

World

Study on Promoting the Use of BIM/CIM in ODA Loan Projects

FINAL REPORT

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Abbreviations

Abbreviation	Description
AbV	Alignment-based View (IFC 4.3 MVD)
AEC	Architect, Engineering and Construction
AIA	American Institute of Architects
AIM	Asset Information Model
AIMS	Asset Information Management System
AIR	Asset Information Requirements
API	Application Programming Interface
ArcGIS	Esri GIS platform
ASTM	American Society for Testing and Materials
BAS	Building Automation System
BCF	BIM Collaboration Format
BCR	Benefit Cost Ratio
BEP	BIM Execution Plan
BESA	Building Engineering Services Association
BI	Business Intelligence
BIM	Building Information Modelling/Management
BLCJ	BIM Library Collaborative research association of Japan
BMS	Building Management System
BOS	BIM Object Standard
BS	British Standard(s)
BSAB	BSAB System
bSDD	buildingSMART Data Dictionary
BSI	British Standards Institution
BSIJ	Building Surveyor's Institute of Japan
CAFM	Computer-Aided Facility Management
CBA	Cost Benefit Analysis
CDBB	Centre for Digital Built Britain
CDE	Common Data Environment
CDM	Construction (Design and Management) Regulations 2015
CIBSE	Chartered Institution of Building Services Engineers
CIC	Construction Industry Council (Hong Kong)
CIM	Construction Information Modelling/Management
CityGML	City Geography Markup Language
CMMS	Computerized Maintenance Management System
COBie	Construction-Operations Building information exchange
DTV	Design Transfer View
DX	Digital Transformation
EAM	Enterprise Asset Management
ECC	Engineering and Construction Contract
EIR	Exchange Information Requirements (ISO 19650)
EIR	Employer's Information Requirements (BS/PAS 1192)
EN	European Norm
ERP	Enterprise Resource Planning
ETL	Extract, Transform, Load

Abbreviation	Description
EU	European Union
FHWA	Federal Highway Administration
FIDIC	International Federation of Consulting Engineers
FM	Facilities Management
GeoJSON	GeoJSON format
GIS	Geographic Information System
GML	Geography Markup Language
GNSS	Global Navigation Satellite System
H&S	Health and Safety
HS2	High Speed 2
HSE	Health and Safety Executive
HVAC	Heating, Ventilation and Air Conditioning
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ICIS	International Construction Information Society
ICT	Information and Communication Technology
IDM	Information Delivery Manual
IDS	Information Delivery Specification
IFC	Industry Foundation Classes
IFC 4.3	Industry Foundation Classes version 4.3
IM	Information Management
IMI	Information Management Initiative
IoT	Internet of Things
IPR	Intellectual Property Rights
IRI	International Roughness Index
IRR	Internal Rate of Return
ISO	International Organization for Standardization
ITS	Intelligent Transport Systems
JCT	Joint Contracts Tribunal
JFMA	Japan Facility Management Association
JICA	Japan International Cooperation Agency
KPI	Key Performance Indicator
LandXML	LandXML format
LOD	Level of Development/Level of Detail
LOG	Level of Geometry
LOI	Level of Information
LOIN	Level of Information Need
MasterFormat	MasterFormat
MEP	Mechanical, Electrical, Plumbing
MIDP	Master Information Delivery Plan
MVD	Model View Definition
mvdXML	Model View Definition XML format
NBIMS	National BIM Standard
NBS	National Building Specification
NEC	New Engineering Contract

Abbreviation	Description
NEC3	New Engineering Contract, Third Edition
NEC4	New Engineering Contract, Fourth Edition
NIBS	National Institute of Building Sciences
NPV	Net Present Value
O&M	Operations and Maintenance
ODA	Official Development Assistance
OGC	Open Geospatial Consortium
OIR	Organizational Information Requirements
OmniClass	OmniClass Construction Classification System
PAS	Publicly Available Specification
PIM	Project Information Model
PIR	Project Information Requirements
PLQ	Plain Language Questions
QA	Quality Assurance
QC	Quality Control
RACI	Responsible, Accountable, Consulted, Informed
RIBA	Royal Institute of British Architects
RICS	Royal Institution of Chartered Surveyors
RISSB	Rail Industry Safety and Standards Board
ROI	Return on Investment
SCADA	Supervisory Control and Data Acquisition
SfG20	Standard maintenance specification for building services (brand: SfG20)
SIR	Security Information Requirements
SQL	Structured Query Language
TfL	Transport for London
TIDP	Task Information Delivery Plan
TOR	Terms of Reference
UI	User Interface
Uniclass	Unified Classification for the Construction Industry

1 OVERALL CONCLUSION OF THE STUDY

1.1 Background and Problem Recognition

The digital transformation of the construction sector has accelerated in recent years, with the introduction of Building Information Modelling/Management (BIM) progressing globally. In the infrastructure sector, however, BIM has often been applied only in a limited and fragmented manner—primarily to improve the accuracy of design and cost estimation or to enhance efficiency during construction. Although the need for BIM in ODA loan projects is increasing, its application remains partial, discontinuous, and at an early stage of maturity.

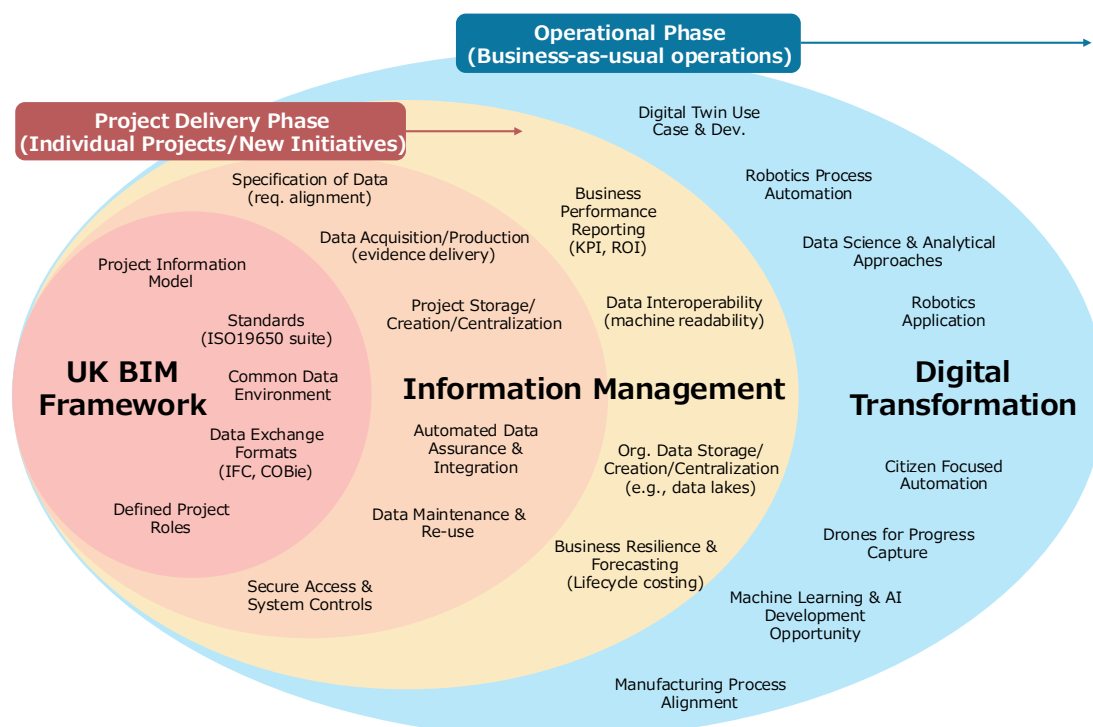
Internationally, by contrast, BIM is positioned as a core mechanism for information management (IM) in the construction and infrastructure domains. The United Kingdom (UK), a leading country in BIM adoption, has conceptualized BIM as a project management methodology that structures an information management framework from the early stages of a project and ensures consistent information management across the entire lifecycle—from planning and design to construction, operation, and maintenance. This approach has since expanded beyond the UK to Europe, Asia, Oceania, South America, and other regions, and is now established as an international standard.

To clarify the significance and purpose of information management through BIM, the UK has developed analytical reports quantifying the “value of information management in the construction and infrastructure sector.” These reports identify six key principles of information quality—accuracy, completeness, validity, timeliness, uniqueness, and consistency—and demonstrate how adherence to these principles leads to measurable value creation, including:

- Improved labor productivity and direct cost reduction (time, labor, materials)
- Macro-economic benefits (enhanced productivity in the construction sector contributing to increased capital stock and GDP)
- Social value creation (sustainable asset management, improved health and safety environments)

Furthermore, digital twins—one of the central themes of digital transformation in the construction sector—are not independent technologies. Rather, they are understood as an extension of the BIM framework centered on ISO 19650, created through appropriate information management principles, structured data environments, and continuity and consistency across systems (See Figure 1-1).

The benefits of BIM-centric information management are relevant not only in advanced economies such as the UK but also in developing countries. The BS 1192 and PAS 1192 frameworks developed in the UK have been standardized as ISO 19650, and many ODA loan recipient countries are now taking steps to apply ISO 19650 to their national infrastructure projects. As ODA loan projects are, by nature, international undertakings, the adoption of ISO 19650-aligned information management practices is essential. Without aligning contract conditions and information exchange mechanisms with international standards, information interoperability and responsibility allocation across the design, construction, and operation and maintenance (O&M) phases become unclear, hindering project implementation and stakeholder collaboration. For this reason, the application of the ISO 19650 framework is not simply a technical requirement but a prerequisite for establishing internationally consistent procurement, contracting, and information exchange.



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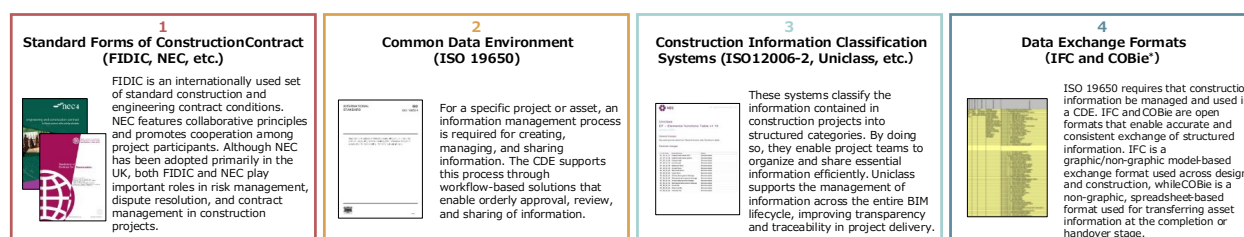
Figure 1-1 Relationship among the BIM Framework, Information Management, and Digital Transformation

1.2 Key Technical Elements Essential for BIM Implementation

As discussed above, the digital transformation of the construction sector is progressing worldwide, and the application of BIM is now indispensable for enhancing project and information management. However, BIM use in ODA loan projects remains at an introductory level. Although a draft handbook for BIM utilization was prepared in 2022, actual project applications remain limited.

The ISO 19650 series serve as the international standard for BIM-based information management in the architecture and civil engineering sectors and was developed from the UK's BS and PAS 1192 frameworks. However, to facilitate international application, UK-specific elements were removed, and the standard was structured as a conceptual framework. As such, ISO 19650 does not provide the detailed technical guidance necessary for project implementation. Therefore, applying ISO 19650 in practice requires the systematic organization of relevant technical domains and the tailoring of their implementation to the characteristics of ODA loan projects.

In particular, ODA loan projects require the establishment of arrangements for contracts, information sharing, classification systems, and data exchange formats that comply with international standards. Figure 1-2 presents four key technical elements that support ISO 19650 implementation.



*IFC (Industry Foundation Classes): A CAD data format used in design and construction projects to represent 3D building and infrastructure models.

*COBie (Construction Operations Building Information Exchange): A non-graphic, tabular format used mainly for transferring asset information required during the handover and O&M stages.

Source: Prepared by the JICA Study Team

Figure 1-2 Four Key Elements Essential for BIM Implementation in Addition to ISO 19650

(1) Standard Forms of Construction Contract

ODA loan projects use the FIDIC Conditions of Contract as the international standard. Therefore, BIM-related requirements and ISO 19650 application conditions must be clearly defined and structured. As frameworks such as NEC4—used in the UK and other BIM-leading countries—differ in structure from FIDIC, appropriate adaptation to the context of ODA loan contract documents is essential.

(2) Common Data Environment (CDE)

The CDE serves as a centralized digital platform for managing and sharing project information, including BIM models, drawings, and specifications. ISO 19650 positions the CDE implementation and operation as prerequisites for BIM projects. The CDE facilitates efficient information exchange, approval workflows, clash detection, and communications among stakeholders.

In the infrastructure sector, the CDE must function as more than a file-sharing system; it must integrate multiple information domains. Key components include:

- BIM models and attribute information: 3D models and associated data for design, construction, and O&M
- Geospatial information (GIS): Spatial data for linear and area-based infrastructure such as roads, railways, and airports
- Project documentation: Contracts, specifications, drawings, and technical documents

By integrating BIM models, GIS, and documentation, the CDE enables seamless information linkage throughout the planning, design, construction, and O&M phases, thereby enhancing project quality and safety.

(3) Construction Information Classification Systems

Classification systems organize vast amounts of information—such as components, equipment, spaces, work activities—according to a consistent structure. This enables cross-sector information management for railways, roads, airports, and other infrastructure assets. ISO12006-2 provides the foundational concepts for classification, and systems such as Uniclass 2015 (UK) and OmniClass (North America) are built upon it. These systems enable cross-country and cross-disciplinary information standardization.

(4) Data Exchange Formats

Data exchange formats allow BIM-generated information to be exchanged across different software platforms and organizations. Industry Foundation Classes (IFC) provides a model-based exchange format, while Construction-Operations Building information exchange (COBie) structures attribute information for facility handover and O&M. These formats enable seamless information continuity from design through construction to asset management.

1.3 Purpose of this Study and Report

The purpose of this study is to enhance the effectiveness of BIM introduction in ODA loan projects by revising the existing draft handbook based on identified issues, restructuring it in alignment with international standards (the ISO 19650 series), and presenting practical and systematic guidelines for project implementation. The study also collects, organizes, and proposes technical information and international examples relevant to applying ISO 19650-based information management in ODA loan projects.

Furthermore, the study develops draft terms of reference (TORs), operational guidelines, and other practical documents for use by JICA staff during the preparatory survey stage, thereby providing direct support for field implementation. Through local consultations and interviews across multiple countries and projects, the study also verifies the practicality and field applicability of the proposed content and extracts key implementation issues and corresponding solutions.

1.4 Structure and Use of this Report

This report provides practical guidance for BIM implementation in ODA loan projects. Each chapter serves the following purpose:

- Chapter 2: Identifying Issues in Existing Handbooks Through Prior Research
- Chapter 3-5: Comparing and Organizing ISO 19650, Related Standards/Tools, and National Guidelines
- Chapter 6: Analyzing and Presenting Information Requirement Templates for OIR, AIR, PIR, EIR, and SIR
- Chapter 7: Organizing BIM Cost-Benefit Analysis and Evaluation Methods
- Chapter 8: Extracting Implementation Insights from International Project Case Studies
- Chapter 9-11: Organizing Implementation Status of Standards/Tools, Sector-Specific Deployment, and Reflection in Contract Documents from a Practical Perspective
- Chapter 12: Defining the Restructuring Policy and Revision Content for the New Handbook
- Chapter 13: Specifying the Implementation and Support Framework for BIM Adoption
- Chapter 14: Organizing the Current Status Survey and Feedback for On-site Implementation
- Chapter 15: Summarizing the Survey Findings, Achievements, Challenges, and Future Recommendations

The report aims to bridge ISO 19650-compliant information management with practical guidelines that are directly applicable in the field. From Chapter 9 onward, it covers implementation, operation, evaluation, and continuous improvement, providing actionable insights for practitioners.

2 REVIEW OF THE PREVIOUS BASELINE STUDY AND POLICY FOR THE CURRENT STUDY

2.1 Purpose of Reviewing the Previous Baseline Study

The 2022 study titled “Data Collection Survey on BIM for ODA Projects” (previous baseline study) was conducted to assess the feasibility of introducing BIM/CIM across JICA-led ODA projects globally. The previous baseline study compiled and analyzed domestic and international BIM utilization cases, identified the benefits of BIM adoption, and extracted key issues. In addition, it developed a draft handbook for BIM/CIM implementation, proposing approaches for applying BIM/CIM within ODA projects.

However, within ODA loan projects, no cases have been identified in which the draft handbook has been applied in actual projects, and BIM implementation remains at an early stage. Contributing factors include insufficient institutional and technical arrangements, as well as limited understanding and lack of consensus among stakeholders.

This chapter aims to verify the survey activities and recommendations provided in the previous baseline study, and to clarify the challenges associated with introducing BIM aligned with the ISO 19650 framework in ODA loan projects. The review focuses on whether the previous baseline study adequately examined and organized the application and alignment of the ISO 19650 information management framework—outlined in Chapter 1 of this report—together with related international standards and technologies, including standard construction contracts (e.g., FIDIC), Common Data Environments (CDE), construction information classification systems (ISO 12006-2, Uniclass, etc.), and data-exchange formats (IFC, COBie, etc.).

Furthermore, the draft handbook developed in the previous baseline study was critically examined from the same perspective. Its practicality and applicability to ODA loan projects were assessed, and areas requiring improvement for future BIM implementation were identified.

2.2 Review of the Previous Baseline Study and the Draft Handbook

2.2.1 Overview and Review of the Previous Baseline Study Report

The previous baseline study aimed to assess the feasibility of introducing BIM/CIM into ODA projects by collecting and analyzing domestic and international case studies and trends, and by identifying the benefits and challenges of BIM adoption. Although the study references the international BIM information management process defined under ISO 19650, its discussion is limited to outlining the basic principles and framework of the standard. ISO 19650 was developed based on the UK’s BS 1192 and PAS 1192 frameworks and related British standards; however, during the process of international standardization, the UK intentionally avoided specifying certain technical details in order to accommodate differences across European countries. As a result, without understanding the background of this standardization process or the technical requirements that were intentionally omitted, it is difficult to gain a full understanding of the ISO 19650 framework, and the standard becomes challenging to apply in practice.

Consequently, the previous baseline study report placed disproportionate emphasis on technologies for creating 3D models and the utilization of such models for secondary digital transformation (DX) applications. This deviates from the primary purpose of BIM as an information management process under ISO 19650.

The following provides a summary and review of each chapter.

(1) Chapter 1: Introduction

The chapter outlines global BIM trends, including ISO 19650 and its predecessor standards, BS 1192 and the PAS 1192 framework. It emphasizes that the ISO 19650 series standardizes information-management processes across the whole asset lifecycle, including O&M, and argues that ODA projects should adopt ISO 19650 as a foundational framework.

However, neither this chapter nor the subsequent chapters investigate or organize how information should be linked and utilized through the O&M stage under ISO 19650. For example, ISO 19650-1 stipulates that object classification must be based on classification structures aligned with ISO 12006-2 (construction information classification systems). These essential technical aspects are almost entirely omitted.

(2) Chapter 2: Domestic and International Case Studies

The study provides a detailed investigation of BIM/CIM utilization in the Japanese architecture and civil engineering sectors; however, it does not examine Japan's current BIM/CIM practices from the perspective of ISO 19650 information management processes. Regarding Common Data Environments (CDEs), although domestic usage trends are summarized, the report does not properly explain key CDE functions employed in large-scale international projects that comply with ISO 19650 and BS/PAS 1192 requirements. Annex 2 presents a list of CDE tools, but their functions, characteristics, and differences are not systematically organized.

The report surveys BIM implementation status and manuals in Singapore, Taiwan, the Philippines, Indonesia, and other countries, noting that these countries have adopted ISO 19650-aligned principles. It further describes the adoption of construction classification systems, such as OmniClass (North America) and Uniclass 2015 (UK), based on ISO 12006-2, as well as the specification of COBie as a data exchange format related to ISO 19650-3 and -4. However, neither this chapter nor any other chapter provides analysis or explanation of ISO 19650 principles, ISO 12006-2 classification systems, or the significance of ISO 19650-3 and -4 for operations and data exchange.

The report also discusses the importance of procedures, tools, and record logs for maintenance in the railway sector but does not elaborate on practical usage methods or ISO 19650 information processes. Even in the examples of overseas advanced BIM projects, only project names are listed; the actual methodologies and approaches adopted in leading cases are largely absent. A similar situation is observed in the aviation sector.

(3) Chapter 3: BIM Implementation Effects and Challenges for ODA Projects

This chapter only provides a qualitative summary of typical BIM benefits. It does not address the challenges associated with applying the necessary technical components described in Chapter 1. The discussion remains limited to hardware and software costs and the need to secure personnel capable of handling BIM.

(4) Chapter 4: Proposed Guidelines, and Chapter 5: Implementation Plan

Chapters 4 and 5 describe BIM utilization approaches for both loan and grant aid projects in line with typical project processes. For loan projects, the recommendations reference the role of CDEs—data platforms essential for information delivery, sharing, and approval under BS/PAS 1192 or ISO 19650 information management processes. However, the proposal recommends introducing CDEs only from the construction stage. This positions the CDE merely as a correspondence tool for managing construction models and as-built data. The critical importance and role of the CDE in managing information processes from the design stage—where BIM models, drawings, and specifications are first developed—are not recognized.

Additionally, the concept of the Employer's Information Requirements (EIR) remains based on PAS 1192-3. Under ISO 19650, this must be updated to the EIR and structured according to the broader classification of information requirements.

(5) Chapter 6: DX Technologies, and Chapter 7: Conclusion

Chapter 6 primarily discusses peripheral DX technologies, such as automatic minute-generation tools and digital applications linked to BIM models. These topics are not related to the ISO 19650 principles, which define BIM as an information-management process. Moreover, the chapter suggests that the entire information management process—from project formulation to operations and maintenance, including the Asset Information Model (AIM)—can be managed through an integrated DX approach using BIM models, GIS, and Synthetic Aperture Radar (SAR) satellite data. This proposal is neither consistent with nor aligned with the ISO 19650 information management framework. While BIM and GIS indeed play important roles

throughout the asset lifecycle, the report does not examine the classification systems or information formats required to ensure consistency in information handover across the design, construction, and O&M stages.

As a result, although Chapter 1 notes that ISO 19650 concepts are being adopted even in ODA recipient countries and that BIM policies for ODA projects should be organized in accordance with ISO 19650, the report ultimately presents recommendations that lack alignment with, and relevance to, ISO 19650.

2.2.2 Overview and Review of the Draft Handbook

Because the draft handbook was developed based on the investigations and analyses presented in the previous baseline study report, it similarly lacks the ISO 19650 information management processes and associated technical perspectives that are essential for BIM implementation.

(1) Structure and Purpose of the Draft Handbook

The draft handbook is positioned as a guideline to support the smooth introduction of BIM/CIM. It includes basic concepts, implementation processes, allocation of responsibilities among stakeholders, and approaches to information sharing. However, no cases have been identified in which the draft handbook has been applied to actual ODA loan projects, and several issues remain regarding its practicality and applicability.

(2) Extraction of Items Relevant to ODA Loan Projects

Within the previous baseline study, only limited content directly relates to ODA loan projects, while much of the description is general and intended for ODA as a whole. In particular, the draft handbook lacks adequate discussion of the positioning of BIM within contract conditions and tender documents, alignment with ISO 19650, and information-management processes extending through O&M.

(3) Validity and Practicality of the Content

Although the draft handbook provides a certain level of organization regarding BIM benefits and fundamental utilization methods, it lacks practical specificity. In particular, descriptions concerning information management for O&M, as well as the application of BIM as a project management methodology, are insufficient.

(4) Application and Challenges

ODA loan projects involve institutional and technical constraints, such as the adoption of FIDIC contract conditions and varying BIM maturity levels among implementing countries and agencies. The draft handbook does not adequately account for these contextual factors. Therefore, supplementary guidelines and case examples are necessary to support practical implementation.

2.2.3 Information Requiring Enhancement or Improvement

As shown in the above review, the following key technical elements described in Chapter 1 must be clearly organized and documented to ensure implementation aligned with ISO 19650 principles.

