| **Design Development** | Design Team + BIM Managers | Fragmented and inconsistent data across disciplines | Lack of standardisation and governance | Apply naming conventions, classification, metadata standards | Ensures consistency and structured data relationships | Interoperable and reliable BIM data |
| **Construction & Documentation** | Contractors + Suppliers + BIM Managers | Disconnected and incomplete asset information | Manual processes; lack of structured data capture | Capture complete asset data using COBie/IFC formats | Maintains structured, machine-readable data continuity | Complete and usable asset database |
| **Handover Stage** | BIM / Information Managers + FM Team | Poor information quality and lack of usability | Absence of validation mechanism | Validate data before transfer; align with FM requirements | Ensures accuracy, completenes and contextual linkage | Reliable and ready-to-use FM datasets |
| **FM Operations** | Facility Managers | Dependence on manual data reconstruction | Interoperability issues; poor input data quality | Integrate validated data into CAFM/CMMS systems | Enables seamless data flow and system usability | Reduced manual work and improved efficiency |

The framework directly addresses the critical information meaning loss identified in the findings by aligning each intervention with a specific lifecycle breakdown. This mapping demonstrates that information meaning loss is not inevitable but can be mitigated through structured and coordinated information management practices.

Importantly, the framework shifts the approach from reactive correction at handover to proactive lifecycle management, reducing the accumulation of information deficiencies.

## 6.10 Expected Impact of the Framework

The implementation of the proposed framework transforms BIM–FM handover into a proactive, information-centric lifecycle strategy.

Key impacts include:

- Alignment of information with FM requirements

- Improved consistency and interoperability of data
- Availability of complete and structured asset information
- Reduction in manual data reconstruction
- Enhanced integration with FM systems
- Improved efficiency and reliability in operations

These outcomes enable a transition toward data-driven facility management, where information supports informed decision-making throughout the building lifecycle.

## 6.11 Critical Reflection

While the proposed framework provides a structured and theoretically grounded solution, its implementation depends on several practical factors.
Successful adoption requires:

- Early and continuous stakeholder collaboration
- Organisational commitment to information governance
- Adoption of standardised and interoperable systems
- Additionally, the framework assumes a level of digital maturity that may not be present across all projects. In contexts with limited BIM adoption, implementation challenges may arise.

As this study is based on literature analysis and interview insights, the framework remains conceptually validated. Future research should focus on real-world application and empirical evaluation to assess its effectiveness.

## 6.12 Synthesis Of Discussion

The discussion establishes that BIM-FM handover failures can be effectively addressed by transitioning from a document-centric approach to an information-centric lifecycle strategy.
The proposed framework ensures that information is:

- Defined early
- Structured consistently
- Validated before transfer
- Integrated into FM systems

This approach preserves the informational meaning of data, enabling its effective use in FM operations.
Ultimately, improving BIM–FM integration is not a technological challenge, but a matter of aligning processes, stakeholders, and information requirements across the lifecycle, thereby enabling more efficient and reliable facility management.

# CHAPTER-7: CONCLUSION

This study examined the causes of information meaning loss in BIM-FM handover and explored how these challenges can be addressed through improved information management practices. The findings demonstrate that handover failures are not isolated technical issues but arise from a systemic breakdown in information continuity across the project lifecycle.

The analysis revealed that information meaning loss originates in early project stages due to the absence of clearly defined FM requirements and limited stakeholder integration. These deficiencies propagate through design and construction, resulting in fragmented, unstructured, and incomplete information at handover. Consequently, FM teams are required to manually reconstruct data, leading to inefficiencies, increased operational costs, and reduced reliability of FM systems.

A key contribution of this study is the identification that the core issue lies not in the lack of data, but in its lack of usability, structure, and alignment with operational needs. This highlights a fundamental disconnect between how information is produced during project delivery and how it is consumed during facility management.

To address this, a BIM-FM Information Continuity Framework (Figure 13) was developed. The framework introduces a lifecycle-oriented approach that emphasises:

- Early definition of FM information requirements (OIR/AIR/EIR)
- Standardisation and governance of information during design
- Structured and interoperable data production during construction
- Validation of information prior to handover
- Direct integration into FM systems

By embedding these interventions across lifecycle stages, the framework shifts the focus from data delivery to information usability, ensuring that information effectively supports FM operations and decision-making.