(1) Contractual Treatment of BIM under Standard Construction Contracts (e.g., FIDIC)

In the previous study, the treatment of BIM implementation in contract clauses was limited, and no specific provisions were identified regarding the application of BIM under FIDIC contracts.

(2) Common Data Environment (CDE)

While the concept of the CDE is introduced, specific operational methods for its use during the design phase, as well as for information approval, sharing, and storage, are not outlined. The CDE is often perceived merely as a correspondence tool for the construction phase or as a sharing environment for construction BIM, indicating sufficient recognition of its core role in BIM functionality.

(3) Construction Information Classification Systems (ISO 12006-2, Uniclass, etc.)

The report does not maintain consistency with ISO 19650 requirements regarding the use of classification systems aligned with ISO 12006-2. Consideration of internationally recognized classification systems, such

as Uniclass 2015, is therefore necessary.

(4) Data Exchange Formats (IFC, COBie, etc.)

The report only provides limited descriptions of open data formats such as IFC and COBie and lacks perspectives related to handover and asset management during the O&M stage.

2.3 Collection of Additional Information and Organization of Key Issues

2.3.1 Identification of Additional Information Required

The review of the previous baseline study and the draft handbook identify several areas in which essential information for BIM/CIM implementation in ODA loan projects remains insufficient. Notable gaps include:

- Practical examples of implementing information requirements in accordance with ISO 19650
- Actual application of BIM under FIDIC contract conditions
- CDE implementation environments and related operational considerations
- Status of development of construction information classification systems and formats

These elements are essential to ensuring effective BIM implementation in ODA loan projects and should be prioritized for collection and analysis in future investigations.

2.3.2 Organization of Key Issues for Consideration

(1) Latest Developments in ISO 19650

The ISO 19650 series is positioned as the international standard for information management in construction projects and is being adopted globally. Parts 1 and 2 provide the fundamental framework for information management in the design and construction stages, while Parts 3 and subsequent parts cover the entire asset lifecycle, including facility management, information security, and health and safety information.

As of January 2025, a new Part 6 on health and safety information has been added. Future BIM utilization will therefore require the formulation of information requirements that reflect these latest developments.

(2) Development of Information Requirements (OIR, AIR, PIR, EIR, etc.)

Information requirements under ISO 19650 form the foundation for the systematic generation, management, and handover of information at each project stage. Specifically, Organizational Information Requirements (OIR) and Asset Information Requirements (AIR) define the information strategy during the early project stages. Inadequate preparation of these requirements can lead to inconsistencies in subsequent Project Information Requirements (PIR), Exchange Information Requirements (EIR), and BIM Execution Plan (BEP).

In ODA loan projects, information requirements must be flexibly defined to reflect the institutional context and capacity of implementing countries and agencies. A phased roadmap for introduction will also be necessary.

(3) Application for ODA Loan Projects

This study plans to verify the practicality of the information requirements and the draft handbook through situational assessments in ODA loan recipient countries. This allows not only theoretical refinement but also validation of applicability in real project settings.

Project selection for situational assessments should consider project phase (study, design, construction, O&M) and sector (e.g., rail, road, airport), thereby ensuring the consistency and implementability of information requirements across all stages.

(4) Survey and Analysis Policy for the Current Study

In this study, information collection and analysis were conducted according to the following principles:

- Collecting examples of ISO 19650 information requirements in BIM-advanced countries (UK, EU, Hong Kong, Australia, etc.)
- Organizing and analyzing BIM application cases under FIDIC contracts
- Implementation environment and operational challenges for CDE
- Survey of application status for construction information systems/formats such as Uniclass2015 and IFC/COBie
- Survey of current status in ODA loan recipient countries and collection of feedback related to information requirements

The results of these investigations were used to update the draft handbook and draft specifications, with the objective of enhancing the effectiveness of BIM/CIM implementation in ODA loan projects.

2.4 Summary of the Review Results and Reflection in the Policy

2.4.1 Summary of the Review Results

The review of the previous baseline survey report and the draft handbook indicates that BIM/CIM implementation in ODA loan projects remains at an early stage, characterized by insufficient institutional and technical arrangements and a limited level of understanding among stakeholders. In particular, information management based on ISO 19650 is neither well understood nor adequately implemented, and mechanisms for information management extending through the O&M stage have yet to be established.

Although the draft handbook provides an initial overview of basic BIM concepts and expected benefits, it lacks the level of specificity required to address the practical requirements of ODA loan projects and does not ensure consistency with contractual and procurement frameworks. Technical elements—including the CDE, construction information classification systems, and data exchange formats—are addressed only superficially, rendering the handbook insufficient as an implementation guideline.

2.4.2 Implications for Updating the Draft Handbook

In updating the draft handbook, the following aspects must be prioritized:

- Reflect the latest developments of ISO 19650 (Parts 3 to 6) and systematically organize information requirements.
- Ensure alignment with FIDIC contract conditions and clarify the positioning of BIM-related clauses within contract documents.
- Present concrete methods for CDE utilization across design, construction, operation and maintenance stages.
- Recommend the adoption of international standards such as Uniclass2015 and IFC/COBie-based information structures and formats.
- Provide guidelines for appropriate LOIN (Level of Information Need) at each stage, including LOG (Level of Geometry) as model detail requirements.
- Offer phased implementation pathways tailored to BIM maturity levels of implementing countries and agencies.

Revising the handbook based on these elements will enhance the effectiveness of BIM/CIM introduction in ODA loan projects.

2.4.3 Application Policy for this Study

The findings of this review will be applied to the following activities going forward:

- Development of draft Terms of Reference (TOR) at the preparatory survey stage.
- Refinement of TORs and evaluation criteria for consultant selection.

- Standardization of BIM-related clauses in bidding documents.
- Implementation and feedback of information requirements through baseline assessments conducted in ODA loan recipient countries.
- Strengthening linkages between BIM and asset management in the operation and maintenance stage.

Through these efforts, it is necessary to establish a foundation that supports phased and sustainable implementation of BIM/CIM in ODA loan projects. The review also highlights the need to address aspects insufficiently examined in previous surveys, particularly BIM utilization during the O&M phase and its integration with asset management. Insights gained from this review will contribute to future updates of the handbook and the development of work specifications.

2.5 Review of Other Operation and Maintenance Survey Reports

The TOR for this assignment also required the review and reference of the “Data Collection Survey on Road Asset Management Platform Technical Support” (March 2022), which focuses on road asset O&M.

Although this report does not address BIM-based information management processes, it provides organized assessments of the current status of road asset maintenance in ODA recipient countries, including classifications by asset type such as pavements, bridges, and earthworks, as well as evaluations of budget levels and organizational structures. The report also references future planned road tunnels in Thailand. Information on maintenance systems and routine inspection items is highly relevant to this study, particularly from the perspective of applying BIM as an information management process.

In the road sector, the findings of this survey can support the development of AIR and AIM under ISO 19650. Leveraging these insights will improve the effectiveness of BIM application during the O&M phase.

3 STRUCTURE AND OVERVIEW OF THE ISO 19650 SERIES

This chapter provides an overview of the ISO 19650 series, outlining its overall structure, the purpose and scope of each part, and key considerations for effective implementation. It emphasizes the significance of standardizing information management across the entire asset lifecycle—spanning design, construction, operation, maintenance, and eventual decommissioning—rather than restricting Building Information Modelling/Management (BIM) to the delivery phase alone.

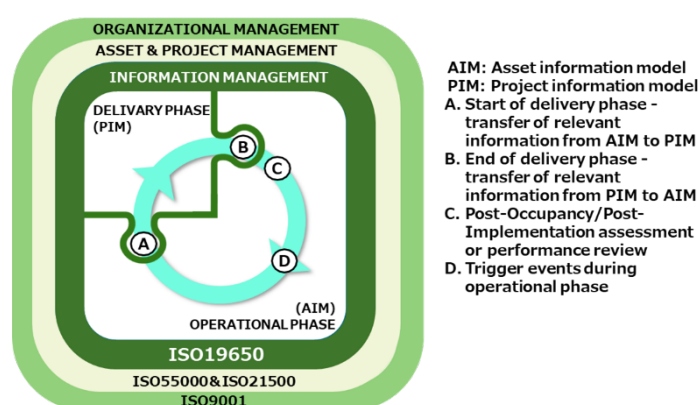
In addition, the chapter explains how the ISO 19650 series align with the ISO 55000 series on asset management, and how their combined application provides a framework for maximizing asset value through effective and structured use of information.

This chapter does not aim to provide an exhaustive commentary on the full text of the ISO 19650 standards. Instead, it establishes the foundational concepts and frameworks necessary to support the more practice-oriented discussions and application examples presented in subsequent chapters. For detailed requirements and formal definitions, readers should refer directly to the ISO 19650 standards.

3.1 Relationship between ISO 19650 and Other Standards

BIM encompasses the entire asset lifecycle—from planning and construction through operation, maintenance, renewal, and decommissioning—and is therefore relevant not only to designers but to all stakeholders involved in asset management. While attention is often placed on the design and construction stages (the Delivery Phase), the greater value of BIM lies in long-term asset operation, including the Operation Phase, where information continuity enables significantly enhanced decision-making and efficiency.

The ISO 19650 series provide a framework for the use of information models throughout the asset lifecycle. By ensuring that information generated during the design and construction is structured and managed in a manner that enables reliable reuse during O&M, the standard enhances both the reliability and efficiency of BIM¹ information. This approach closely aligns with the objectives of the ISO 55000 series, which focuses on maximizing asset value through systematic asset management. When applied together, ISO 19650 and ISO 55000 support strategic and sustainable asset management, whereby information management under ISO 19650 underpins value creation and long-term performance in accordance with ISO 55000. As illustrated in Figure 3-1, the two standards are complementary, with information management forming an essential foundation for effective asset management within the organizational and asset management framework.



Source: Prepared by the JICA Study Team based on ISO 19650-1

Figure 3-1 Positioning of Information Management within Organizational and Asset Management Frameworks (ISO 19650-1, Figure 3)

¹ In Chapters 1 and 2, the term “BIM/CIM” is used in consideration of terminology employed in previous baseline studies and related reference materials. From Chapter 3 onward, as well as in the draft version of this handbook, the term “BIM” is used in accordance with the international information-management framework defined in the ISO 19650 series.

Asset management processes, as defined in the ISO 55000 series, are built on principles aimed at value creation, risk management, and the optimization of resources. The ISO 55000 series consist of the following three documents:

- ISO 55000: Overview, principles, and terminology of asset management
- ISO 55001: Requirements for an asset management system
- ISO 55002: Guidelines for the application of ISO 55001

These standards are applicable to any organization that owns or operates physical assets. In asset-intensive sectors such as railway infrastructure, their relevance is particularly high, as they address asset management across the entire lifecycle—from acquisition through O&M to renewal or disposal.

In the practical application of the ISO 55000 series, particular emphasis is placed on establishing a clear “line of sight” between organizational objectives and on-the-ground activities. This concept refers to the alignment and linkage between the asset management policy, the strategic asset management plan, asset management objectives, asset management plans, and operational activities. By establishing a robust line of sight, organizations can ensure that decision-making is transparent and traceable, and that day-to-day activities are clearly connected to overarching organizational goals.

3.2 Structure and Overview of the ISO 19650 Series

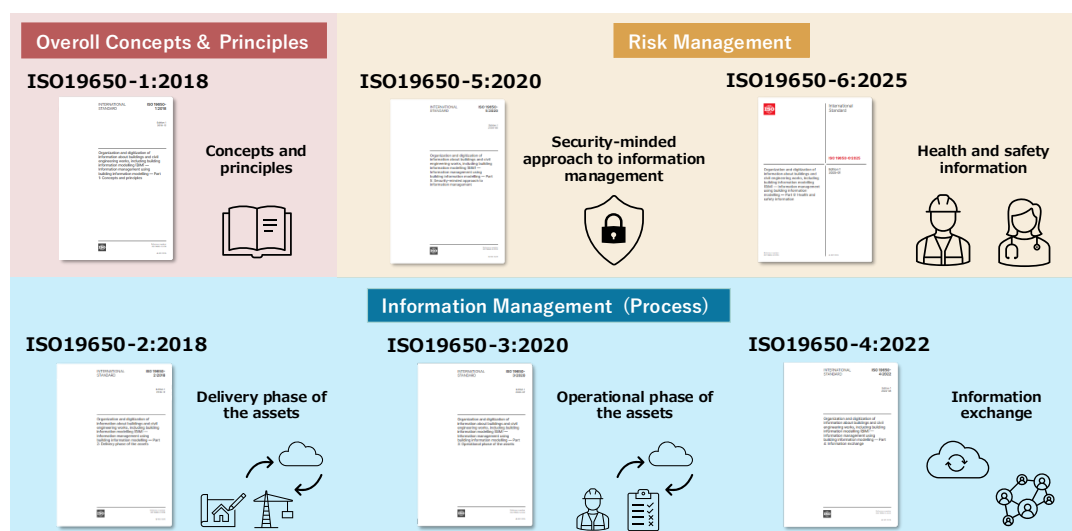
3.2.1 Overall Structure of the ISO 19650 Series

The ISO 19650 series is an international set of standards for information management in the building and civil engineering sectors, providing a comprehensive framework for structuring, sharing, and using information enabled by BIM. The series is intended to ensure consistency, availability, and reliability of information throughout the entire lifecycle of projects and assets, while promoting effective collaboration among involved stakeholders.

The standards are founded on BS 1192 and the PAS 1192 series, which were developed in the United Kingdom (UK) as part of the UK Government’s BIM Level 2 policy. Building on the knowledge and practical experience accumulated through these standards, the ISO 19650 series internationalizes established UK practices and provides a common language for information management in globally executed projects.

A notable feature of ISO 19650-2 is the introduction of National Annexes, which allow individual countries to reflect their specific legal frameworks, institutional arrangements, and cultural practices within the overarching international standard. Several countries have already developed their own National Annexes, enabling flexible and context-sensitive implementation while adhering to the core principles of ISO 19650.

As shown in Figure 3-2, the ISO 19650 series consist of six parts, all of which had been formally published as of January 2025. The most recent document, ISO 19650-6:2025 (Health and Safety Information), was issued on January 13, 2025 and focuses on the structured management and sharing of health and safety information across the lifecycle of built assets.



Source: the JICA Study Team

Figure 3-2 Structure of the ISO 19650 Standards Series

3.2.2 Purpose and Scope of Each Part

Table 3-1 summarizes the purpose and scope of application of each part of the ISO 19650 series.

Table 3-1 Purpose and Scope of the ISO 19650 Series

Part	Title	Year of publication	Purpose	Scope of application
Part 1	Concepts and Principles	2018	Establishes the fundamental concepts, terminology, and principles of information management, clarifying the overall structure of BIM-enabled information management.	Serves as the foundation for information management across the entire lifecycle of built assets.
Part 2	Delivery Phase of Assets	2018	Standardizes processes related to information requirements, the common data environment (CDE), roles and responsibilities, and information delivery during the design and construction phases.	Provides practical guidance for the creation and management of the Project Information Model (PIM).
Part 3	Operational Phase of Assets	2020	Defines information management approaches for the operation and maintenance phase, supporting the long-term value of information assets through the use of the Asset Information Model (AIM).	Applies to the use of information during operation, maintenance, refurbishment, and disposal phases, with strong linkages to OIR and AIR.
Part 4	Information Exchange	2022	Specifies technical requirements for information exchange, review criteria, and quality control of deliverables to ensure information consistency and reliability.	Supports structured and standardized information exchanges across design, construction, and operational phases.
Part 5	Security-minded Approach	2022	Establishes an approach to addressing security risks in information management, including information protection, access control, and risk assessment.	Intended for projects in which security considerations are critical, such as national infrastructure and sensitive facilities.
Part 6	Health and Safety Information Management	2025	Provides a framework for structuring, sharing, and using health and safety information throughout the asset lifecycle.	Applies to the management of health and safety information across design, construction, operations, and disposal phases, and is applicable to both BIM and non-BIM environments.

Source: the JICA Study Team

3.3 Overview of Each Part

3.3.1 Part 1: Concepts and Principles

ISO 19650-1 forms the foundation of the ISO 19650 series and systematically defines the core concepts and principles of information management. This part establishes the theoretical and conceptual framework underpinning the entire series, upon which the more practice-oriented requirements set out in Part 2 and subsequent parts are built. In the context of UK BIM practice, ISO 19650-1 plays a central role as the successor to BS 1192, and also provides the basis for the IMI Framework (formerly the UK BIM Framework)². Through this role, the standard promotes international consistency and standardization in information management, enabling its effective application as a common information management baseline for international projects, including ODA projects.

The primary objective of ISO 19650-1 is to establish a shared language for information management. To this end, the standard is structured around the following key elements:

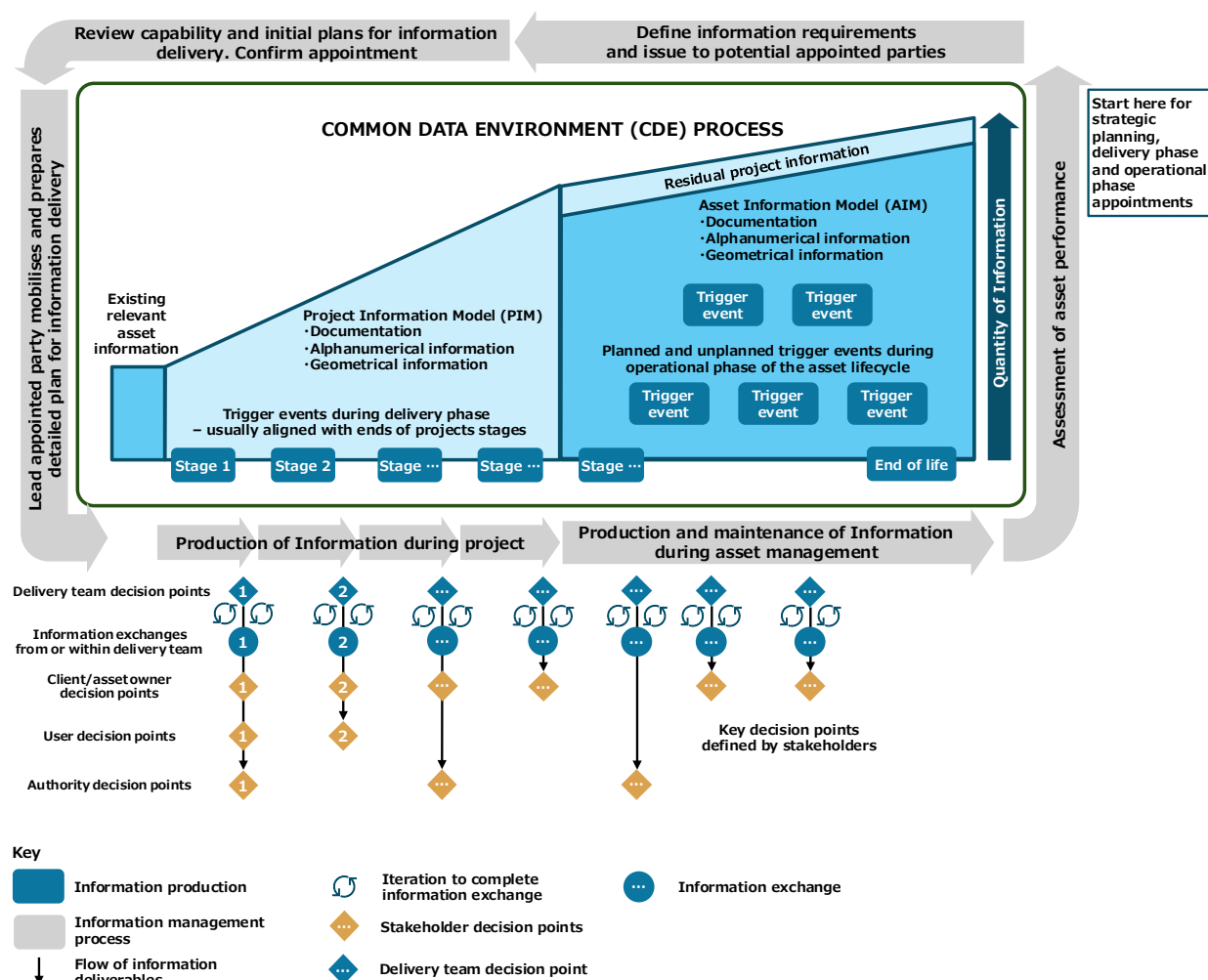
(1) Terminology Framework for Information Management (Clause 3)

To ensure a shared understanding of information management practices, ISO 19650-1 defines key terms and concepts in a structured and systematic manner. This includes the classification of information requirements such as OIR, AIR, PIR and EIR, as well as terminology related to information structures, including AIM, PIM, and the CDE. These definitions form a fundamental basis for preventing misalignment among stakeholders and enable the consistent creation, exchange, and management of information throughout the lifecycle of assets and projects.

(2) Perspectives and Value Structure of Information Management (Clause 4)

Information management is positioned not as a single technical activity, but as a framework that integrates the perspectives of multiple stakeholders. ISO 19650-1 defines four perspectives—those of the asset owner, asset user, project delivery parties, and wider society—and clarifies the objectives and expected outcomes of information from each perspective. This structure enables the value of information to be understood in a multilayered manner and contributes to improved transparency, accountability, and quality of decision-making.

² [IMI Framework – BIM Standards, Guides & Resources](#)



Source: Prepared by the JICA Study Team based on ISO 19650-1

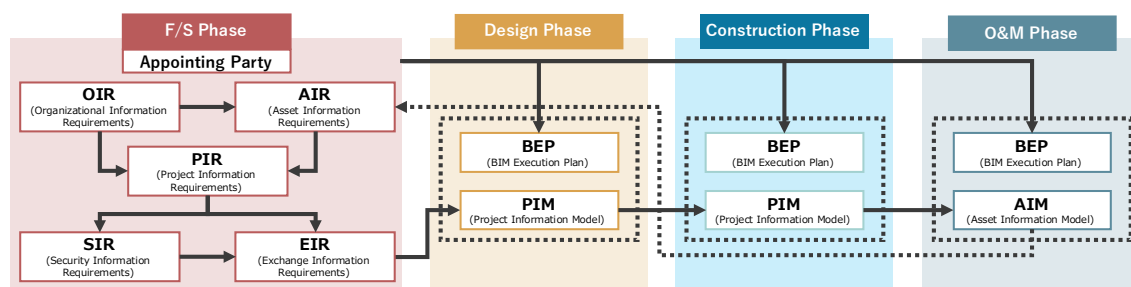
Figure 3-3 Conceptual Overview of Information Management

(3) Hierarchy of Information Requirements and Structuring of Information Models (Clause 5)

ISO 19650-1 structures information requirements hierarchically, defining the content, level of detail and format of information required at each stage from organizational strategy through project execution. Information requirements originate at the organizational level as OIR, are developed into AIR for asset operation and PIR for project execution, and are further translated into EIR for contractual and procurement purposes.

Based on this hierarchy, information models are developed for each lifecycle phase, with the AIM supporting asset operation and the PIM supporting project delivery. These models are structured in accordance with the objectives of each phase and provide a basis for ensuring information consistency, reusability, and traceability in both asset management and project management.

Figure 3-4 illustrates the relationships among these information requirements in schematic manner, supporting a structured understanding that helps avoid both excessive and insufficient information provision. Although not explicitly defined in ISO 19650-1, SIR are included in the figure considering its practical importance. SIR addresses requirements related to information confidentiality, access control, and protective measures, and are particularly relevant for projects involving high-security facilities and public infrastructure.



Source: the JICA Study Team

Figure 3-4 Schematic Representation of Relationships among Information Requirements

(4) Information Delivery Cycle and Lifecycle Integration (Clause 6)

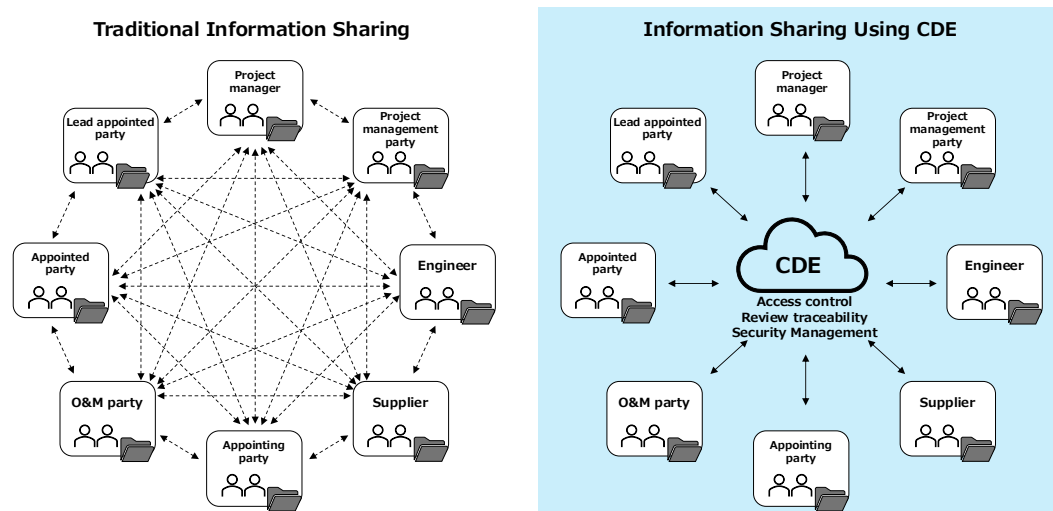
Processes for requesting, producing, reviewing, and integrating information are deployed progressively in line with the asset lifecycle, including planning, design, construction, operation, maintenance, and disposal. ISO 19650-1 provides a framework that links these information processes with management system standards such as ISO 55000 and ISO 9001, thereby institutionally supporting quality assurance and continual improvement in information management.

(5) Structuring of Information Management Functions and Assignment of Responsibilities (Clause 7)

Information management functions are defined across the levels of asset management, project management, and task management, with roles and responsibilities clarified through responsibility matrices. This structure supports information integrity, quality, and traceability and ensures that transparency and reliability are maintained even in complex delivery environments.

(6) Information-container-based Collaboration and Security Management (Clause 9)

Information is divided and structured into information containers according to defined purposes and responsibility boundaries, with each task team responsible for creating and managing its own information. Through the use of a CDE, access control, review history, and security management are implemented in a centralized and systematic manner. Information containers may be segmented based on spatial criteria, such as building levels or zones, or on functional criteria, such as structural or building services disciplines. This approach allows multiple teams to work in parallel while maintaining information consistency and avoiding duplication or interference. Segmented information is subsequently integrated as required to support decision-making and operational use, thereby enhancing information reusability, transparency, and quality in collaborative environments.

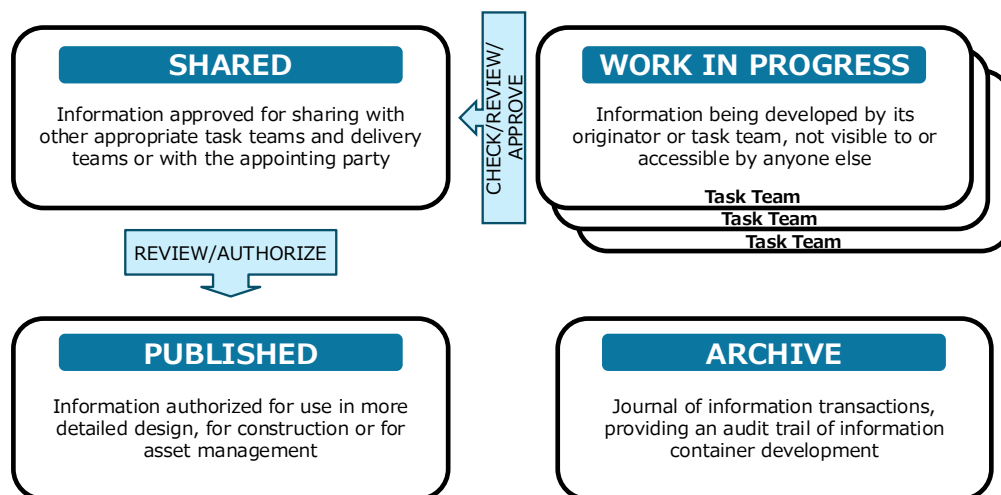


Source: the JICA Study Team

Figure 3-5 Information Sharing Utilizing a CDE

(7) CDE Operating Model and Information Status Management (Clause 12)

The CDE provides management processes based on clearly defined information states, enabling control of information throughout its lifecycle. Each information container is managed using status codes and revision codes, making information reliability, intended use, and change history explicit. This mechanism strengthens information reuse and auditability while ensuring authenticity, integrity, and traceability, thereby supporting contractual, regulatory, and dispute-resolution requirements.



Source: Prepared by the JICA Study Team based on ISO 19650-1

Figure 3-6 Conceptual Diagram of Information Management Based on Information Status

(8) Annex A: Federation Strategy and Information Container Breakdown

Annex A presents practical strategies for the division and federation of information models, illustrating approaches based on spatial, functional, and security-related considerations. The examples relating to linear assets, such as tunnels, and high-security facilities are particularly relevant to infrastructure projects and ODA-financed programmes, where structured information management and security considerations are of critical importance.

3.3.2 Part 2: Delivery Phase of Assets

ISO 19650-2 provides an international standard for the practical implementation of information management during the design and construction stages and sets out a structured framework for the development and use of the PIM. The standard aims to promote collaboration among project participants by standardizing the processes for information creation, sharing, review, authorization, and delivery.

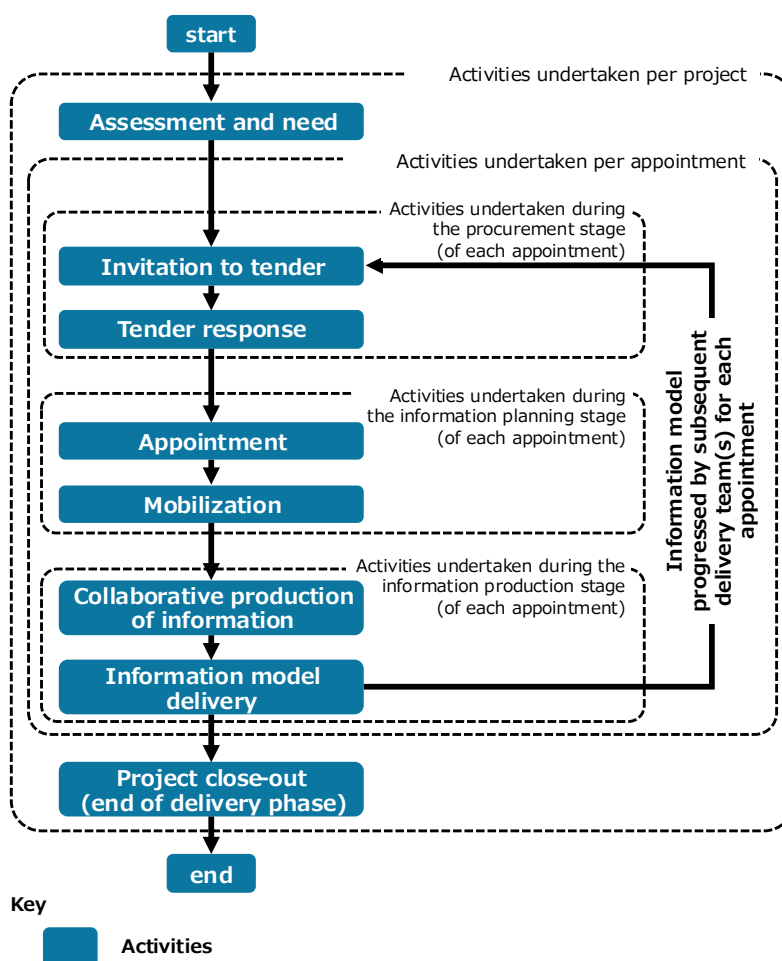
This part focuses on: (1) Defining the appointing party's EIR; (2) Establishing and operating the CDE; (3) Managing information delivery milestones; (4) Reviewing and approving of deliverables; (5) Clarifying roles and responsibilities of all participating parties. Particular emphasis is placed on designing workflows that ensure the reliability and traceability of information, thereby enabling quality assurance and effective decision-making throughout the information lifecycle.

ISO 19650-2 clearly defines mechanisms for information status management, including suitability coding, as well as verification and approval processes at the level of individual information containers. These mechanisms secure the consistency and reusability of information, enhancing transparency in information sharing between the appointing party, designers, and contractors, which improves project efficiency and the quality of deliverables.

“Transparency” in information sharing refers to a state in which all parties can access the information they require at the appropriate time and where the creation, modification, and approval history of information is centrally managed. For example, when design changes and approval statuses are recorded and shared via the CDE, all parties can confirm who made each decision and on what basis. This supports clarity in decision-making, accountability, helps prevent misunderstandings and concealment of information, and

contributes to overall project reliability with respect to quality, safety, contractual compliance, and risk management.

As illustrated in Figure 3-7, this part structures the flow of information during the design and construction stages into eight phases, applied progressively in line with project development.



Source: Prepared by the JICA Study Team based on ISO 19650-2

Figure 3-7 Information Management Process During the Design and Construction Stages

These phases aim to improve the quality of project deliverables and the accuracy of decision-making through the planned creation, management, and delivery of information. The process is structured as follows.

(1) Assessment and Need

At the outset of the project, the appointing party defines the information management framework and establishes arrangement aligned with its long-term asset management strategy. Key activities include:

- Appointment of information management roles: Assigning information management functions either within the appointing party or to third parties, and clarifying responsibilities, authority, and required competencies.
- Definition of PIR: Identifying the information required to support project decision-making at each stage.
- Specification of information standards: Documenting classification systems (aligned with ISO 12006-2), information structure, quality criteria, and naming conventions
- Establishment of information production methods and procedures: Standardizing processes for review,

approval, distribution, and security management.

- Establishment of the CDE: Providing a platform for centralized information management and access control
- Definition of information protocols: Establishing contractual rules relating to intellectual property rights, licenses, allocation of liability, and reuse of information.

(2) Invitation to Tender

The appointing party issues the EIR and clarifies expectations regarding information management to prospective lead appointed parties. Key activities include:

- Issue of the EIR: Formalizing organizational, asset-level, and project-level information requirements, and defining acceptance criteria for deliverables
- Provision of reference information and shared resources: Sharing existing asset information, templates, and libraries via the CDE.
- Definition of tender information requirements: Specifying submission requirements such as the BEP, capability assessments, mobilization plans, and risk assessments.

(3) Tender Response

Prospective lead appointed parties develop and submit their proposed information management arrangements in response to the appointing party's EIR. Key activities include:

- Preparation of the pre-appointment BEP: Outlining the proposed information management approach, organizational structure, allocation of responsibilities, and use of technology.
- Capability assessment: Assessing the information production and management capabilities of task teams, including IT environments and training arrangements.
- Development of a mobilization plan: Proposing plans for CDE configuration, resource allocation, and education and training.
- Risk management: Identifying risks related to information delivery and defining mitigation measures.

(4) Appointment

Following contract award, the lead appointed party formally documents responsibilities and plans for information management. Key activities include:

- Finalization of the MIDP: Integrating overall information delivery schedules and responsibilities.
- Development of the TIDP: Detailing information delivery plans for each task team
- Establishment of responsibility matrices: Clarifying who is responsible for delivering what, when, and how information.
- Incorporation into contractual documentation: Embedding the EIR, BEP, MIDP, and information protocol into the contract and placing them under formal change control.

(5) Mobilization

After appointment, the lead appointed party prepares the environment for information production. Key activities include:

- Preparation of the IT environment: Configuring required software, hardware, and CDE connections.
- Delivery of education and training: Ensuring that relevant personnel acquire the knowledge and skills required for the agreed information management approach.
- Testing of information production methods: Validating information container structures, shared resources, and procedural implementation.

(6) Collaborative Production of Information

Task teams produce and share information collaboratively while maintaining quality control. Key activities include:

- Information production: Creating information in accordance with defined standards and methods, ensuring neither underproduction nor overproduction.
- Quality assurance checks: Verifying compliance of information containers with structural, attribute, and classification requirements.
- Review and approval processes: Checking suitability for use, intended purpose, and coordination with other teams.
- Model coordination: Ensuring consistency of the overall information model and resolving inter-team issues.

(7) Information Model Delivery

Information models are formally delivered following approval by the lead appointed party and acceptance by the appointing party. Key activities include:

- Approval by the lead appointed party: Confirming completeness and conformity of information in accordance with the MIDP.
- Acceptance by the appointing party: Evaluating the information model against the EIR and acceptance criteria, and formally receiving it.

(8) Project Close-out

At project completion, the appointing party ensures long-term preservation of information and captures of lessons learned. Key activities include:

- Transition to AIM: Transferring relevant information from the PIM to the AIM.
- Archiving of information: Storing information containers within the CDE for future reference and reuse.
- Capture and sharing of lessons learned: Documenting knowledge gained during the project for application in future projects.

3.3.3 Part 3: Operational Phase of Assets

ISO 19650-3 provides guidance on information management during the O&M phase of assets, supporting the long-term preservation of asset value and improvements in operational efficiency through the use of the AIM.

This part places particular emphasis on alignment with OIR and AIR and systematically organizes methods for the collection, updating, and use of information during the operational phase. In particular, it highlights the importance of process design to ensure the consistency and reusability of information during operational events such as refurbishment, renewal, and disposal.

The standard defines mechanisms for providing information in forms and levels of detail appropriate to the needs of facility managers and operators and assumes integration with FM through the use of BIM where applicable.

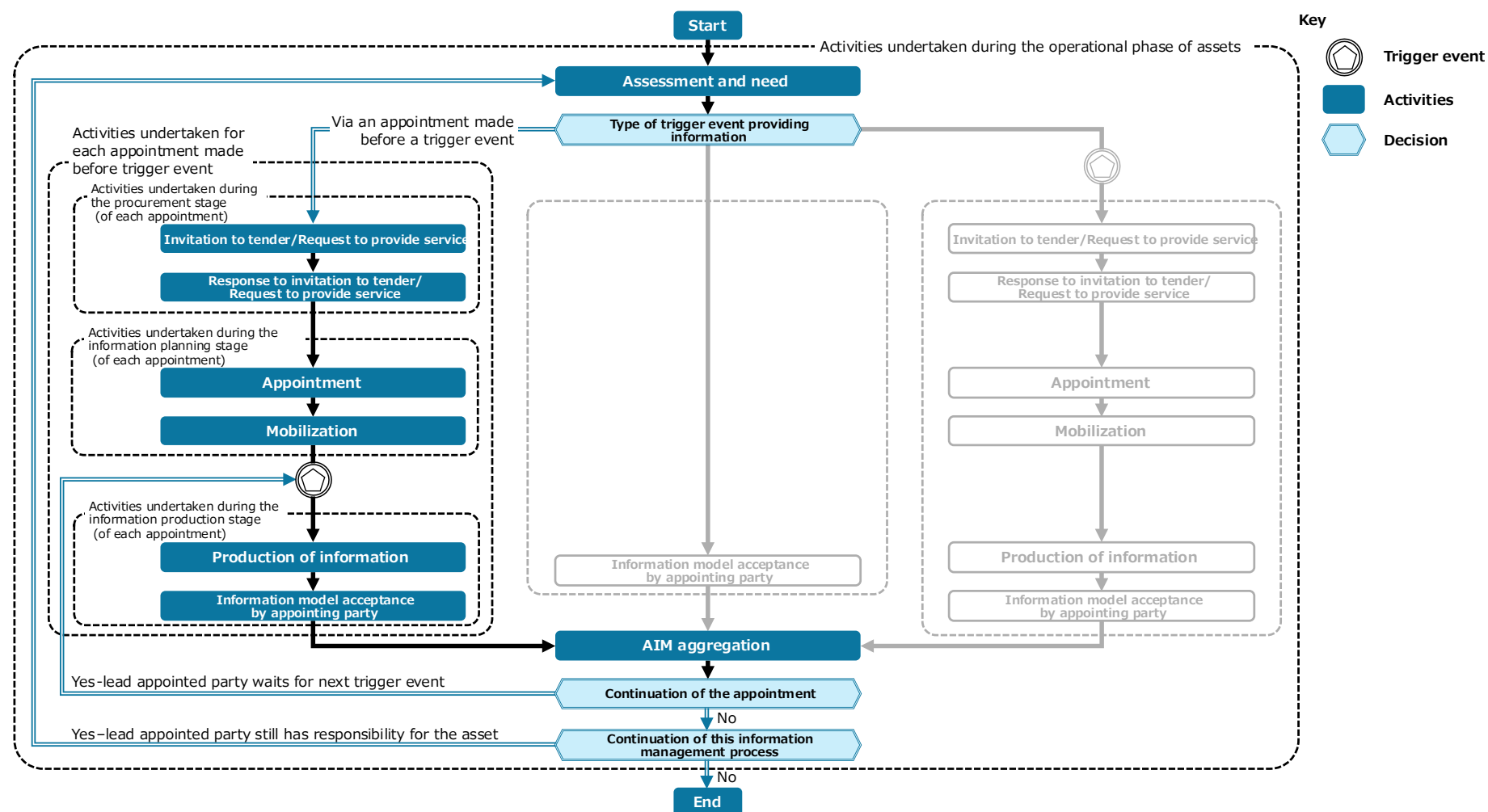
The information management processes for the operational phase defined in ISO 19650-3 consist of key activity groups, as illustrated in Figure 3-8 to Figure 3-10, which are initiated by trigger events and branch into multiple process paths. Whereas ISO 19650-2 establishes a predefined sequence of information management activities at the start of a project, ISO 19650-3 activates information management processes each time a trigger event occurs during the O&M phase.

Figure 3-8 illustrates the information management process for foreseeable trigger events (referred to as “planned trigger events” in Figure 3-1). Typical examples include periodic inspections and statutory

examinations, for which appointments can be made in advance, and information can be prepared in a planned manner.

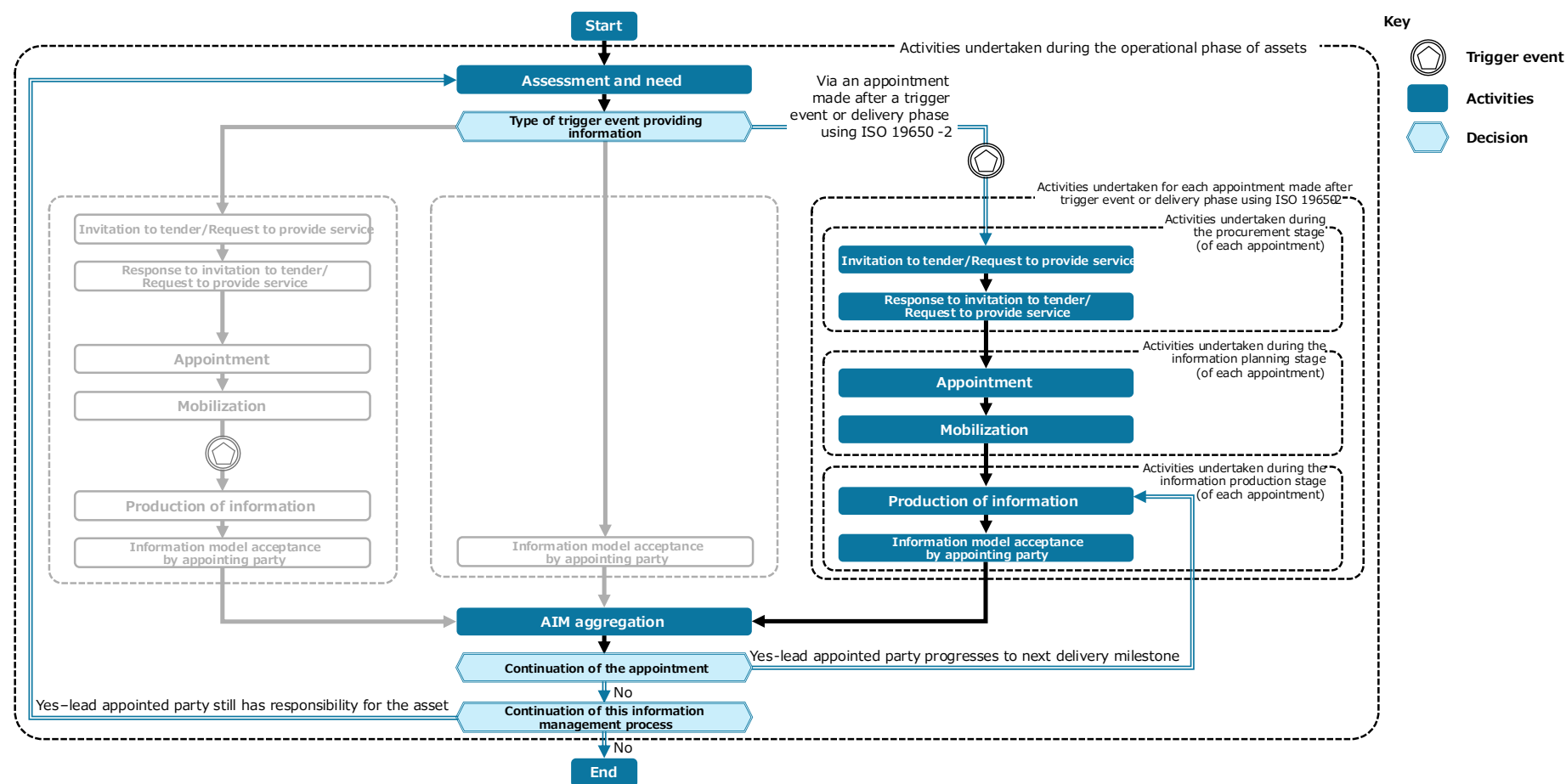
Figure 3-9 illustrates the process for unforeseeable trigger events (referred to as “unplanned trigger events” in Figure 3-1), such as fires or equipment failures. In these cases, appointments are made after the event has occurred, making it impracticable to prepare information management processes in advance. Information is therefore generated using the information delivery processes defined in ISO 19650-2.

Figure 3-10 illustrates the information management process where information is obtained from an appointing party or an existing asset owner—for example, when a building or facility is transferred from another owner.