Overall, this study contributes to BIM-FM research by demonstrating that effective handover depends on continuous, structured, and demand-driven information management, rather than technological capability alone.

While the framework is conceptually grounded in literature and supported by industry insights, its practical effectiveness remains to be validated. Future research should focus on applying the framework in real-world projects and evaluating its impact across different project scales and organisational contexts.

Ultimately, improving BIM-FM handover requires a fundamental shift from a document-centric mindset to an information-centric lifecycle approach.

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# APPENDIX

#### Appendix 1: Layer 1 Thinking: "What I think I know About the Problem"

Construction projects deliver large volumes of handover information, including drawings, asset registers, and operational documents. However, this information frequently lacks clarity, structure, and contextual meaning when it reaches facility management teams. As a result, FM practitioners rely on manual interpretation, rework, or parallel documentation systems to operate and maintain assets. Digital tools intended to support FM workflows often fail to deliver expected value because the data they consume is fragmented and semantically weak.

**Who Faces This Problem**
- Facility Managers
- Asset and Maintenance Engineers
- BIM / Handover Coordinators
- Operations Teams

**Where It Appears**

The problem emerges primarily at the construction–FM interface, during project closeout and early operational phases, particularly in large public-sector and complex projects with multiple stakeholders.

**Why Existing Practice Fails**
- Handover is treated as document delivery rather than information continuity.
- FM requirements are not embedded early in design and construction.
- There is no consistent ownership of information quality.
- Delivered data lacks explicit relationships and operational context.
- Digital tools depend on structured inputs that are absent at handover.

**What This DRP Will Not Study**
- To maintain feasibility within the project timeframe, this research explicitly excludes:
- Software performance benchmarking
- Vendor or platform comparison
- Technical BIM modelling
- AI algorithm evaluation
- Organisational change management strategies
- Procurement or contractual reform analysis

The study focuses solely on informational meaning loss and data structure at the construction–FM handover interface.

The following represents the researcher's initial understanding of construction–FM handover challenges, based on experience and preliminary exposure:

**Information**
- Handover packages contain excessive documents but limited usable knowledge.
- Asset data is inconsistent across drawings, spreadsheets, and manuals.
- O&M manuals are often generic and disconnected from actual installed assets.
- Relationships between spaces, systems, and assets are rarely explicit.

**Process**

- Handover is treated as a final-stage administrative activity rather than a lifecycle process.
- FM teams are rarely involved during design or construction.
- There is no systematic validation of information quality from an FM perspective.
- Delivery schedules prioritise completion dates over information readiness.

**People**

- Contractors focus on contractual closure rather than operational usability.
- BIM teams deliver files but not interpretive knowledge.
- FM teams are forced to rebuild asset registers manually.

**Digital Tools**

- CAFM/CMMS platforms require structured inputs that are not provided at handover.
- AI-enabled FM tools assume clean and connected datasets.
- Tool failures are commonly attributed to software, rather than to poor data foundations.

**Experience-Based Beliefs**

- COBie is available but rarely implemented meaningfully.
- FM teams develop parallel documentation systems to compensate for unusable handover data.
- Responsibility for data quality is unclear across stakeholders.
- These assumptions serve only as a starting point and will be tested, refined, or rejected through subsequent literature review and empirical investigation.

**Appendix 2:Layer 2 Mind Map : What I know v/s I don't know**

**Table 6: What I know v/s What I don't know**

| Area | What I Know | What I Don't Know |
|---|---|---|
| **Information** | Handover delivers large volumes of data, but FM receives fragmented and low-usability information. | Where meaning first degrades (design, construction, or handover), and which data types are most affected (assets, systems, documents, or context). |
| **Process** | Handover is treated as a secondary activity compared to design and construction. | How information responsibilities are distributed across stakeholders and what validation mechanisms exist for FM usability. |

| | | |
|---|---|---|
| **Technology** | BIM and digital FM tools are widely adopted but rarely support O&M effectively in practice. | Why semantic technologies succeed conceptually but struggle operationally, and what assumptions digital tools make about input data quality. |
| **People / Organisation** | FM teams often rebuild knowledge manually due to unusable handover information. | How FM practitioners interpret delivered data and how siloed working specifically disrupts lifecycle continuity. |

**Appendix 3:Layer 3 Thinking: What Literature Introduced That I Missed**

Review of the mapped literature extended the understanding of construction–FM handover beyond initial assumptions. While earlier observations focused on fragmented information delivery, literature highlighted deeper systemic issues including lifecycle information depreciation, unclear ownership of data responsibility, lack of semantic relationships between assets and systems, and the absence of operational context in handover datasets.