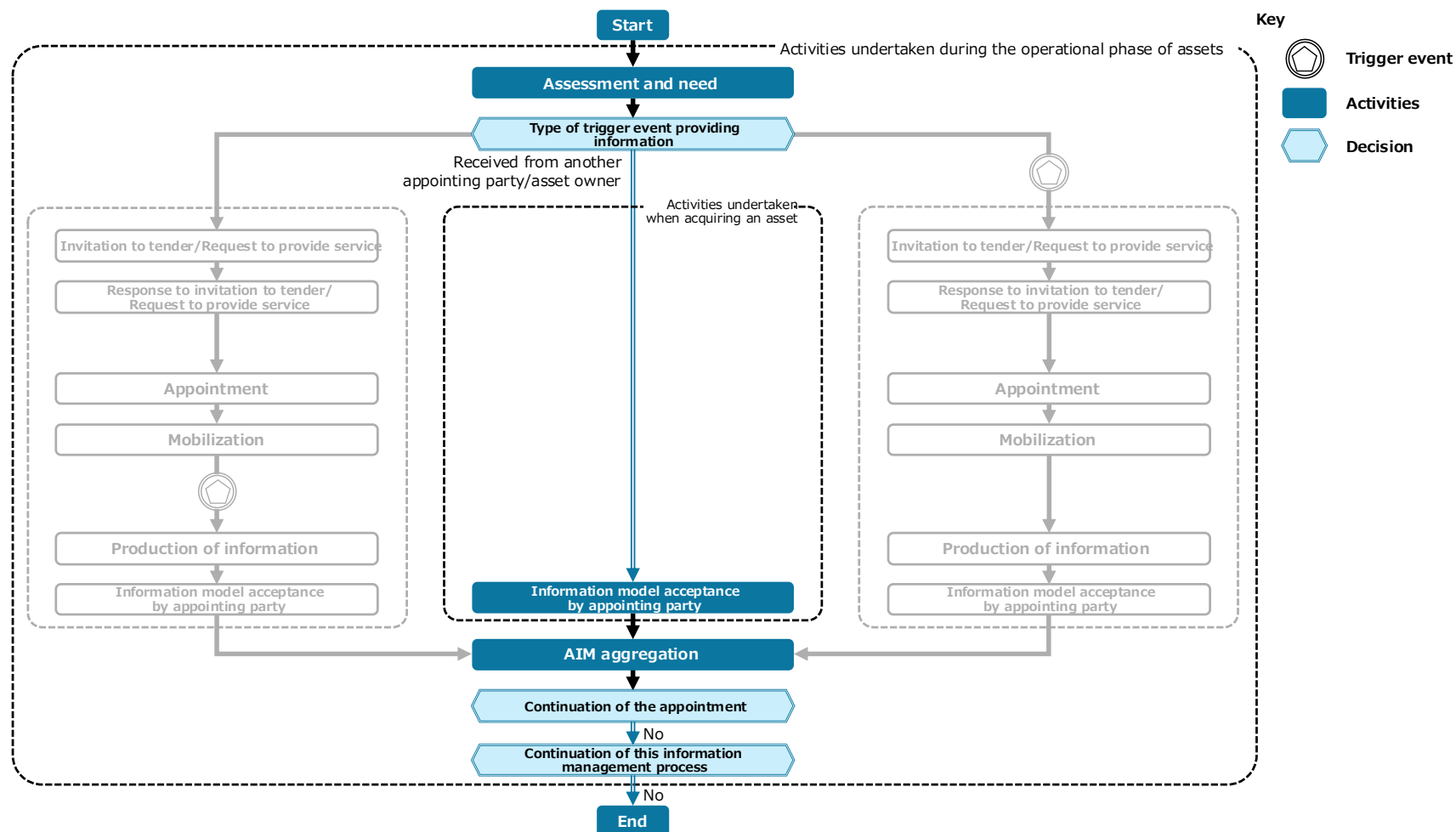
Source: Prepared by the JICA Study Team based on ISO 19650-3

Figure 3-8 Information Management Process During the Operational Phase (Planned/Foreseeable Trigger Events)



Source: Prepared by the JICA Study Team based on ISO 19650-3

Figure 3-9 Information Management Process During the Operational Phase (Unplanned/Unforeseeable Trigger Events)



Source: Prepared by the JICA Study Team based on ISO 19650-3

Figure 3-10 Information Management Process During the Operational Phase (Asset Transfer and Similar Cases)

This framework is intended to address information needs arising during asset operation and is structured as follows:

(1) Assessment and Need

The appointing party undertakes the following activities to establish the foundations for information management:

- Appointment of information management roles and clarification of responsibilities
- Definition of OIR and AIR
- Identification of assets under management and relevant trigger events
- Establishment of the design principles for the AIM and the associated maintenance and operational processes

(2) Invitation to Tender / Request to Provide Service

Depending on the nature of the trigger event, the appointing party defines the scope of information services and undertakes the following activities:

- Determination of activity types and contracting arrangements, reflecting the process paths shown in Figure 3-8 to Figure 3-10
- Definition of EIR
- Preparation of reference information and assessment criteria

(3) Response to Invitation

Prospective lead appointed parties prepare proposals in response to the appointing party's EIR, including:

- Preparation of the BEP
- Assessment of the capability and structure of the delivery team
- Preparation of the risk register and supporting submission documents

(4) Appointment

The appointing party and the lead appointed party formally establish the information delivery arrangements by incorporating the following into the contract:

- Preparation of the MIDP and TIDP
- Clarification of responsibilities for information delivery
- Integration of information requirements into contractual documentation

(5) Mobilization

The lead appointed party undertakes the following activities in preparation for information production:

- Mobilization of personnel and IT infrastructure
- Testing of information production methods and preparation of shared resources
- Establishment of arrangements for rapid response to trigger events

(6) Production of Information

Task teams generate and manage information under the direction of the lead appointed party through the following steps:

- Information production, quality assurance, review, and approval
- Development of information models and registration within the CDE

(7) Information Model Acceptance

The appointing party receives and evaluates the information containers submitted by the lead appointed party and undertakes the following:

- Review of the information model and acceptance decision
- Transition of approved information to a published state within the CDE

(8) AIM Aggregation

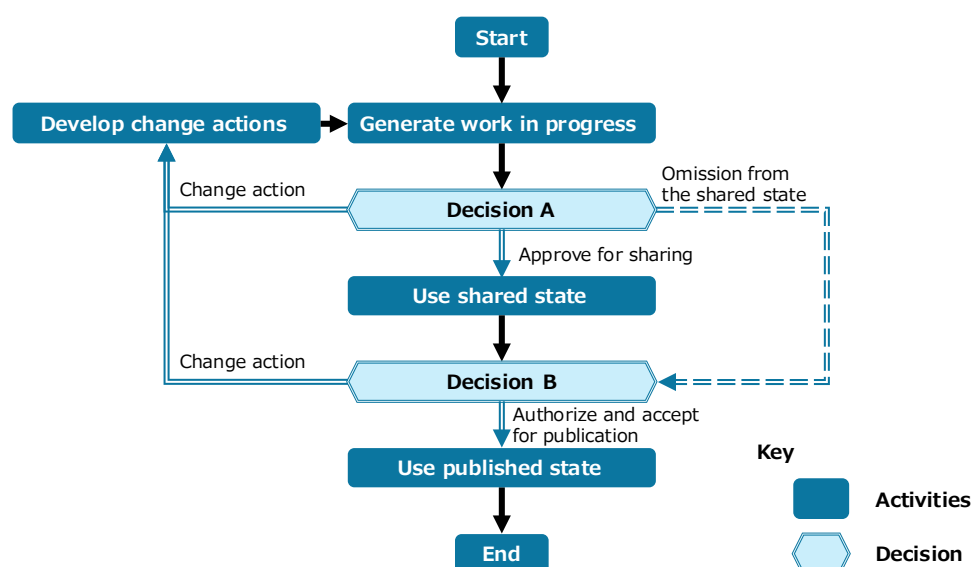
The appointing party integrates approved information into the AIM and carries out the following activities on an ongoing basis:

- Aggregation of information models and verification of consistency with existing information
- Updating, maintenance, and archiving of the AIM

3.3.4 Part 4: Information Exchange

ISO 19650-4 defines the technical specifications for information exchange across the design, construction, and operational stages, with the objective of ensuring the quality and reliability of deliverables through the structuring and standardization of information. This part provides a technical framework specifying review criteria for information exchange, methods for verification of deliverables, and requirements for submission formats and metadata, thereby supporting consistency and reusability of information.

Part 4 places particular emphasis on processes for the planning, execution, approval, and change management of information exchanges, providing practical support for efficient information transfer among multiple parties. By establishing clear and objective criteria for information exchange, this part aims to secure the quality, integrity, and trustworthiness of information used within BIM-based project and asset management.



Source: Prepared by the JICA Study Team based on ISO 19650-4

Figure 3-11 Flow of the Information Exchange Process

(1) Structure of the Information Exchange Process (Clauses 4–5)

ISO 19650-4 classifies information exchange into three information states: Work in Progress (WIP), Shared, and Published. For each state, the standard defines processes for information creation, review, approval, and change management. This structure clarifies how information progresses from internal development, through coordination with other parties, to formal release for agreed uses.

(2) Decision-making Associated with State Transitions (Clause 6)

When information transitions to the Shared or Published state, formal decisions are required: Decision A (approval for sharing) and Decision B (approval for publishing). Each decision is assessed against the evaluation criteria defined in Clause 7, ensuring that information meets required quality and suitability thresholds before being made available for broader use.

(3) Review Criteria for Information Exchange (Clause 7)

To assure information quality, ISO 19650-4 defines seven technical review criteria for application during information exchange:

- 1). Compliance with CDE requirements, including naming and metadata
- 2). Conformity with specified schemas and formats
- 3). Continuity of information across exchanges
- 4). Prevention of information degradation
- 5). Consistency
- 6). Completeness
- 7). Other applicable legal and functional requirements

These criteria provide an objective basis for verifying the suitability of information for its intended purpose and support systematic quality control across exchanges.

(4) Open Formats and Schemas (Annex A)

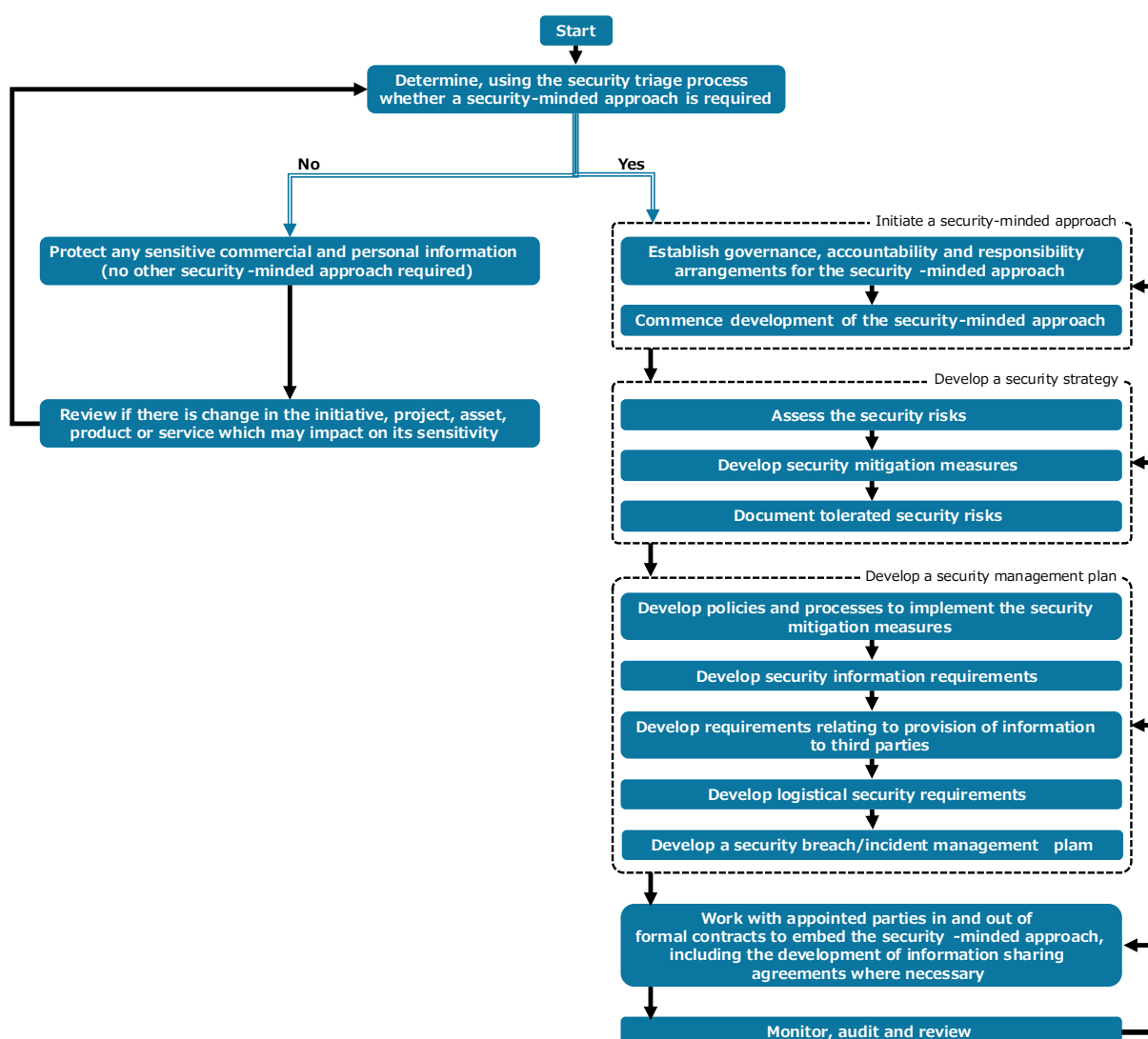
Annex A introduces open formats and schemas such as IFC, GML, and COBie, which are recommended as standard means of improving interoperability in information exchange. The use of such open standards supports vendor-neutral data exchange and enhances the long-term usability of information across different systems and lifecycle stages.

3.3.5 Part 5: Security-minded Approach

ISO 19650-5 addresses security risks in BIM-enabled information management and provides a framework for information protection and risk management in projects that involve sensitive information, such as national infrastructure and critical facilities.

The standard systematically organizes approaches for the identification of sensitive information, access control, risk assessment, and the development of security strategies and management plans across the entire lifecycle of projects, assets, and services. It presents a practical and proportionate approach to minimizing the risks of information leakage and unauthorized access. In particular, it requires the definition of SIR and the establishment of information management arrangements based on these requirements, placing emphasis on process design to ensure confidentiality, integrity, and availability of information.

Figure 3-12 illustrates the security implementation procedure presented in ISO 19650-5.



Prepared by the JICA Study Team based on ISO 19650-5

Figure 3-12 Security Implementation Process

This procedure presents a structured sequence of steps for introducing and operating a security-minded approach, as outlined below.

(1) Security Triage (Clause 4.7)

An assessment is conducted to determine whether the project or asset involves sensitive information and to identify the appropriate level of security. Security triage provides the basis for applying ISO 19650-5 by evaluating whether the project or asset contains sensitive information or provides access to sensitive information of third parties.

(2) Establishment of Governance and Accountability (Clause 5.1)

Responsible persons within and outside the organization are identified and governance arrangements are established to enable coordinated security management among relevant parties.

(3) Development of a Security Strategy (Clause 6)

A security strategy is developed, including risk assessment, definition of risk mitigation measures, and arrangements for the recording, review, and acceptance of residual risks.

(4) Development of a Security Management Plan (Clause 7)

A security management plan is prepared, addressing the definition of SIR, information-sharing arrangements, logistics, and the establishment of audit and review mechanisms.

(5) Development of a Security Incident Response Plan (Clause 8)

Procedures are defined for the detection, containment, recovery, and prevention of recurrence in the event of a security incident, with clear actions and responsibilities specified.

(6) Coordination with Contracting Parties and Information-sharing Arrangements (Clause 9)

Security requirements are incorporated into contractual documentation, coordination with contracting parties is ensured, and arrangements for information handling at contract completion are established.

(7) Continuous Audit, Review, and Improvement

Security measures are regularly reviewed and updated in response to changes in projects or assets, ensuring that security arrangements remain effective and appropriate throughout the lifecycle.

3.3.6 Part 6: Health and Safety Information Management

ISO 19650-6 provides a framework for systematically structuring, sharing, and using health and safety information across the design, construction, operation, and disposal stages. This part integrates information on health and safety risks, hazards, incidents, and corresponding mitigation measures into information management processes.

The standard defines requirements for the classification, recording, updating, sharing, and generalization of health and safety information. It supports integration with geometric and programme models within BIM environments and allows flexible implementation in non-BIM environments.

Health and safety information management includes site-level safety measures that form part of construction management, such as worker safety training, identification of hazardous areas, and management of accident records. ISO 19650-6 goes beyond these measures by enabling systematic management of health and safety information across the entire asset lifecycle. This includes risk anticipation during design, implementation of safety measures during construction, and the recording and sharing of accident and health information during operation. For example, hazardous locations may be visualized within design models; risk registers and records of mitigation measures may be shared through the CDE during construction; and historical incident information and responses may be managed and utilized during operation. This approach enables all parties to understand health and safety risks and supports prompt response and prevention of recurrence.

By ensuring transparency and traceability of health and safety information among stakeholders, the standard promotes early identification and response to risks, supports accident prevention, and contributes to the development of a positive safety culture. Health and safety information is shared via the CDE, and designers, contractors, operators, and appointing parties are required to collaborate in managing such risks.

ISO 19650-6 does not prescribe specific risk assessment methods; instead, it focuses on how information related to risk is communicated and shared. Risk assessment methodologies are addressed by existing standards such as ISO 31000, ISO 45001, and ISO 45002. ISO 19650-6 therefore serves as a common language and procedural framework for information exchange.

Through systematic information management of health and safety risks, this part aims to improve safety performance and prevent accidents across the entire asset lifecycle. Its main components are outlined below.

(1) Schema Structure for Health and Safety Information

ISO 19650-6 requires health and safety information to be structured and classified according to an agreed schema. The schema consists of the following four key elements:

- Context: Background conditions under which a risk arises, including relevant working environments and asset information.
- Risk: Attributes such as risk type, extent of impact, and likelihood of occurrence.
- Incident: Identifiers for past accidents or events, dates of occurrence, and severity.
- Treatment: Mitigation measures or responses, responsible parties, and implementation status.

Each element is defined with dedicated attributes, and information is organized in formats such as risk registers, incident records, and mitigation plans. By representing this information in digital formats such as CSV files or IFC property sets (e.g., *Pset_Risk*, *Pset_Incident*), interoperability with BIM tools and FM systems is supported, enabling long-term and consistent management of information.

(2) Identification and Classification of Information

Information is uniquely identified through attributes such as project identifiers, originator identifiers, and record types. Classification is structured in accordance with Annex B, with categories including health, welfare, safety, and environment.

(3) Creation, Sharing, Presentation, Use, and Generalization of Information

Information generated at each phase is shared among stakeholders through the CDE and used to support decision-making during design, construction, and operation. Design models and programmes are expected to include health and safety metadata, and the EIR should specify how BIM contributes to health and safety management. During delivery phases, as-built models may be filtered using

safety-related attributes to generate the final health and safety file.

(4) Process Management and Implementation Considerations

Key implementation aspects are identified, including provision of existing information, evaluation criteria at the time of contract award, collaborative working arrangements among teams, integration with IFC, and the use of risk evaluation indicators as described in Annex C.

(5) Advanced Health and Safety Information Management Using IFC 4.3

ISO 19650-6 encourages the use of open, machine-readable formats for managing health and safety information. By introducing schema-based structured data, the reusability of information and interoperability between software platforms are improved. As illustrated in Figure 3-13, IFC 4.3 enables risk information to be associated directly with entities such as *IfcElement*, *IfcTask* and *IfcSpace* using property sets such as *Pset_Risk*. Health and safety information can therefore be represented both visually and structurally within the model and utilised across design, construction, and operational phases. Designers and contractors may be required to create hazard logs in structured databases, such as spreadsheets or SQL tables, and upload them to the CDE to link them with model elements.

6.4.4.17 Pset_Risk

PSET_TYPEDRIVENVERRIDE / IfcProcess, IfcProduct, IfcGroup

An indication of exposure to mischance, peril, menace, hazard or loss. Documentation of a potential hazard, likelihood and consequence aligned with AS/NZS 4360 and BS PAS 1192-6:2017, which can be assigned to or associated with a product, activity and/or location. Alternatively it may be assigned to an ISO 3864 annotation symbol.

HISTORY: Extended in IFC2x3, Revised IFC4x3

There are various types of risk that may be encountered and there may be several instances of Pset_Risk associated to an instance or type.

Properties

PSD-XML

Name	Type	Description
RiskName	P_SINGLEVALUE / IfcLabel	A locally unique identifier for the risk entry that can be used to track the development and mitigation of the risk throughout the project life cycle
RiskType	P_ENUMERATEDVALUE / IfcLabel / PEnum_RiskType	Identifies the predefined types of risk from which the type required may be set.
NatureOfRisk	P_SINGLEVALUE / IfcLabel	A description of the generic nature of the context or hazard that might be encountered.
RiskAssessmentMethodology	P_SINGLEVALUE / IfcLabel	An indication or link to the chosen risk assessment methodology, for example PAS1192-6 or a chosen ISO13100 annex.
UnmitigatedRiskLikelihood	P_ENUMERATEDVALUE / IfcLabel / PEnum_RiskRating	Identifies the likelihood of the hazard prior to any specific mitigation.
UnmitigatedRiskConsequence	P_ENUMERATEDVALUE / IfcLabel / PEnum_RiskRating	Identifies the consequence of the hazard prior to any specific mitigation.

Source: buildingSMART Technical

Figure 3-13 Pset Risk in IFC 4.3

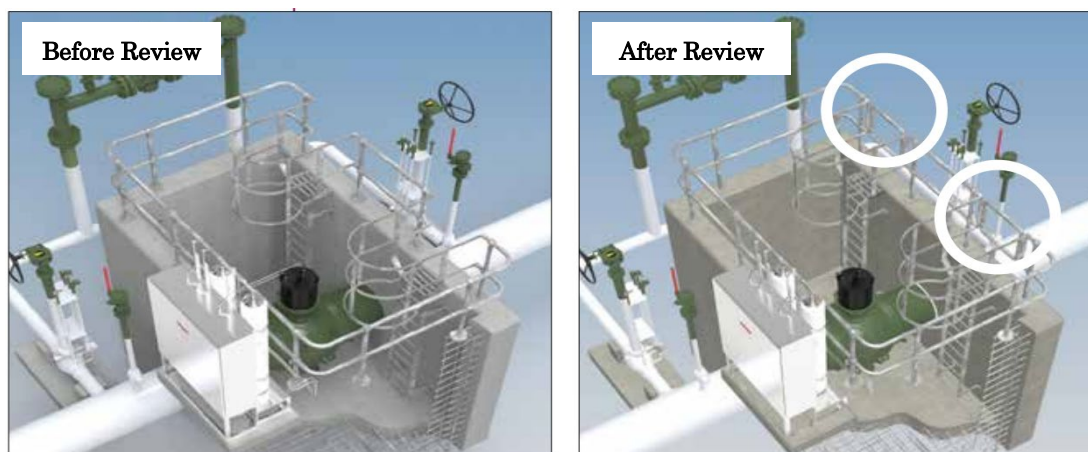
(6) Examples of Health and Safety Information Use in Construction

ISO 19650-6:2025 represents the international standardization of PAS 1192-6:2018 and provides a structured approach to managing health and safety information in construction projects. Development was led by the BIM4 Health & Safety Working Group, and the standard was published as BS EN ISO 19650-6:2025 in January 2025.

According to BSI³, the UK construction industry incurs approximately GBP 1.3-1.4 billion annually in health- and safety-related costs and experiences more than 2.5 million lost working days. ISO 19650-6 promotes the early integration of health and safety information into digital models as a means of addressing these challenges.

In line with the “Golden Thread” concept, improved safety performance is sought through visualization and sharing of risk information across design, construction, and operation phases.

One example, published by the Health and Safety Executive (HSE)⁴ in “Improving Health and Safety Outcomes in Construction”⁵, describes a design review of a valve pit for National Grid. While the original design included only safety ladders and barriers, review using a 3D model enabled safety managers to identify the need for additional gated access, resulting in early-stage risk mitigation and improved safety outcomes.



Source: Improving Health and Safety Outcomes in Construction: Making the Case for Building Information Modelling (BIM)

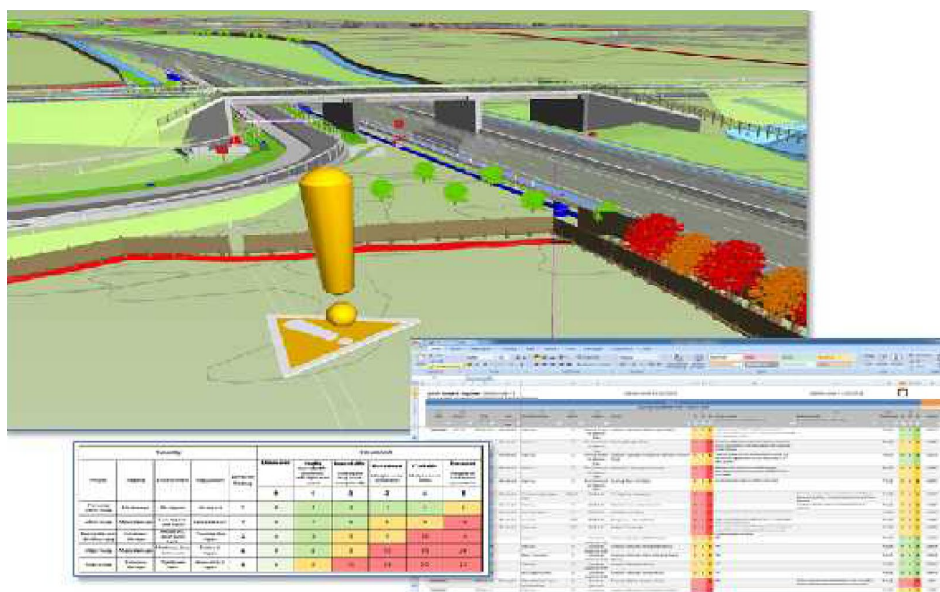
Figure 3-14 Addition of Gated Access Following Safety Review Using a BIM Model

Another example, from the A556 Project, demonstrates safety management using hazard triangles within the model and a linked risk register. Hazard markers were associated with model components and connected to the risk register, with risks color-coded by severity and automatically updated as mitigation measures were applied. These markers were also reproduced in associated documents, such as screenshots and 2D drawings, enabling effective risk management throughout the project and rapid identification of hazards on site.

³ [Bridging safety and technology: The role of BS EN ISO 19650-6:2025 ... | BSI Knowledge](#)

⁴ [Building Information Modelling \(BIM\)—HSE](#)

⁵ [Improving Health and Safety Outcomes in Construction: Making the Case for Building Information Modelling \(BIM\)](#)



Source: Improving Health and Safety Outcomes in Construction: Making the Case for Building Information Modelling (BIM)

Figure 3-15 Hazard Triangles and Risk Register in the A556 Project

(7) Strengthening of ISO 19650-6 and UK Background

PAS 1192-6:2018, which underpins ISO 19650-6, expanded the scope of health and safety information management beyond construction activities to encompass the full asset lifecycle. This development was influenced by the Grenfell Tower fire in 2017, which highlighted deficiencies in the availability and traceability of information on materials and building safety characteristics. Subsequent investigations revealed that such information was unavailable for a large proportion of existing buildings.

To address this gap, the Golden Thread Policy was introduced in 2018 to ensure that critical safety information remains accurate, accessible, and continuously maintained throughout the lifecycle, with clear accountability. This approach was subsequently embedded in legislation through the Building Safety Act 2022, which mandates its application to higher-risk buildings.

In the UK, guidance has been published to bridge health and safety information management using BIM with the requirements of The Construction (Design and Management) Regulations 2015⁶. In addition, while IFC enables attribution of risk-related properties, its attribute hierarchy may be insufficient in certain cases, such as applications to existing buildings not linked to models. For this reason, the use of construction information classification systems in parallel is recommended. In Uniclass 2015, tables for risk (RK), materials (Ma), and properties and performance (PC) were added in 2023, with the RK table recommended for risk classification.

3.4 Revision Trends of the ISO 19650 Series

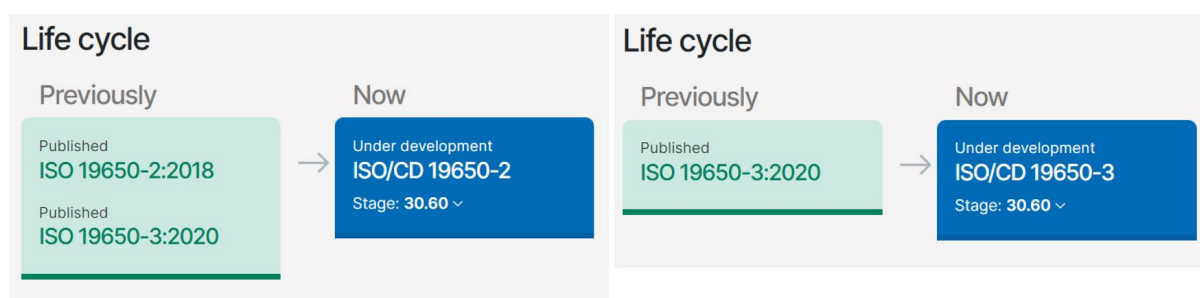
Since their publication, the ISO 19650 series has become established as an international standard for

6 BIM 4 WG: Digitizing CDM-A Client's Guide to improving Information Management in Construction Projects A Bridge between PAS 1192-6 and ISO 19650

BIM and information management. However, in response to increasing industry maturity and issues identified in practical implementation, revision activities are currently underway. Key discussion points include: (1) potential integration of the delivery phase (Part 2) and the operational phase (Part 3); (2) refinement of terminology and definitions; (3) reconsideration of the CDE concept; (4) strengthened responses to practical challenges, such as trigger events and procurement approaches; and (5) consideration of restructuring Part 3 as an implementation-focused guidance document.

The revision process commenced in 2024 and is proceeding through the standard ISO stages, including working drafts, committee drafts, and public commenting. Publication of revised editions is expected from 2025 onwards. At present, the relevant standards are classified as under revision, with progress information made publicly available on the ISO official website. As illustrated in Figure 3-16, ISO 19650-2 and ISO 19650-3 have both transitioned from Published status to Under Development (Stage 30.60).

Following the revision, greater consistency of information management across the entire asset lifecycle, together with increased flexibility for practical implementation, is anticipated. Practitioners are advised to monitor the latest developments and, where necessary, review and update operational procedures, contractual documentation, and related practices to remain aligned with the evolving standards.



Source: ISO official website, [ISO/CD 19650-2](#) and [ISO/CD 19650-3](#)

Figure 3-16 Status of ISO 19650 Revisions (as of November 11, 2025)

4 STANDARDS AND TOOLS RELATED TO ISO 19650 IMPLEMENTATION

4.1 Associated Technologies, Standards, and Tools for Implementing ISO 19650

ISO 19650 provides a framework for information management in construction projects. It intentionally avoids prescribing detailed technical specifications and instead focuses on fundamental principles and concepts. As a result, effective implementation within actual projects requires a solid understanding of the related standards and tools that ISO 19650 references or relies upon.

ISO 12006-2 defines a foundational classification framework for construction information, modelling the relationships between objects (entities) and processes (activities). This structure is essential for ensuring consistency and coherence in information management. ISO 19650 also assumes alignment with these classification principles, which form the basis for collaborative information creation and quality management.

Industry Foundation Classes (IFC) is an open data schema for the exchange and sharing of BIM information across the built environment. Standardized as ISO 16739, IFC provides a neutral format that supports interoperability between software systems, enabling the structured exchange of geometry, attributes, and relationships throughout design, construction, and asset management. Within ISO 19650-based information management, IFC functions as a core technology for model-based information exchange.

COBie provides a schema for handing over structured information from design and construction to facilities management systems. It is essential for integration with FM systems such as CAFM and CMMS and supports asset information delivery.

The CDE serves as a shared platform for managing and exchanging information, providing transparency and full traceability across all project participants.

Level of Information Need (LOIN) establishes the required level of detail and purpose of information at each project stage, preventing both overproduction and underproduction of information.

When these standards and tools are integrated with enterprise systems such as FM platforms, they enable consistent information use across the entire asset lifecycle—from strategic briefing through operation and maintenance.

In summary, effective project-level implementation of ISO 19650 requires a coordinated understanding of these associated technologies, standards, and tools. This chapter therefore outlines their current status and clarifies the elements necessary for practical implementation.

4.2 ISO 12006-2 Construction Information Classification Systems

4.2.1 Specification of ISO 12006-2 Classification Systems within ISO 19650

ISO 19650, as described in the previous chapter, defines the fundamental framework for information management. In ISO 19650-1: Concepts and Principles, Section 11, Managing the Collaborative Production of Information, Subsection 11.3, Information Quality, it specifies that “classification of objects should be in accordance with the principles in ISO 12006-2. Object information should be in accordance with ISO 12006-3 to support object exchange”.

The first edition of ISO 12006-2 was published in 2001. However, to align with BIM-centric information management and the newly introduced ISO 19650 framework, a major revision was undertaken in 2015. Accordingly, all references to ISO 12006-2 in this report refer to the 2015 edition (ISO 12006-2:2015).¹

¹ ISO 12006-2:2015 Building Construction Organization of Information About Construction Works Part 2: Framework for Classification

4.2.2 Development, Revision, and Purpose of the Construction Information Classification System in ISO 12006-2

ISO 12006-2:2015 Building construction — Organization of information about construction works — Part 2: Framework for classification provides a standard framework for the organization and classification of information. It has been expanded to reflect developments in information technology, particularly the adoption of BIM and evolving construction procurement methods such as design-build. It applies across all construction sectors, including architecture, civil engineering, and plant-related fields. The background and purpose of its development and revision are as follows.

- The standard aims to serve as a “common language” to ensure consistency in information structures and maintain information integrity from the planning stage through to the O&M phases of construction projects. This is achieved through the consistent use of terminology and classification structures that explicitly and formally define construction information as an ontology—that is, a formal and explicit specification of concepts and relationships within the domain.
- It establishes strictly structured classification rules to manage the vast volumes of digital data generated in the construction sector, particularly in BIM-based workflows, while conforming to ISO 22274, which defines the principles and structure of classification systems.
- The standard provides a globally unified classification framework that supports international projects and cross-border transactions.
- It enables diverse construction project information to be structured using a faceted classification approach, allowing information to be categorized from multiple perspectives.
- When combined with IFC (ISO 12006-3 and ISO 16739) to achieve information structuring, forming the foundation for digital twins understandable by both humans and computers

4.2.3 Structure of the Construction Information Classification System in ISO 12006-2

ISO 12006-2 requires that the structure of a construction information classification system be organized in the following manner.

(1) Object and Process Model

A construction project is not limited to the physical act of building an asset; rather, it comprises a complex sequence of activities in which multiple types of information interact. For this reason, ISO 12006-2 models the relationship between objects (the entities that make up the built environment) and processes (the activities carried out during the project), providing a structured way for organizing information flows.

ISO 12006-2 divides the principal construction processes into the following four stages.

Table 4-1 Construction Processes in ISO 12006-2:2015

Process	Description
1. Pre-design	The stage in which project requirements are identified and the overall strategic approach is developed.
2. Design	The stage in which design documentation—including drawings, specifications, and related information—is produced.
3. Production	The stage in which the physical construction work is carried out.
4. Maintenance	The stage in which the completed asset is operated, maintained, and managed.

Source: Prepared by the JICA Study Team based on ISO 12006-2:2015

The construction processes described above are structured around the principle that resources—people, products, and information—are used within processes to produce results, namely the constructed asset or space.

The outputs of construction activities can be categorized as follows:

- Construction Complex: A group of related facilities, such as an airport or a university campus.

- Construction Entity: An individual building or structure.
- Construction Element: Components that make up the building, such as walls, floors, or roofs.
- Space: Areas designated for human activity (e.g., patient rooms, corridors, meeting rooms).

The resources used in construction include:

- Products: Construction materials and equipment.
- Aids: Tools and machinery.
- Agents: People involved in project delivery, such as designers, contractors, and managers.
- Information: Drawings, specifications, manuals, and other documentation.

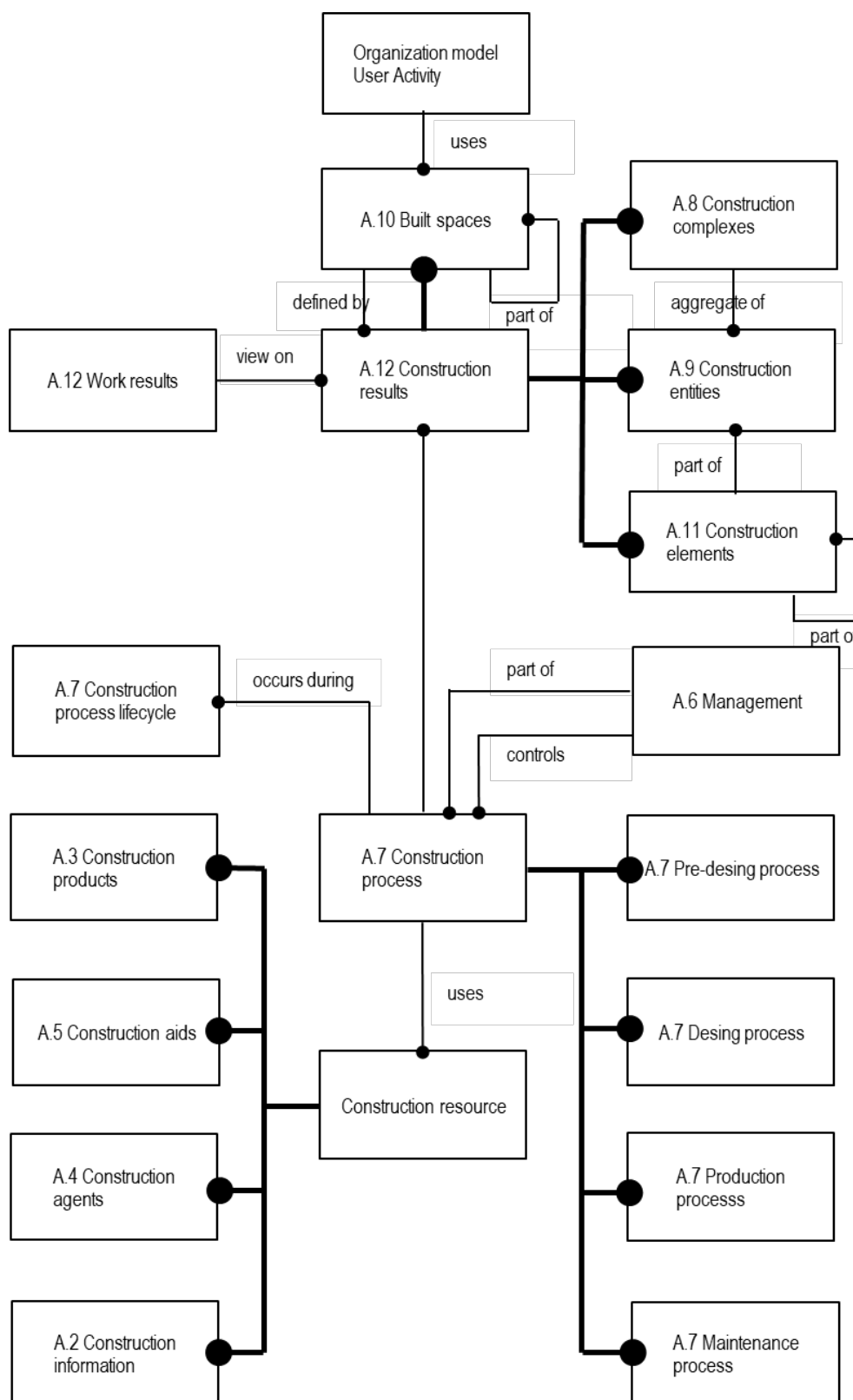
Through their use within processes, these resources are transformed into results in the form of physical buildings, infrastructure, and spatial arrangements.

All objects (such as buildings, components, and spaces) possess properties—attributes that define their characteristics. For example, a wall may have properties such as fire resistance, thermal performance, or material type, which influence design and construction decisions.

ISO 12006-2 provides a framework for organizing construction information according to the sequence resource → process → result → property, enabling clarity regarding who uses what information, at which stage, and for what purpose. This fundamental structure is based on the concept of Production Management in manufacturing and clearly defines the irreversible flow of construction projects (production). Consequently, when deliverables fail to meet specified properties, it becomes possible to trace back to factors within the resources or processes, enabling discrepancies between project management plans and reality to be identified and addressed.

Object classes are subdivided based on specific "specialization principles", which constitute the classification tables. If another principle of specialization is important for a class, it may be applied separately to create a distinct classification structure. An object must always belong to only one hierarchy (class) in a particular classification element or point of view (table) (See Table 4-3 for classes and tables). For example, "A.8 Construction Complex" and "A.9 Construction Entity" represent different hierarchies with different resolutions of information. The former represents the whole at a macro perspective, while the latter represents a more detailed part. Classifying an object under both simultaneously is not permitted, as it would lead to confusion of hierarchies. Similarly, within a single classification table, an object must not have multiple classification; the most appropriate classification should be selected.

Table 4-3 presents the recommended classification tables from ISO 12006-2, derived from Table 5 and Annex A of the standard. It shows the specialization principles applied to each of the major classes. These classification tables may be used individually or in combination, depending on project requirements. The simplified relationships between the tables are illustrated in Figure 4-1.



Note: Bold lines and circles indicate "a type of" relationships. Non-bold lines represent other types of relationships. For the classification tables referenced, see Table 4-3.

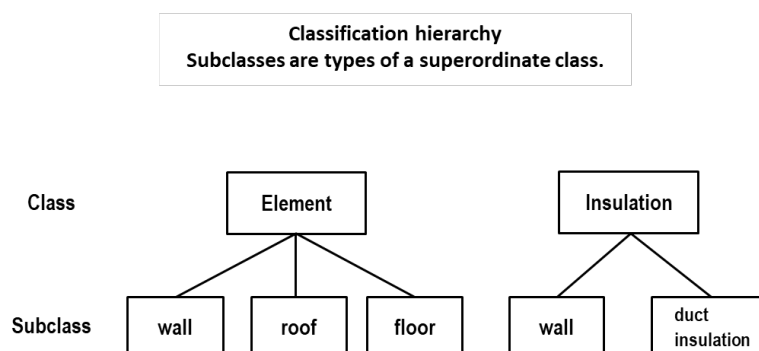
Source: Prepared by the JICA Study Team based on ISO 12006-2:2015

Figure 4-1 Simplified Relationships Between Classification Tables in ISO 12006-2:2015

(2) Classification and Composition

ISO 12006-2 “4.2 Classification and Composition”, clearly distinguishes between the two concepts of classification and composition, defining their respective roles. A classification hierarchy may, in some cases, include an associated compositional structure; however, classification and composition remain distinct concepts in ISO 12006-2. This structure indicates how objects are incorporated as parts into a whole composition.

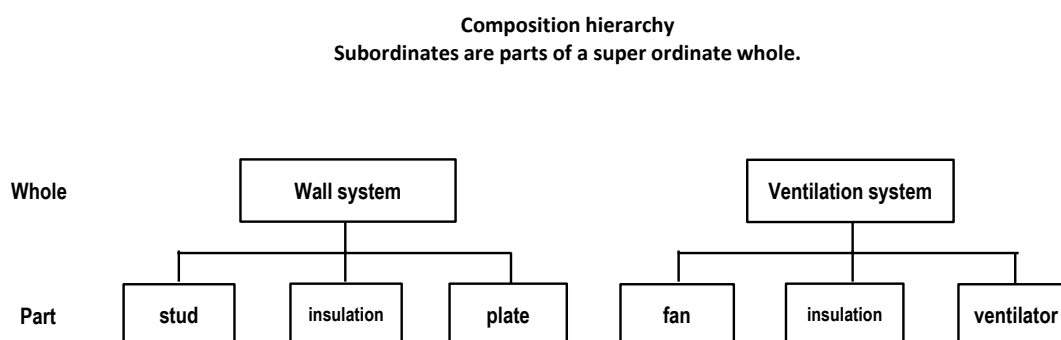
As an example of classification, Figure 4-2 shows that the class “Element” is broken down into subclasses such as wall, roof, and floor. This constitutes classification because it divides the broad category of construction elements into types based on shape or functional properties. Classification serves as a dictionary defining the types and characteristics of walls, roofs, and floors. For instance, if a wall is classified as a fire-resistant wall, it becomes possible to specify the necessary specifications required for that type of wall.



Source: Prepared by the JICA Study Team based on ISO 12006-2:2015

Figure 4-2 Conceptual Diagram of the Classification Hierarchy

On the other hand, Figure 4-3 shows that a wall system is composed of parts such as studs, insulation, and wall plates. This defines the elements constituting each system and is used to organize the necessary information for each system unit. For example, if a maintenance manager handles a ventilation system as one of the basic components in the asset management register, it becomes clear that it is composed of a fan, insulation, and a ventilator.



Source: Prepared by the JICA Study Team based on ISO 12006-2:2015

Figure 4-3 Conceptual Diagram of the Composition Hierarchy

ISO 12006-2 (Framework for Classification of Construction Information) enables different types of information to be obtained from a single model and dataset according to its intended use. It recommends a faceted classification system that allows multifaceted categorization from different perspectives. ISO 22274 (Systems to Manage Terminology, Knowledge, and Content — Concept-related Classification Systems — Principles and Guidance) defines the construction and principles of classification systems, including concept-related aspects for classification system development and internationalization. It permits both faceted and enumerative classification; however, due to the advantage of obtaining information from

different perspectives, all major construction information classification systems described later incorporate elements of faceted classification.

By classifying construction information as a faceted approach and organizing it according to the distinction between classification and composition, the whole can be structured. As a result, the meaning of individual pieces of information and the relationships between them can be identified and managed. This two-part structure for classifying construction information is particularly important in BIM, where information must be handled from different perspectives during the design, construction, and maintenance phases.

(3) Classification (“Type-of”)

As described above, in a classification structure, categories are progressively specialized from general to more specific. For example, within the broad class Construction Elements, lower-level categories such as walls, floors, and roofs exist, and each of these can be further subdivided into more detailed subcategories.

ISO 12006-2 represents this hierarchical specialization using “type-of” relationships, indicating that a subclass is a type of the class above it. This expresses the logical progression from a general category to a specific instance within the classification hierarchy.

(4) Structuring Systems and Components (“Part-of”)

In ISO 12006-2, the concept of a system is defined broadly and in non-discipline-specific way. Any object can be regarded as a system. By adopting a systems-based approach, designers and information managers can distinguish the whole from its parts, identify the systems involved, and understand and monitor the relationships between them.

Systems can therefore be defined and used in many ways as follows.

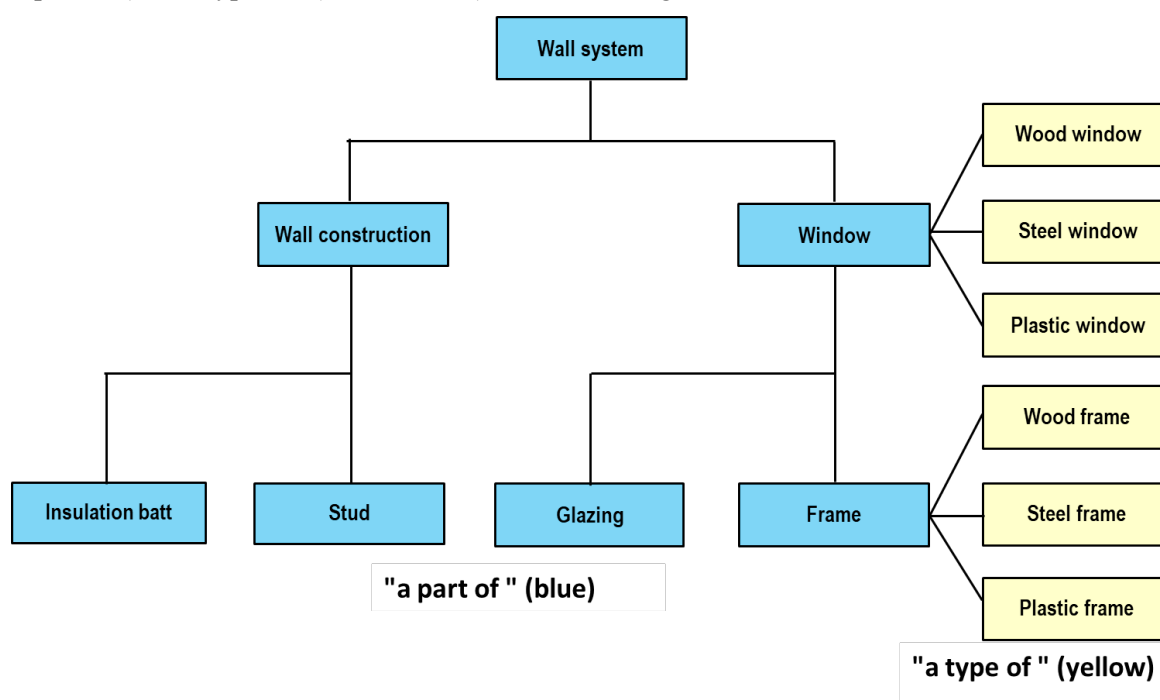
Table 4-2 Example of Systems in ISO 12006-2:2015

1. Construction System
Large networks and mechanisms that support the functions of the entire building and major infrastructure. - Load-bearing system (ensures the stability of the entire structure) - HVAC system (controls the building environment, including air conditioning and ventilation) - Drainage system (manages water treatment infrastructure for the entire building) - Electrical system (provides power supply for the building) - Communication system (supports information network infrastructure) - Transportation system (includes elevator, escalator, etc.) - Landscape system (organizes external space configuration of the entire site) - Management system (establishes maintenance and operation rules and mechanisms) - Hospital system (defines flow lines and functional arrangement for the facility to function as a hospital) - Education system (establishes mechanism for facilities to function as schools) - Ecosystem system (integrates natural energy and material circulation with the site and surrounding environment)
2. Element System
A set of combined several products forming a specific part of the building. - Roof system (roof structure with waterproofing, insulation, and finishing components) - Wall system (substrate, insulation, and wall layers combining interior and exterior finishes) - Window systems (assemblies of sashes, glass, sealants, other components) - Suspension system (group of parts for hanging ceilings and equipment) - Hinge system (combination of hardware parts that control the operation of the opening) - Fan system (unit consisting of a blower, controls, and mounting parts) - Prefabricated system (building component unit manufactured off-site in a factory) - Planting system (unit that integrates soil, irrigation, and plants)

3. Work Section System	
-	A system that focuses on activities and procedures, such as construction processes, production methods, or commercial flow
-	Coating system (series of process rules such as primer, middle coat, and top coat)
-	Repair system (procedures and maintenance programs for repair)
-	Procurement system (business processes for selecting, ordering, and delivering materials)

Source: Prepared by the JICA Study Team based on ISO 12006-2:2015

Composition indicates the relationship between a whole and its parts. For example, a wall system can be composed of elements such as the wall structure, insulation material, and wall plate. Thus, when an object is made up of multiple parts, their relationship is expressed as a "part-of". An example combining "part-of" (composition) and "type-of" (classification) is shown in Figure 4-4.