Studies revealed that FM teams often receive technically complete yet operationally meaningless information, requiring manual reconstruction of asset knowledge. Literature also introduced the distinction between information availability and information usability, showing that structured formats such as COBie and BIM models alone do not ensure meaningful FM integration. Furthermore, interoperability challenges were shown to be socio-technical rather than purely technical, influenced by organisational silos, process misalignment, and limited FM involvement during earlier project stages.

Importantly, while existing research proposes technological solutions, limited attention is given to how FM practitioners interpret delivered information or how meaning degrades across lifecycle transitions. This confirmed that construction–FM handover failure cannot be understood solely through tool adoption frameworks and requires investigation into informational meaning loss.

**Appendix 4: Questionnaire Survey**

This survey is part of an academic Directed Research Project (DRP) examining information transfer between construction and facility management during project handover. The study explores how data usability and meaning may degrade across the lifecycle.
All responses are confidential and will be used strictly for academic research purposes only.

### Section 1: Background Information

1. Name (Optional): ___________________________
2. Organization: ___________________________
3. Role/Designation: ___________________________

4. Years of FM Experience:
   ☐ 0–3 years
   ☐ 3–7 years
   ☐ 7–15 years
   ☐ 15+ years
5. Type of Project Involved In:
   ☐ Commercial
   ☐ Healthcare
   ☐ Residential
   ☐ Institutional
   ☐ Infrastructure
   ☐ Other: ______________

**Section 2: Project Handover Experience**

**1. Can you describe the most recent project handover you were involved in?**

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**2. What documents or data did you receive at handover?**

(Select all that apply)

☐ Asset Register

☐ As-built Drawings

☐ O&M Manuals

☐ BIM Model

☐ Commissioning Reports

☐ Warranty Documents

☐ Test Certificates

☐ Equipment Datasheets

☐ Digital FM Database

☐ Other: _______________________

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**3. Which of these were immediately usable without modification?**

☐ All documents

☐ Most documents

☐ Some documents

☐ Very few

☐ None

Please explain:

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**4. Which documents required reinterpretation, correction, or restructuring?**

☐ Asset Register

☐ BIM Model

☐ O&M Manuals

☐ Drawings

☐ Commissioning Data

☐ Other: _____________

What type of issues were encountered?

☐ Missing data

☐ Inconsistent naming

☐ Incorrect asset coding

☐ Format incompatibility

☐ Duplicate entries

☐ Incomplete metadata

☐ Other: _____________

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**5. Were there inconsistencies across documents?**

☐ Yes

☐ No

If yes, please describe examples:

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**Section 3: Data Validation & Trust**

**6. How do you validate the accuracy of asset data after handover?**

☐ Physical site verification

☐ Cross-check with drawings

☐ Recommissioning tests

☐ Third-party audit

☐ Trust contractor data

☐ Other: ____________

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**7. Have you rebuilt or reformatted asset registers after handover?**

☐ Yes

☐ No

If yes, why was this necessary?

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**Section 4: Digital Systems & Tools**

**8. Which FM system do you use?**

☐ Archibus

☐ Maximo

☐ SAP PM

☐ Planon

☐ Excel-based system

☐ Other: ____________

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**9. How does your FM system rely on handover data?**

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**10. When digital tools fail, what is usually the reason?**

☐ Poor data structure

☐ Incomplete information

☐ Incorrect asset classification

☐ Lack of metadata

☐ BIM-FM incompatibility

☐ User training issues

☐ Other: ____________

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**Section 5: Lifecycle Information Breakdown**

**11. At what stage do you think information begins to break down?**

☐ Design stage

☐ Construction stage

☐ Commissioning stage

☐ Handover stage

☐ Post-Handover operations

Please explain why:

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**Section 6: Reflection**

**12. In your opinion, what is the biggest challenge in Construction–FM handover?**

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**13. What improvements would you recommend improving informational continuity?**