Source: Prepared by the JICA Study Team based on ISO 12006-2:2015

Figure 4-4 Example of a Combined Structure Using “Part-of” (blue) and “Type-of” (yellow)

(5) Property

Properties exist as part of a class and can be used and specified to break down into more detailed levels. Since properties themselves are treated as objects in ISO 12006-2, they function as a specialized form of classification that permeates resources, processes, and results.

(6) Recommended Object Classes and Application Principles in ISO 12006-2

Table 4-3 presents the recommended classification tables from ISO 12006-2, derived from Table 5 and Annex A of the standard. It shows the specialization principles applied to each major classes. These classification tables may be used individually or in combination, depending on project requirements. The simplified relationships between the tables are illustrated in Figure 4-1.

Table 4-3 Principles for Applying Object Classes in ISO 12006-2:2015

Class		Table	
		Classification Principle	Representative Examples
CLASSES RELATED TO RESOURCE			
A.2	Construction information	Content	Agreements; commercial/financial data; analyses; meeting records; geometric information; specifications; quality management; time management; resource management
A.3	Construction products	Function, form, material, or combinations of these	Function + form examples: ground improvement and retaining products; structural and partitioning components; cladding and finishes; civil engineering products; mechanical/electrical equipment; furniture Material examples: timber products; stone; cement-based products; metal products; plastics; glass; composite products
A.4	Construction agents	Discipline, role, or combinations of these	By discipline: architects; structural engineers; civil engineers; MEP engineers; project managers; real-estate professionals; facility managers. By role: client; manager; main contractor; supplier; manufacturer; designer; project manager; site supervisor; quality manager
A.5	Construction aids	Function, form, material, or combinations of these	Function + form examples: formwork and scaffolding; lifting equipment and conveyors; excavators; bulldozers; drafting equipment; computers and peripherals; maintenance tools; explosives
CLASSES RELATED TO PROCESS			
A.6	Management	Management activities	Administrative management; financial management; human resource management; marketing and sales; project management; risk management; cost management; time management
A.7	Construction Process	Lifecycle stages of construction activities, or combinations	By construction activity: procurement planning; feasibility studies; business case development; public briefing sessions; design competitions; concept design; detailed design; cost estimation; preparation of fabrication information and bills of quantities; tender procedures; site construction; decommissioning/demolition By lifecycle stage: design; production; maintenance
CLASSES RELATED TO RESULT			
A.8	Construction complexes	Forms, function, user activity, or combinations	Transport facility groups; public health complexes; industrial complexes; administrative complexes; health and welfare complexes; rest/service areas; entertainment complexes; sports facilities; educational complexes
A.9	Construction entities	Forms, function, user activity, or combinations	By form: buildings; prefabricated buildings; roads; railways; landscapes; tunnels; embankments; bridges; pipelines By combined form/function/activity: hospitals; pedestrian bridges; railway embankments; airport terminals; schools; sports facilities; housing; motorways; tramways; sewer pipelines
A.10	Built spaces	Forms, function, user activity, or combinations	By function (human activities): living spaces; sanitary spaces; isolation spaces; workspaces; gathering spaces By function (storage/use): material storage; equipment storage; animal spaces; plant spaces By combined function: office spaces; operating theatres; wards; consultation rooms; dining halls; amphitheatres; stadiums; bedrooms; roads; corridors
A.11	Construction elements	Function, form, location, or combinations	By function: floor systems; wall systems; water supply systems; ventilation systems; power systems; transportation systems; fire protection systems; furniture systems By form + location: piles; foundations; natural ground; road embankments; railway track structures; slabs; beams/columns; windows; roofs; furniture
A.12	Work results	Work activities and applied resources	Pre-design results: inception, procurement planning, feasibility studies, business plans Design results: competition outcomes; concept design; detailed design; fabrication information; bills of quantities Production results: excavation and backfilling; structural concrete; fire-protection systems; lift installation Maintenance results: maintained assets; refurbished or altered assets; decommissioned/demolished assets
CLASSES RELATED TO PROPERTY			
A.13	Construction properties	Property Type	Structural performance; fire performance; acoustic performance; form/size; weight/density; color; volume; comfort; naming; classification; metadata

Source: Prepared by the JICA Study Team based on ISO 12006-2:2015

4.2.4 Global Use and Adoption of Construction Information Classification Systems

The global status of construction information classification systems that follow the principles of ISO 12006-2 is summarized in Table 4-4 and Figure 4-5.2 Across Europe, national classification systems have been actively structured and widely adopted, while in North America, the OmniClass system is commonly used.

In other regions, only a limited number of countries have formally defined the classification systems they employ, and many have not yet adopted a construction information classification framework aligned with ISO 19650 or ISO 12006-2.

Denmark's CCS and Estonia's CCI are considered to be derived from, or heavily influenced by, Sweden's Sfb, BSAB, and CoClass systems. As a result, CCS and CCI have structures very similar to CoClass and can be treated as part of the CoClass family of classification models.

Finland's Talo 2000 appears to be used primarily within Finland, with limited information available internationally.

For these reasons, most comparative analyses and reference materials that examine international construction information classification systems focus on three major systems:

- CoClass (Sweden)
- Uniclass2015 (United Kingdom)
- OmniClass (United States / Canada)

This report follows the same approach: it introduces these three major classification systems and presents a comparison based on the referenced literature 2, 3, 4, 5, 6.

Table 4-4 Global Use and Adoption of Construction Information Classification Systems Aligned with ISO 12006-2 Principles

Region	Country / City	Classification System	Notes
Europe	Finland	Talo 2000	Updated periodically to accommodate BIM use
	Sweden	CoClass	Revised in 2016 from Sfb/BSAB to align with ISO 12006-2:2015
	Denmark	CCS	Derived from, or structurally similar to, Sfb and CoClass
	Estonia	CCI	Derived from, or structurally similar to, Sfb and CoClass
	UK	Uniclass2015	Revised in 2015 to comply with ISO 12006-2:2015; updated quarterly
North America	Canada	OmniClass	Very limited revision since 2006
	United States	OmniClass	Very limited revision since 2006
Other Regions	Australia	Uniclass2015	Adopted following international comparison of classification systems
	New Zealand	Uniclass2015	Used by KiwiRail for railway asset management
	Hong Kong	OmniClass	Mainly uses the product-related Table 23

Source: Prepared by the JICA Study Team based on Reference 2, 3, 4, 5, 6

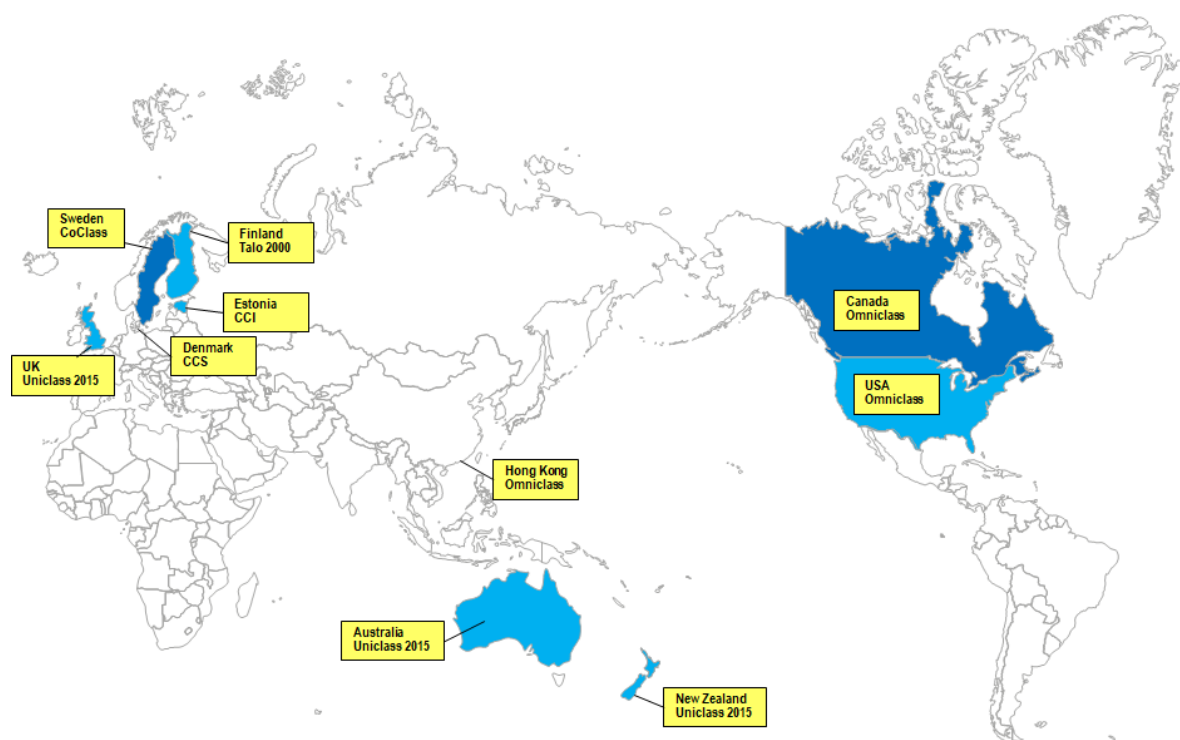
2 V.Royano, V.Gibert, C.Serrat, J.Rapinski: Analysis of Classification Systems for the Built Environment: Historical Perspective, Comprehensive Review and Discussion, Journal of Building Engineering 67 (2023)

3 C.Serrat, V.Royano, V.Gibert, J.Rapinski: Classification Systems for the Built Environment: A Cornerstone for the Long-term Performance Analysis, XVI International Conference on Durability of Building Materials and Components DBMC 2023

4 Comparison of OmniClass, Uniclass, Cuneco and CoClass with reference to ISO 12006-2 and ISO 81346-12, International Construction Information Society 2018

5 J.Gelder, The Principles of a Classification System for BIM: Uniclass2015, Research for a Better Built Environment: 49th International Conference of the Architectural Science Association 2015, pp.287–297. ©2015, The Architectural Science Association and The University of Melbourne.

6 Information Classification Systems and the Australian Construction Industry, TECH report TR02 of NATSPEC, 2025



Source: Prepared by the JICA Study Team based on Reference 2

Figure 4-5 Global Use and Adoption of Construction Information Classification Systems Aligned with ISO 12006-2 Principles

4.2.5 Background, Structure, and Characteristics of CoClass, Uniclass2015, and OmniClass

(1) CoClass (Sweden)

Background and History

Research into construction information classification in Sweden began in the 1930s. By the 1940s, this work had evolved into AMA (the Swedish General Material and Work Specification), and in 1950 Sweden published SfB (*Samarbetskommittén för Byggnadsfrågor*, “Cooperation Committee for Building Issues”), which became the prototype for CoClass. SfB is widely regarded as the world’s first construction information classification system. When ISO 12006-2:2001 was developed, SfB was one of the main references. Both Uniclass (UK) and OmniClass (US/Canada) are also considered to have drawn on the principles of SfB and its successors.

Within Sweden, SfB was continually updated as the BSAB series. Following the extensive revision of ISO 12006-2 in 2015—which re-aligned the standard with BIM-enabled, lifecycle-oriented information management—Sweden released CoClass in 2016 as its national classification system conforming to ISO 12006-2:2015.

Structure and Characteristics of CoClass

A distinguishing feature of CoClass is that, in addition to ISO 12006-2 principles, it is structured in accordance with the ISO/IEC 81346 series (Industrial Systems, Installations and Equipment—Structuring Principles and Reference Designations). ISO/IEC 81346 provides a classification framework particularly suited to the operation and maintenance of equipment and industrial systems, using multiple aspects for identifying objects such as, Product aspect, Function aspect, and Location aspect.

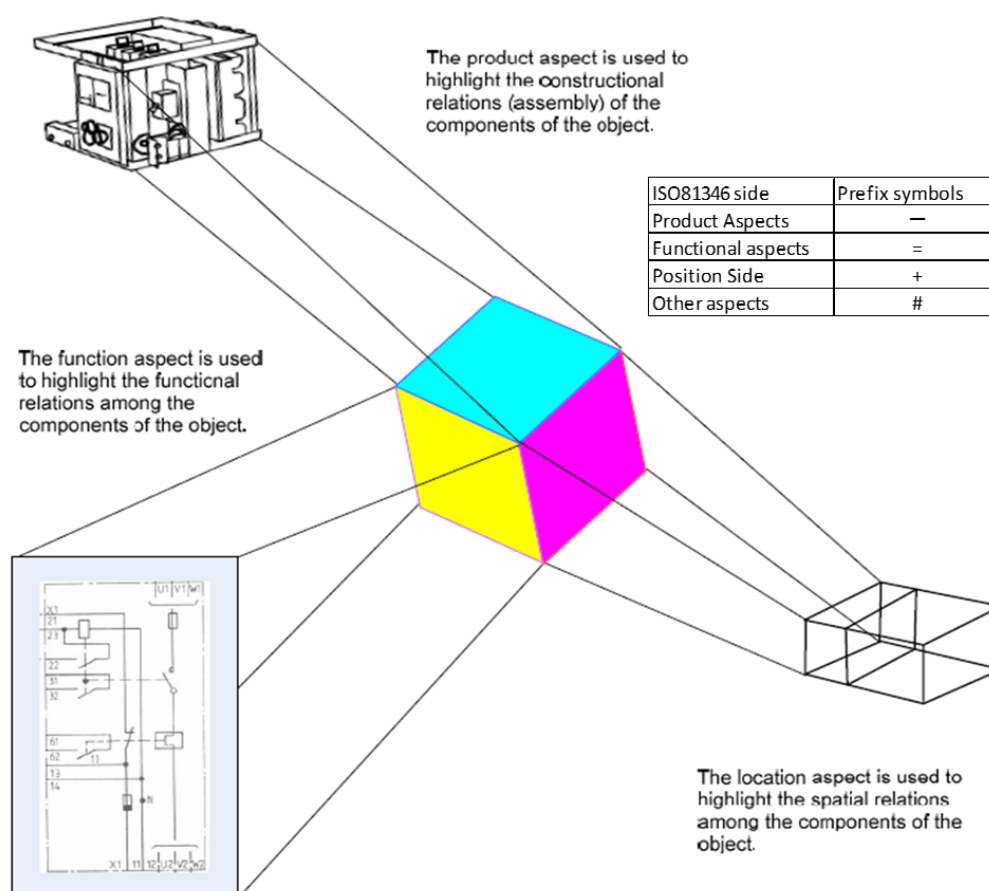
This multi-faceted, equipment-oriented approach allows detailed identification and classification of systems and components at the product level, making CoClass well aligned with FM needs.

In CoClass:

- Seven tables are provided for classifying objects.
- A dedicated table exists for lifecycle activities (AK: Activity) relevant to the construction process.
- Property codes are available for material and attribute definitions. Although properties do not form separate tables, they attach to object codes to express characteristics. Because CoClass integrates ISO/IEC 81346, it is considered highly effective for identifying and managing equipment and systems from a functional perspective.

However, compared with Uniclass2015 and OmniClass, both of which more closely align with ISO 12006-2:2015, CoClass is generally regarded as having lower conformity to ISO 12006-2. As a result, many publications note that CoClass is less aligned with the full ISO 19650 lifecycle framework than the UK and North American systems.

Figure 4-6 below provides a conceptual illustration of ISO/IEC 81346 and the CoClass table structure.



Source: Prepared by the JICA Study Team based on ISO/IEC 81346.

Figure 4-6 Object Aspects in ISO/IEC 81346

Table 4-5 CoClass Table

Code	Table Name	Purpose / Description
Object		
BX	Construction Complex	Aggregations of multiple buildings or facilities intended to support specific functions or activities. Based on ISO/IEC 81346-2:2019. Examples: A – Residential complexes; B – Activity complexes (hotels, educational facilities); C – Media complexes; D – Transport complexes.
BV	Construction Entity	Independent units within the built environment designed to support at least one function or activity, with a defined spatial structure. Based on ISO/IEC 81346-2:2019. Examples: A – Buildings for human activities; B – Technical facilities; C – Infrastructure; D – Civil engineering works; E – Artefacts/monuments; F – Archaeological remains.
UT	Spaces	Activity spaces for people or equipment; architectural and natural spaces. Examples: A – Living spaces; B – Human activity spaces; C – Storage spaces; D – Technical system spaces; E – Infrastructure spaces; F – Circulation/transport spaces.
FS	Function System (Construction Elements)	Objects characterized primarily by their inherent functional role. Based on ISO/IEC 81346-12:2018. Includes spatial systems (walls, floors, pavements) and installation systems (HVAC, transport systems).
KS	Constructive System (Construction Elements)	Objects representing coherent technical solutions with specific functions. Based on ISO/IEC 81346-12:2018. Examples: D – Railway track construction systems; L – Monitoring and control systems; R – Furniture systems.
KO	Component (Construction Elements)	Structural components used to realize construction system design. Based on ISO/IEC 81346-2:2019.
PR	Work Results	Combinations of activities and resources used to define requirements in building and civil engineering works. Primarily used for describing construction deliverables. Shares structure with the BSAB system.
Property		
	Properties	Attribute definitions managed across the lifecycle, based on ISO 12006-2 principles. Mainly used for cultural asset attributes and material properties (function, composition, spatial/size, required time). Properties do not have independent table codes; they attach to object/component codes as specification attributes.
Activity		
AK	Activities	Activities across the construction lifecycle (planning, design, production/construction, operation, maintenance, decommissioning, recycling). Does not include general human activities such as living, working, recreation, or transport.

Source: Prepared by the JICA Study Team based on CoClass

(2) Uniclass2015 (United Kingdom)

Background and History

In the United Kingdom, the SfB classification system originated in Sweden and spread throughout Europe. Influenced by this, research into a construction information classification system began in the 1950s, using SfB as a reference. In 1968, the Royal Institute of British Architects (RIBA) published Construction Index/SfB (CI/SfB), the British version of SfB. Subsequently, further studies were conducted in the 1980s and 1990s. Due to increasing complexity of construction projects and advances in information technology, Uniclass was created in 1997 as a comprehensive classification system. The original Uniclass comprised 15 tables, but encountered issues such as:

- Inconsistent alignment between tables
- Limited compatibility with BIM

- Incomplete conformity with the international standard ISO 12006-2:2001

With the UK government promoting BIM adoption and ahead of the significant revision of ISO 12006-2, work began to update Uniclass. However, between 2006 and 2011, the revision effort stalled. There was even consideration of introducing OmniClass (the US/Canadian classification system) into the UK, as OmniClass already had partial alignment with ISO 12006-2:2001.

This option was ultimately rejected due to several key issues:

- Major differences in construction terminology between the UK and US
- Incompatibility with UK regulations, design processes and public procurement
- The absence of Complex and System tables in OmniClass
- Inconsistencies in table hierarchy and structure

In line with the UK government's strategy to achieve BIM Level 2 adoption across all public procurement by 2016, Innovate UK (part of UK Research and Innovation) launched a call for proposals under the BIM Toolkit Project to develop a revised classification system.

National Building Specification (NBS), then under the umbrella of RIBA and now a private company, was appointed and subsequently developed Uniclass2015, fully aligned with ISO 12006-2:2015.

Originally focused on the buildings sector, Uniclass2015 has expanded significantly through collaboration with organizations such as Transport for London and the UK water sector, as well as international partners in rail and power infrastructure. As a result, the system now covers rail, water, power, and other infrastructure domains comprehensively.⁷

Structure and Characteristics of Uniclass2015

Uniclass2015 uses a faceted classification structure, enabling an object to be classified simultaneously from multiple perspectives and therefore assigned multiple codes.

Table 4-6 lists all Uniclass2015 tables. Each classification is assigned a “code” following a prescribed format, where the first two alphabetical characters identify the Uniclass 2015 table.

The seven primary tables (shown in Table 4-6) classify objects representing resources and results. Between 2015 and 2021, 12 tables were published. In 2023, three additional tables were introduced:

- RK (Risk)
- Ma (Materials)
- PC (Properties and Performance)

This expansion was influenced in part by the 2017 Grenfell Tower fire, where combustible cladding materials played a major role in the disaster. The event prompted the UK government to establish the Golden Thread Policy in 2018, requiring accurate and accessible safety-related information—including design decisions, construction work, refurbishments, materials used, and performance characteristics—throughout the asset lifecycle. This became legally mandated for high-rise buildings (18 m or seven storeys and above) under the Building Safety Act 2022.

The addition of RK, Ma, and PC tables strengthen alignment with ISO 19650-3 (operational phase information management) and ISO 19650-6 (information management for health and safety), supporting the delivery of the Golden Thread. The policy is now being applied beyond high-rise buildings to general public buildings and public infrastructure such as the UK rail network (e.g., Network Rail⁸).

The hierarchy and structural relationships of the seven main tables representing the resources and outcomes

⁷ <https://www.thenbs.com/knowledge/uniclass-2015-january-2018-update>

⁸ Network Rail, Design Manual NR/GN/CIV/200/01 Material Components, section 1.5 Guiding Principles of Material Selection (Golden Thread), 2024.9

highlighted in bold in Table 4-6 are shown in Figure 4-7.

Table 4-6 Uniclass2015 Table

Code	Table Name	Purpose / Description
Ac	Activities	Activities (purposes and functions)
Co	Complexes	Complexes (campuses, estates, grouped facilities)
En	Entities	Construction entities (buildings, structures, infrastructure units)
SL	Spaces/Locations	Spaces and locations (rooms, zones, sites)
EF	Elements/Functions	Elements and functions (walls, floors, structural systems)
Ss	Systems	Systems (HVAC, electrical, water services, etc.)
Pr	Products	Products (materials, equipment, components)
TE	Tools and Equipment	Tools and equipment (construction tools, survey instruments)
PM	Project Management	Project management information (plans, schedules, quality documents)
FI	Form of information	Information forms (drawings, specifications, models)
Ro	Roles	Roles (designers, contractors, managers)
RK	Risk	Risk (safety, hazards, uncertainty)
Ma	Materials	Materials (concrete, steel, timber, etc.)
PC	Properties and Characteristics	Properties and performance (fire rating, thermal resistance, strength, etc.)
Zz	CAD and modelling content	CAD and modelling content (BIM model components, drafting content)

Source: Prepared by the JICA Study Team based on Uniclass2015.

Uniclass2015 tables follow a four-level hierarchy:

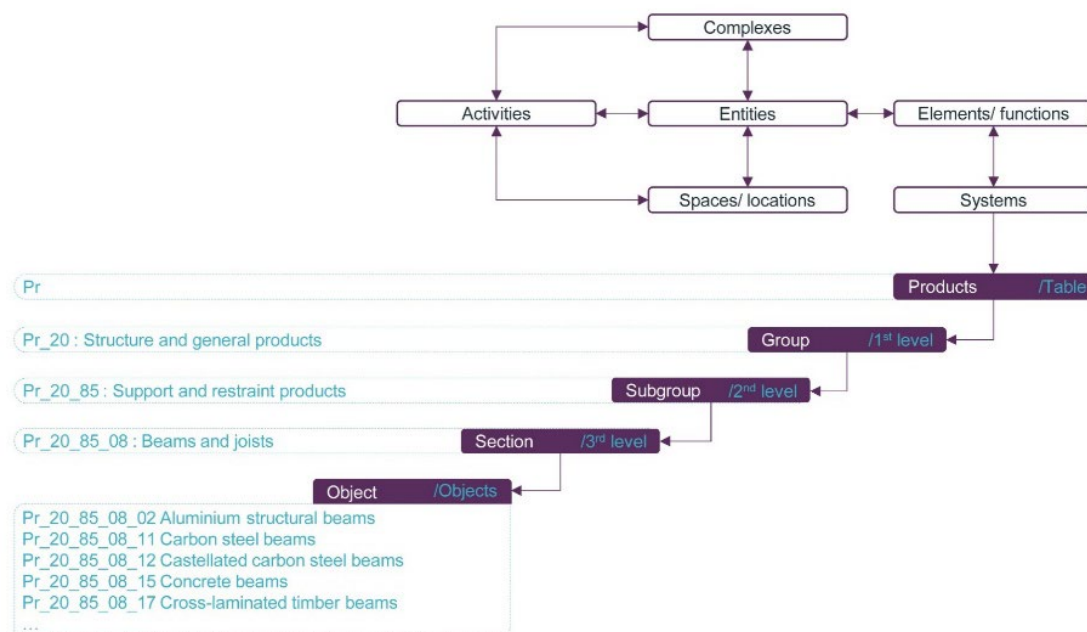
- Group (Level 1)
- Subgroup (Level 2)
- Section (Level 3)
- Object (Level 4)

The two-letter table code followed by up to four sets of numbers uniquely identifies each item and expresses its hierarchical level.

For example, Figure 4-7 shows the four-level hierarchy in the Pr (Products) table.

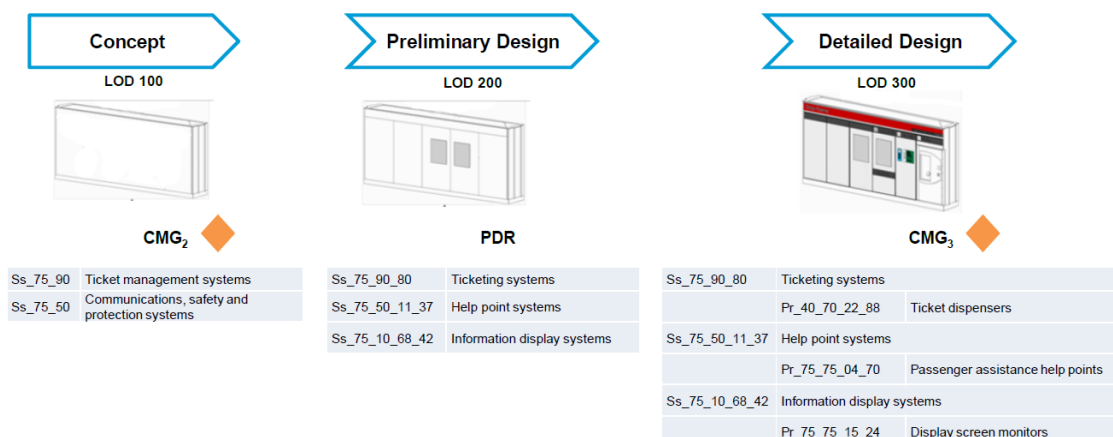
A key advantage of this structure is that its applicability across the entire asset lifecycle (Figure 4-8):

- In early design stages (concept and preliminary design), when only high-level system requirements are known, users can select a general Level 2 code from the Ss (Systems) table (e.g., Ss_75_90 for station ticketing systems).
- Later, during detailed design and procurement, more specific requirements can be expressed by linking Level 3 or Level 4 system codes with corresponding Pr (Product) codes, allowing the classification to reflect added detail.



Source: NBS.

**Figure 4-7 Structural Relationships of the Seven Primary Uniclass2015 Tables
(Based on ISO 12006-2 Principles)**



Source: Reference 9

**Figure 4-8 Example of Applying Uniclass2015 System (Ss) Hierarchy
(According to LOD/LOG Requirements at Each Project Stage)**

Integration of Uniclass2015 with Other Systems

In the UK, Uniclass2015 functions as a core component of information management across the entire asset delivery lifecycle under ISO 19650. It provides a common language through which project information can be consistently structured, exchanged, and handed over across all phases, including design, construction, and operation.

To support these activities such as quantity take-off, cost estimation, asset management and maintenance, Uniclass codes are linked with other classification systems, ensuring coherent and efficient digital information flow throughout the lifecycle.

A key example is the New Rules of Measurement (NRM), developed by Royal Institution of Chartered Surveyors (RICS), which provides the UK standard for measurement, cost planning, maintenance, and lifecycle costing.

Mappings have been created between the Uniclass2015 Systems (Ss) table and NRM3 (maintenance and operations costing). This allows system classifications used during design to feed directly into NRM3-based quantity and cost management workflows. Table 4-7 shows examples of these mappings.

Although NRM3 classifications are often more granular than their Uniclass equivalents, mapping enables efficient and accurate transfer of information for cost planning. However, as shown in Table 4-7, the relationships are not always one-to-one, so practical use may require care and the addition of supplementary information. The same considerations apply when using Uniclass in conjunction with asset data dictionaries or other structured datasets.

Table 4-7 Example Mapping Between Uniclass2015 System (Ss) and NRM3

Uniclass2015		NRM3	
Code	Description	Code	Description
Ss_15_10_30_25	Earthworks excavating systems	0.4.2	Soil stabilization measures
Ss_15_10_30_25	Earthworks excavating systems	0.1.1	Toxic or hazardous material removal
Ss_15_10_30_27	Earthworks filling systems	1.1.4	Basement excavation
Ss_15_10_30_27	Earthworks filling systems	1.1.5	Basement retaining walls

Source: [uniclass_ss_nrm_mapping/uniclass_ss_map_to_nrm.csv at master · BIMsense/uniclass_ss_nrm_mapping · GitHub](#)

In the UK FM sector, the standard framework for maintenance schedules is SfG20, managed by the Building Engineering Services Association (BESA). SfG20 provides a structured library defining what, when, and how often different building services components should be inspected and maintained.

NBS and BESA have entered an official partnership to map SfG20 maintenance schedules to Uniclass2015.¹⁰ Systems and components classified in a BIM model using Uniclass can eventually be automatically linked to their corresponding maintenance activities in SfG20. Like NRM3, SfG20 uses a highly detailed set of codes, which can be difficult to apply directly in early design stages when equipment specifications are not yet defined. Mapping through Uniclass2015 bridges this gap and supports consistent information flow across the asset lifecycle.

NBS Chorus, managed by NBS, is a cloud-based platform that integrates Uniclass classification with project specifications and BIM models (available as a paid service).

Key capabilities include:

- Automated specification authoring
- Multi-user simultaneous editing
- Linking specifications to relevant BS (British Standards)
- Applying classification within authoring tools such as Revit

¹⁰ NBS and BESA partner to join-up digital construction - Mapping Uniclass2015 to SFG20, NBS

- Detecting inconsistencies between model data and specifications
- Supporting ISO 19650-2-compliant information management workflows

Across the UK, Uniclass2015 is widely used as a standardized, cross-disciplinary classification language, enabling structured asset information management throughout design, construction, and operation.

Its integration with NRM, SfG20, NBS Chorus and other systems makes it a core component for delivering consistent, lifecycle-oriented information management in line with ISO 19650.

(3) OmniClass (United States / Canada)¹¹

OmniClass is widely used in the United States and Canada. Its development began in the late 1990s and early 2000s in response to increasing project complexity and the growing need to systematically organize large volumes of construction information.

Its foundations lie in several long-established North American classification systems. OmniClass integrates these systems into a unified structure aligned with ISO 12006-2:2001.

The principal predecessor systems were:

- **MasterFormat**
Originally published in 1963 by Construction Specifications Institute, USA (CSI) and Construction Specifications Canada (CSC). After many revisions, MasterFormat was re-edited in 2004 for use as OmniClass Table 22 (Work Results). CSI continues to publish specification standards aligned with MasterFormat, linked to technical standards from ASTM, ACI and others.¹²
- **UniFormat**
Classifies building and infrastructure elements based on function and physical composition. Published in 1998, jointly developed by ASTM, CSI, and CSC. UniFormat contributed the basis for OmniClass Table 21 (Elements).
- **EPIC**
An international standard developed in 1990 by representatives from ten European countries to support interoperability between construction product databases. EPIC Version 1 was published in 1994; Version 2 followed in 1999. EPIC Version 2 has been revised to comply with ISO 12006-2 and is used as OmniClass Table 23. Tables 41 (Materials) and 49 (Properties) are also structured according to the basic EPIC framework. Development of EPIC is currently suspended.

Structure and Characteristics of OmniClass

OmniClass consists of 15 tables compliant with ISO 12006-2:2015, providing a structure capable of classifying information throughout the entire project lifecycle. As a faceted classification system, each table functions independently while also being designed to be linked to other tables. This multifaceted approach enables information to be classified from various perspectives, such as the functional aspects of a building, the products used, the construction process, and the roles involved. While many tables follow a four-level hierarchy (major classification → medium classification → minor classification → detail), as shown in Table 4-8, tables exist ranging from three levels to a maximum of seven levels. Consequently, consistency and coherence in the hierarchical structure between tables is not maintained. This occurs because additional hierarchical levels, like branch numbers, are added at the detail level to provide finer classification, as seen in Table 23 (Products) and Table 41 (Materials). Examples of differences in hierarchical structures between tables are shown in Table 4-9.

Although OmniClass Edition 1 was published in 2006 and updated in 2012 and 2013, the system has seen very limited revision since, raising concerns regarding its alignment with BIM workflows, ISO 19650, and ISO 12006-2:2015.

¹¹ OmniClass TM, A Strategy for Classifying the Built Environment, Introduction and User's Guide Edition 1.0, 2006, CSI

¹² David Kent, ARCHITECT'S HANDBOOK of Construction Detailing, 2009, FAIA, CSI

Table 4-8 OmniClass Tables

Code	Table Name	Purpose / Description	Maximum Levels	Notes
11	Construction Entities by Function	Functional classification of entities (e.g., educational or public facilities)	4	
12	Construction Entities by Form	Physical/structural classification (e.g., buildings, bridges, substructures)	4	
13	Spaces by Function	Functional classification of spaces (e.g., service spaces, parking spaces)	4	
14	Spaces by Form	Spatial/structural classification (rooms, floors, shafts)	4	
21	Elements	Building/structural elements (e.g., substructure, shell, interiors)	4	UniFormat
22	Work Results	Construction work results (e.g., concrete work, metal work)	4	MasterFormat
23	Products	Products and equipment	7	EPIC
31	Phases	Project phases	3	
32	Services	Delivered services and functions	4	
33	Disciplines	Professional disciplines	5	
34	Organizational Roles	Roles (designer, contractor, etc.)	4	
35	Tools	Tools for management, design and construction	6	
36	Information	Information forms (drawings, specifications, estimates)	6	
41	Materials	Materials (concrete, steel, etc.)	6	EPIC-derived
49	Properties	Performance, quality and environmental attributes	4	EPIC-derived

Source: Prepared by the JICA Study Team based on OmniClass.

Table 4-9 Examples of OmniClass Hierarchy Structures

Table Code	OmniClass Number	Level 1 Title	Level 2 Title	Level 3 Title	Level 4 Title	Level 5 Title	Level 6 Title	Level 7 Title
Table 21 Elements	21-01 00 00	Substructure						
	21-01 10		Foundations					
	21-01 10 10			Standard Foundations				
	21-01 10 10 10				Wall Foundations			
	21-01 10 10 30				Column Foundations			
Table 22 Work Results	22-03 00 00	Concrete						
	22-03 01 00		Maintenance of Concrete					
	22-03 01 30			Maintenance of Cast-in-Place Concrete				
	22-03 01 30 51				Cleaning of Cast-in-Place Concrete			
	22-03 01 30 61				Resurfacing of Cast-in-Place Concrete			
Table 23 Product	23-13 00 00	Structural and Exterior Enclosure Products						
	23-13 31 00		Structural Concrete Products					
	23-13 31 21			Reinforcement and Prestressing Components				
	23-13 31 21 13				Prestressing Components			
	23-13 31 21 13 11					Stressing Tendons		
	23-13 31 21 13 11 11						Steel Stressing Tendons	
	23-13 31 21 13 11 11 11							Steel Strand Stressing Tendons
	23-13 31 21 13 11 11 13							Steel Wire Stressing Tendons

Source: Prepared by the JICA Study Team based on OmniClass.

Integration of OmniClass with Other Systems

OmniClass, built on long-established North American classification systems such as MasterFormat, aligns naturally with construction practices and standards across the United States and Canada. OmniClass codes are integrated with CSI specifications, which are in turn linked to ASTM, ACI, and other technical standards.

Similar to Uniclass2015, OmniClass is also embedded in authoring tools such as Autodesk Revit, enabling its use directly within BIM models. Several Computerized Maintenance Management Systems (CMMS) and other FM platforms support OmniClass natively, without requiring data conversion or mapping.

This widespread compatibility contributes to OmniClass' broad adoption across the North American construction sector.

4.2.6 Comparison of CoClass, Uniclass2015 and OmniClass

(1) Evaluation in Existing Literature

Based on comparisons presented in Reference 2, Table 4-10 summarizes the correspondence between ISO 12006-2:2015 and the three major classification systems: CoClass, Uniclass2015, and OmniClass.

CoClass

CoClass conforms to ISO/IEC 81346, an equipment-oriented classification standard, making it highly suitable for FM. However, many studies note that CoClass does not fully correspond to several ISO 12006-2 tables (specifically A2–A6).

As a result, with respect to full lifecycle information management under ISO 19650, and comprehensive alignment with ISO 12006-2:2015, CoClass is generally assessed as less aligned than the other two systems.

Additionally, CoClass's primary language is Swedish, and despite ongoing English translation efforts, its usability outside Swedish-speaking regions remains limited.

The core tables are not freely available and require a paid license. Consequently, the use of CoClass—including related variants such as CCS and CCI—remains largely confined to Nordic countries.

Uniclass2015

Uniclass2015 is widely regarded as the classification system that most closely follows the principles of ISO 12006-2. It continues to be updated quarterly, and with the 2023 expansion, it also supports alignment with ISO 19650-6:2025 (Health and Safety Information Management).

Moreover,

- It has been progressively expanded to support civil engineering and infrastructure, through collaboration with domestic and international organizations (e.g., rail and utilities).
- Its compatibility with the ISO 19650 framework is considered very high.
- Although NBS Chorus (the integrated specification platform) is now subscription-based, the core Uniclass tables (Excel format) remain freely available and regularly updated.
- Uniclass2015 shows the widest adoption internationally, including on numerous multi-country projects.

Overall, existing literature consistently identifies Uniclass2015 as the most mature and internationally scalable system among the three.

OmniClass

OmniClass, first released in 2006, was initially the classification system most closely aligned with ISO 12006-2:2001, integrating several long-established North American frameworks. However, following limited revisions in 2012 and 2013, its development effectively stalled. Since then, a number of structural issues have been noted, including inconsistent hierarchy depths across tables, absence of a comprehensive systems table, and limited compatibility with ISO 12006-2:2015 and the broader ISO 19650 framework.

These limitations, together with the narrow sectoral coverage in some tables, have led many studies to conclude that significant further development of OmniClass is unlikely. Consequently, its international adoption outside the North American market has remained limited. Additionally, the core tables, previously freely available, have become paid resources, further reducing accessibility.

Considering the literature assessments and the current state of each classification system, adopting Uniclass2015 for ODA loan projects appears to be the most pragmatic and realistic option.

The following section outlines the international uptake of Uniclass2015 and examines how it has been evaluated and applied within Japan.

Table 4-10 Comparison of Alignment with ISO 12006-2 Principles

ISO 12006-2:2015		CoClass		Uniclass2015		OmniClass	
CLASSES RELATED TO RESOURCE							
A.2	Construction Information			FI	Form of Information	36	Information
A.3	Construction Products			Pr	Products	23	Products (EPIC)
				Ma	Material	41	Material
A.4	Construction Agents			Ro	Roles	33	Discipline
						34	Organization Roles
A.5	Construction Aids			TE	Tools and Equipment	35	Tools
CLASSES RELATED TO PROCESS							
A.6	Management			PM	Project Management (in part)	32	Services
A.7	Construction Process	AK	Activities	-	No table, in part by PM, Ac	31	Phases
CLASSES RELATED TO RESULT							
A.8	Construction Complexes	BX	Construction complex	Co	Complex		
A.9	Construction Entities	BV	Construction entity	En	Entities	11	Construction entities by Function
						12	Construction entities by Form
A.10	Built Spaces	UT	Space	SL	Space and Location	13	Spaces by Function
						14	Spaces by Form
A.11	Construction Elements	FS	Functional systems	EF	Elements/Functions	21	Elements (UniFormat)
		KS	Constructive systems	Ss	Systems		
		KO	Components				
A.12	Work Results	PR	Work result	Ss	Systems (in part), Ss>Pr	22	Work Results (MasterFormat)
				Pr	Products (in part), Ss>Pr		
CLASSES RELATED TO PROPERTY							
A.13	Construction Properties	-	Properties	Pc	Properties and Characteristics	49	Properties
ISO 12006-2 non-mandatory category				Ac	Activities, cross-cut for Co/En/SL		
				Rk	Risk (optional facet for ISO19650-6)		
				Zz	CAD and Modeling Contents		

Note: "In part" is partially supported, and Ac in Uniclass is a cross-sectional application facet that deals with Co/En/SL

Source: Compiled and adapted by the JICA Study Team based on Reference 2

(2) Adoption of Uniclass2015 in Other Countries and Major Projects

Australia

In Australia, the adoption of Uniclass2015 has progressed alongside structured technical evaluations. In New South Wales—whose capital is Sydney and which is home to the country’s largest urban population—the state transport authority, Transport for New South Wales (TfNSW), conducted a detailed review as part of its Digital Engineering Strategy. Based on this review, TfNSW decided to adopt Uniclass2015 as its construction information classification system. In preparing the report, TfNSW collaborated with NBS, proposing extensions to Uniclass for rolling stock and for classifications covering rail operations and maintenance activities, several of which were subsequently incorporated. TfNSW outlined its rationale for adopting Uniclass2015 as follows.

Table 4-11 Reasons for TfNSW’s Adoption of Uniclass2015

Evaluation Criterion	Explanation
Open standards	Preference for widely adopted, internationally recognized standards such as ISO 12006-2, which embody best practices.
Vendor compatibility	The classification must be immediately usable within industry-standard tools to support the creation, sharing, and validation of information.
Use of industry expertise	Leveraging external partners’ expertise improves project capability while reducing learning and development costs.
Lifecycle applicability	The standard must support all project stages, enabling the accumulation and verification of asset data throughout the lifecycle.
Dynamic and well-governed standard	Selection favors standard that are continuously improved by a specialist community under active governance.
Balance with global practice	The standard should evolve based on feedback from real projects, reducing the need for maintaining internal bespoke standards.
Cost efficiency	Management and operational costs should be minimized and offset by the benefits achieved through adoption.

Source: Prepared by the JICA Study Team based on Reference 9

Following TfNSW’s work, the national rail standards body Rail Industry Safety and Standards Board (RiSSB) published AS773913—Part 1 in 2022 and Part 2 in 2024—as a national framework to advance digital engineering in rail. These standards recommend the use of Uniclass2015, further consolidating it as the preferred classification for rail projects in Australia.

Australia’s national specification framework, NATSPEC, maintains its own classification. However, in light of the need for ISO 12006-2 alignment, the shift toward object-oriented digital engineering, and the adoption direction signaled by TfNSW and RiSSB—it published an evaluation⁶ concluding that Uniclass2015 should be used complementarily within Australian specifications due to its advantages for digital workflows.

Beyond buildings and rail, the roads sector has also undertaken structured assessment. Austroads, a non-government organization funded by Australian and New Zealand transport agencies, published a comparative study mapping IFC4¹⁴, Uniclass2015 and the Austroads Data Standard. This work demonstrated that Uniclass2015 provides a viable foundation for infrastructure asset classification and digital asset management, resulting in many infrastructure agencies in Australia either adopting the system or actively evaluating it for future use.

Adoption in Rail Baltica (Baltic States)

Rail Baltica¹⁵ is an EU-funded, European standard-gauge railway project connecting Estonia, Latvia, and Lithuania. To enable unified, cross-border information management and effective BIM use, the project has

¹³ Digital engineering for rail, Australian STANDARD AS7739, RiSSB, 2022

¹⁴ Asset Data Harmonization Stage III, BIM IFC Alignment Review, AP-T333-18, Austroads, 2018

¹⁵ [RB Rail's BIM documentation | Rail Baltica](#)

adopted Uniclass2015 as its construction information classification system. The key reasons and objectives for adoption are as follows:

- Reliability as an international standard for construction information classification
- Alignment with ISO 12006-2
- Support for BIM model attribute management, quantity take-off and asset management
- Consistency with the ISO 19650 series (information management processes), ensuring coherent information across the full lifecycle—design, construction and operation
- Compatibility with IFC (Industry Foundation Classes) for attribute mapping
- Establishing a foundation for future smart infrastructure and digital twin development

Beyond the UK, other countries and projects are increasingly adopting Uniclass2015 aligned with ISO 12006-2 to support lifecycle-wide management under ISO 19650.

(3) Status of Efforts in Japan on Construction Information Classification (Uniclass2015)

Japan has a history of exploring faceted classification for the built environment. One notable effort was the Building Code Index (BCI), published in 2002 as the final report of the Architectural Institute of Japan's Committee on Developing a Common Building Code/Index. Despite these investigations, no classification system achieved broad uptake across the construction industry as a foundation for information management.¹⁶

With the spread of BIM, the drive to integrate quantity take-off and cost estimation within BIM, and the need to apply lifecycle information management aligned with ISO 19650, Japan began researching and assessing international classification systems—primarily Uniclass2015 and OmniClass—around 2020.^{16, 17, 18} Current activities include work by the International Construction Information Society (ICIS) Japan Working Group¹⁹, and evaluations under the Japan's Ministry of Land, Infrastructure, Transport and Tourism (MLIT) "Building BIM Promotion Conference—Subcommittee 4." In that context, the BSIJ (Japan Association of Architects' Quantity Surveying and Cost Management Council) has examined classification for BIM and cost integration, decided to adopt Uniclass2015, and published Japanese materials translating Uniclass along with its "BIM Rough-Cost Guidebook" aimed at fusing BIM data with cost information.²⁰

In parallel, MLIT's subsidized programmes—BIM-enabled Efficient Models for Building Production and O&M Processes—have run proof-of-concepts using Uniclass2015 both for cost planning²¹ and for asset management^{22, 23}. As a result, Uniclass2015 is now prevailing as Japan's de facto construction information classification for BIM-based lifecycle management.

(4) Summary

As synthesized in the literature, Uniclass2015 demonstrates the strongest alignment with ISO 12006-2 and clear compatibility with ISO 19650. It has been adopted or validated across Australia, various European

¹⁶ Haruhiko Moriya, Kumiko Eto, Building Information Classification System Using BIM and Its Application in FM (in Japanese), Annual Report No.29, NTT Facilities Research Institute, 2018.6

¹⁷ Masao Ando, Consideration on BIM and Building Classification Standards (Focusing on the Reading of ISO 12006-2:2015, Uniclass2015) (in Japanese), Building Cost Research, No.110, 2020.7

¹⁸ Kazuya Shide, How Architects Live in the ICT Era Part 3 The Relationship between BIM and Classification System (in Japanese), Core Tokyo, 2020.8

¹⁹ Architectural Specifications in the BIM era (in Japanese), IIBH, 2024.3

²⁰ <https://www.bsj.or.jp/info/bsijconference.html?date=20201119>

²¹ Matsuda Hirata Sekkei Co., Ltd., Verification of Consistency and Cost Management with the British Classification System (Uniclass2015) by BIM Design (in Japanese), 2020

²² Kashima Corporation, Validation of Building Lifecycle Information Management Using BIM and Support by Digital Twin and Software Ecosystem (in Japanese), 2022.3

²³ Shinryo Cooling & Heating Industry Co., Ltd, Verification of the Effect of BIM Utilization throughout the Life Cycle of the Building in the New Construction Plan of the Central Laboratory (in Japanese), 2020-2023.3

projects, and in Japanese pilot initiatives, indicating consistent suitability for lifecycle-wide asset information management. Table 4-12 presents a comparative evaluation of classification systems.

Given the current state of practice, the application of the ISO 19650 framework to ODA loan projects is best supported by adopting Uniclass2015 as the construction information classification. That said, in countries where US specifications and related standards have strong influence, it may be appropriate—depending on the project ecosystem—to consider OmniClass for better alignment with locally used specifications and standards. Selection should therefore remain context-sensitive, reflecting procurement frameworks, regulatory vocabularies, and stakeholder toolchains in the host country.

Table 4-12 Comparison and Evaluation of Construction Information Classification Systems

Item	CoClass	Uniclass2015	OmniClass
Hierarchy depth	3 levels	4 levels	3–7 levels
Number of tables	9	15	15
Code format	Alphanumeric	Alphanumeric	Numeric
Code notation	Complex	Simple	Simple
Availability of core tables	Paid	Free	Paid
Alignment with ISO 12006-2	○ (with gaps)	◎ (including consideration of ISO 19650-6 alignment)	○ (inconsistent hierarchy; some gaps)
Alignment with ISO 19650	○	◎ (including consideration of ISO 19650-6 alignment)	○
Update frequency	◎ (ad hoc updates)	◎ (quarterly updates)	△ (little since 2013)
Extensibility	◎ (expanded as needed)	◎ (expanding coverage in civil/infrastructure)	△ (little since 2013)
Software compatibility	○ (strongest in Nordic ecosystem)	◎ (widely supported internationally)	◎ (widely supported internationally)
International uptake	△ (only Nordic countries, including similar classifications; English support is also not fully implemented.)	◎ (growing use outside the UK, notably Australia and Europe)	○ (mainly North America; advantageous where US specs are used)
Other notes	Also aligned with ISO/IEC 81346		
Overall evaluation	△	◎	○
	Usage is concentrated in the Nordics; Swedish language environment and partial alignment with ISO 19650/12006-2 make adoption in ODA loan projects difficult	Given current practice and ongoing expansion, the most suitable choice for ODA loan projects	Minimal updates limit future prospects; however, alignment with US specs (e.g., ASTM, ACI) is strong
Legend: ◎ = excellent / strong; ○ = good / partial; △ = limited / weak.			

Source: Prepared by the JICA Study Team

4.3 Formats and Guidelines Developed by buildingSMART, Including IFC

4.3.1 About buildingSMART

In this section, Industry Foundation Classes (IFC) is presented as part of the openBIM framework developed and advanced by buildingSMART to organize and evolve the technical foundations required for implementing ISO 19650. buildingSMART International is a global, non-profit body that promotes the standardization of construction data, interoperability and professional assurance across the built environment, with the objective of enabling openBIM throughout the industry. Its initiatives—summarized in Table 4-13—support consistent information exchange and structured data management across disciplines and phases. As noted in Chapter 3, buildingSMART also operates approval and certification schemes related to ISO 19650-aligned information management, helping to embed reliable processes for the delivery and exchange of information over the asset lifecycle.

Table 4-13 Key openBIM Initiatives Led by buildingSMART International

Term / Format	Description
Industry Foundation Classes (IFC)	A vendor-neutral data schema that enables the exchange and sharing of BIM information. It supports integrated representation of architectural, structural, building services (MEP), and other domain data.
Construction-Operations Building information exchange (COBie)	A data schema for delivering structured asset information required for facilities management. Commonly used at handover following construction to populate CAFM/CMMS and related enterprise systems.
BIM Collaboration Format (BCF)	A lightweight issue-exchange format for BIM coordination that carries viewpoints, screenshots, and comments. It can be used alongside, but independently of, IFC model files to manage coordination issues.
Information Delivery Manual (IDM)	A guideline for defining information flows and exchanges required at each project phase. Used together with MVD to specify IFC subsets for particular exchanges (ISO 29481).
Information Delivery Specification (IDS)	A machine-readable (XML) way to specify the information requirements that an IFC model must contain, enabling automated compliance checking. Formalized as a standard in June 2024.
buildingSMART Data Dictionary (bSDD)	A central platform for managing and sharing terms, classifications, and properties used in the built environment. It can host entries even where the underlying terminology/classification does not fully meet ISO 12006-2 prerequisites, supporting cross-mapping and harmonization.

Source: Prepared by the JICA Study Team

4.3.2 IFC and Its Current Status

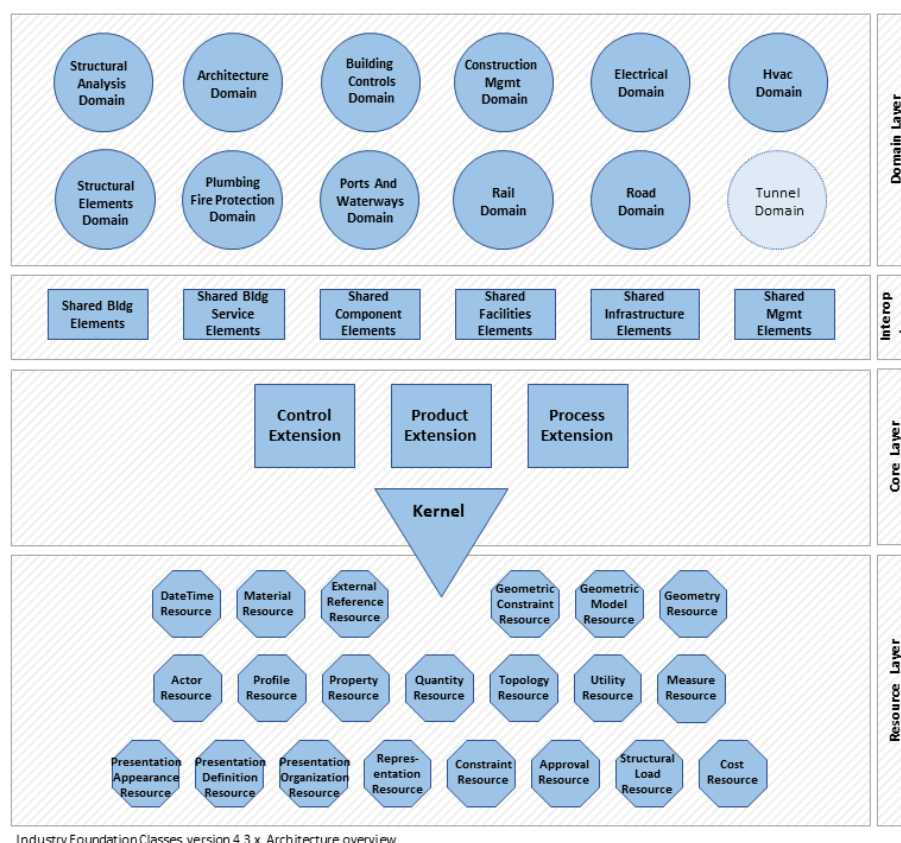
Industry Foundation Classes (IFC) is the international standard developed by buildingSMART at the core of the openBIM initiative. It defines the specification for representing the elements that comprise buildings and civil infrastructure as an object model. IFC is formally standardized as ISO 16739 (Industry Foundation Classes—Data sharing in the construction and facilities management industries)²⁴.

As of 2025, the latest officially published version is IFC 4.3.2. Ongoing work continues to expand domain coverage—such as tunnelling domain—thereby strengthening applicability across civil and infrastructure. In parallel, planning for IFC 4.4 and development of the next-generation IFC 5 (including modularization, API-friendly structures, and schema streamlining) are progressing, with the standard evolving through continuous updates.

Conceptually, IFC provides the class definitions for object data within three-dimensional construction information models across the asset lifecycle of buildings and infrastructure. This formal specification is referred to as the IFC schema. The IFC schema is organized into four layers, as illustrated in Figure 4-9

²⁴ ISO 16739-1:2024: Industry Foundation Classes (IFC) for Data Sharing in the Construction and Facility Management Industries, Part 1: Data Schema

and summarized in Table 4-14.



Source: IFC 4.3.2

Figure 4-9 IFC Schema (by Layers)

Table 4-14 Four Layers of the IFC Schema

Layer Name	Description
Domain Layer	Contains schema components specific to individual project domains—such as structural analysis, architecture, building services engineering and civil engineering. Each domain defines concepts that are unique to its discipline.
Interoperability Layer	Covers shared elements used across multiple domains. For example, beams, columns and walls are defined within Shared Building Elements, while assets, occupants and furniture are included in Shared Facilities Elements.
Core Layer	Defines abstract concepts that underpin the entire schema, including spaces, sites, buildings, building elements, processes and products.
Resource Layer	Comprises 21 resource groups defining fundamental properties such as geometry, geometric relationships, materials, measures and time-related information.

Source: Prepared by the JICA Study Team Based on IFC 4.3.2

These schemas are written in EXPRESS, the data modelling language defined in ISO 10303-11:2004, which allows the structure of product data to be described in a form that is both human-readable and machine-interpretable. Files generated according to this schema use the .ifc extension, enabling different authoring tools to exchange geometric information and IFC-based attribute data without loss.

In essence, IFC provides the standardized class structure for representing both the three-dimensional geometry of building and infrastructure components and the domain-specific attributes associated with them. Files exported in IFC format can be shared and referenced across software platforms certified by buildingSMART without compromising the integrity of model geometry or attribute information, making IFC a neutral and interoperable file format for openBIM workflows.

4.3.3 Attributes Covered by IFC

The classes defined in IFC cover information items relevant to the full lifecycle of buildings and civil infrastructure. As summarized in Table 4-15, these classes play a central role in managing classification and attribute data during design and construction phases. Where IFC's native hierarchies or levels of detail for classification and properties are insufficient for specific operational needs, they can be complemented by construction information classification systems such as Uniclass2015 and by asset data dictionaries such as bSDD, enabling the consistent use of the data into the operation and maintenance phase.

Table 4-15 Examples of IFC Class Scopes and Information Types

Information Type	Scope / Examples
Project information	Project name, units of measurement, true north, and other project context settings
Spatial structure	Site, building, storey/level, space/room, and related spatial hierarchy
Architectural elements	Walls, columns, windows, doors, and other objects in the architectural model
Structural elements	Steel members, reinforcement, and other objects in the structural model
Building services elements (MEP)	HVAC, plumbing/sanitary, electrical, and controls equipment contained in the services model
Civil/infrastructure elements	Roads, bridges, rail, and other objects typically modelled in civil works
Geometric information	2D/3D shape representations, including solid and topology-based geometry
Object relationships	Containment, connectivity, and other inter-object relationships
Systems / networks	Building services systems and functional groupings
Attributes	Property Sets (Psets) used to attach attribute data to objects
Quantities	Mechanisms for attaching counts, lengths, areas, volumes, and other quantities
Classification codes	Links to external construction classification systems
Other	Structural analysis, actors (people and organizations), 4D, 5D, and asset management-related data

Source: Prepared by the JICA Study Team based on Reference 22

4.3.4 Practical Use of IFC, and the Roles of MVD and IDM

As noted in the previous section, the IFC format can carry a substantial volume of attribute information. In practice, however, it is not feasible for a single task team to author all required attributes for a project during model creation. In a typical building project, for example, the architectural team will author the building geometry, spatial breakdown, and related structural coordination, whereas mechanical and electrical information is authored by the building services (MEP) team. To produce a model that contains all required information, the models authored by each delivery team must therefore be federated into a single integrated model. Within IFC 4.3, the fully detailed, design-stage exchange of an integrated model is defined as the Design Transfer View (DTV). The DTV is intended for the complete exchange of design intent and supports bidirectional coordination between models. Because it carries comprehensive content, the dataset size is typically large.

Not all information created during design and construction needs to be shared with the appointing party or with other task teams. IFC supports selective exchange by allowing the removal of non-essential data and the sharing of only what is required for a particular purpose. In IFC 4.3, such a purpose-specific subset is defined using a Model View Definition (MVD). MVDs are commonly provided as .mvdXML (machine-readable) and may also be documented for human use in HTML or Excel. The items defined within an MVD can be extracted from the integrated IFC model and used or referenced independently, without exchanging the full model.

IFC 4.3 formally defined three principal MVDs:

- Design Transfer View (DTV) - the full, bidirectional exchange for design intent as described above.
- Reference View (RV) - a lean exchange intended primarily for one-way reference models.

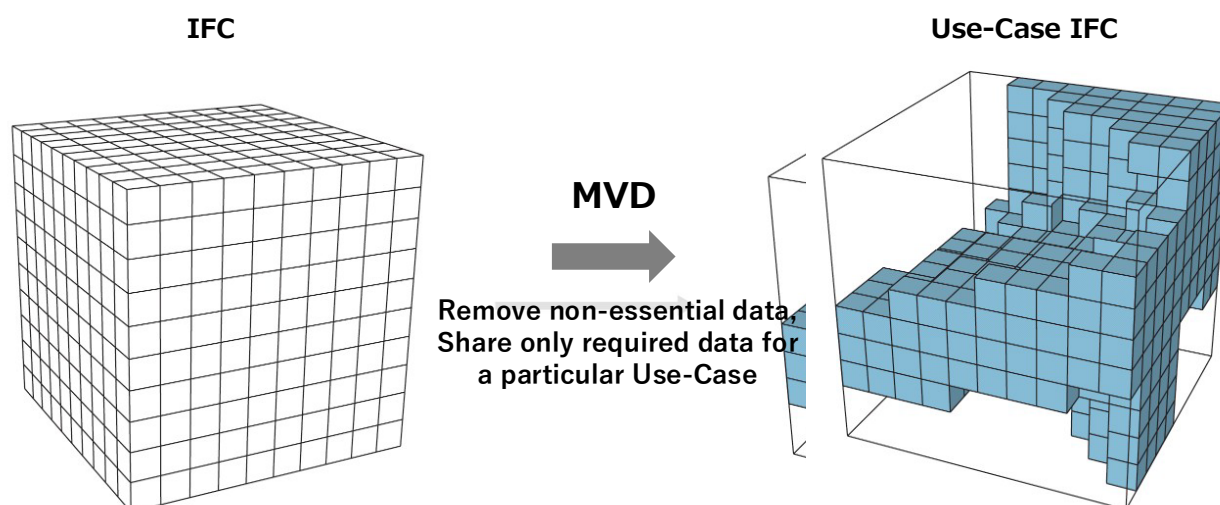
- Alignment-based View (AbV) - an exchange focused on linear alignment and associated concepts for infrastructure domains such as railways and roads.

Beyond these, projects may define bespoke MVDs tailored to specific exchange purposes and workflows.

Examples of MVD use:

- Extracting only geometric information from architectural and services models to perform clash detection.
- Extracting structural geometry information and stiffness or section properties to perform structural analysis.

Historic MVDs have been catalogued by buildingSMART; however, because the catalogue is not always synchronized with subsequent IFC version updates, content drift may occur, and users should therefore exercise caution when selecting legacy MVDs.²⁵



Source: Prepared by the JICA Study Team based on Reference 26

Figure 4-10 Illustration of MVD Use

In planning model exchanges, it is essential to specify, in a clear narrative form, who shares which information, at what stage, for what purpose, and using which MVD. The technical specification that documents this planning is the Information Delivery Manual (IDM). IDM is governed by ISO 29481-1, 2, 28, 29 and sets out detailed rules for drafting and handling process-oriented information exchanges. It should be prepared at the early project stages and explicitly referenced within ISO 19650 documentation, namely the Exchange Information Requirements (EIR) and the BIM Execution Plan (BEP). The relationship between IDM and MVD in information management under ISO 19650 is shown in Figure 4-11.

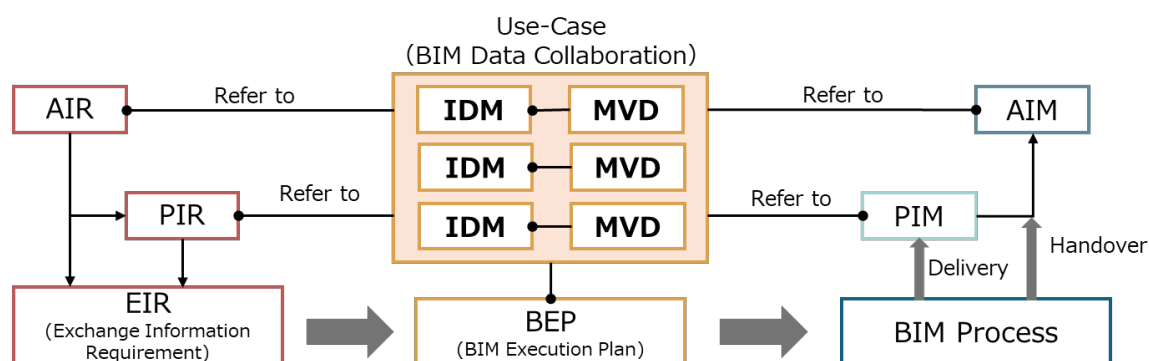
²⁵ [MVD Database - buildingSMART Technical](#)

²⁶ Mark Baldwin: The BIM Manager, building SMART, 2019

²⁷ ISO 29481-1:2016: Building Information Models, Information Delivery Manual, Part 1: Methodology and Format

²⁸ ISO 29481-2:2012 (2025ver. Under preparation): Part 2: Interaction Framework

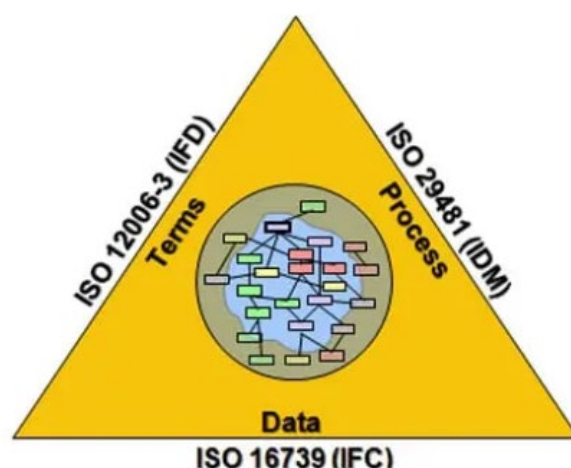
²⁹ ISO 29481-3:2022: Part 3: Data Schema



Source: Prepared by the JICA Study Team based on Reference 22

Figure 4-11 Relationship Between IDM and MVD in ISO 19650-Based Information Management

In summary, IDM defines the processes and responsibilities for information delivery, while MVD defines the precise data subset to be exchanged in IFC for that process. Together, they ensure that information exchanges are purpose-built, lean, and verifiable, supporting robust lifecycle information management under the ISO 19650 framework.



Source: buildingSMART

Figure 4-12 Three Standards Defining IFC and Related Requirements (Terms, Process and Data)

4.3.5 OpenBIM Workflow (bSDD, BCF, IDS, etc.)

To support an end-to-end openBIM workflow during project delivery—built on the use of IFC and MVD—buildingSMART has developed a cohesive ecosystem of tools, standards, and guidelines. As summarized in Table 4-13, several formats and specifications are currently in active use within this ecosystem. The principal components are outlined below.

(1) buildingSmart Data Dictionary (bSDD)³⁰

The buildingSmart Data Dictionary (bSDD) is an open, common dictionary that centrally manages terminology, classifications, attribute information, and other data used in the construction industry. It complements the meaning and specifications of information in conjunction with IFC models. While IFC can represent geometry and basic attributes (e.g., location, size, use, etc.), it cannot define detailed, discipline-specific attributes. Therefore, buildingSMART developed bSDD to link with construction information classification systems, such as Uniclass.

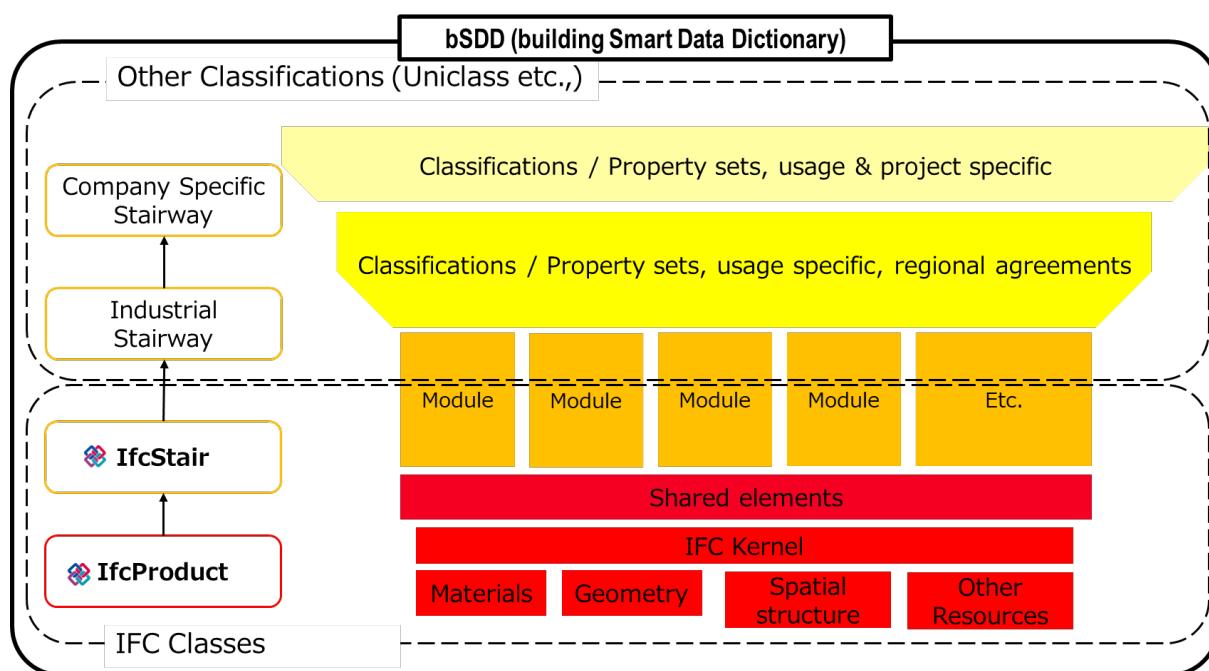
While IFC can represent geometry and core attributes (e.g., location, size, and general purpose), it does not

³⁰ [buildingSMART Data Dictionary - buildingSMART International](#)

exhaustively capture domain-specific property sets required in practice. To address this gap, and to enable explicit linkage to construction information classification systems such as Uniclass2015, buildingSMART developed bSDD as a platform for structured definition management. Within bSDD, teams can curate and govern classification codes, property names, meanings, data types, units, and permissible values, and can cross-reference or compare heterogeneous schemes used by different countries, organizations, and project stages (e.g. Uniclass, OmniClass). A web interface supports discovery and human review, and standard integrations allow bSDD definitions to be embedded within authoring and checking workflows, thereby improving consistency, accuracy, and reusability of project data.

Furthermore, by linking with an IDS, it standardizes and automatically verifies requirements such as “what information is needed and what its meaning and constraints are.” It functions as a foundation enabling all project stakeholders to efficiently exchange complete information based on the same definitions.

Moreover, bSDD allows registration not only of the construction information classification system compliant with the ISO 12006-2 principles, as required by ISO 19650 and described in Section 4.1, but also of various other classification systems. For example, classification systems primarily used for operation and maintenance, such as ETIM³¹ and the BLCJ BIM Object Standard³², which focus on electrical and mechanical products, are also registered. Therefore, when using a construction information classification system within the ISO 19650 framework, it is important to be mindful of clearly defining the method and purpose of its use.



Source: Prepared by the JICA Study Team based on buildingSMART International materials

Figure 4-13 Overview of bSDD

(2) Information Delivery Specification (IDS)

The Information Delivery Specification (IDS) is a computer-interpretable XML document that defines exchange conditions for model-based information exchanges. These conditions can specify objects, classifications, properties, values, and units.

IDS can be used as the formal mechanism for defining the Level of Information Need (LOIN) within an ISO 19650 context, thereby enabling automated validation of IFC models by clients, information producers, and analysis software. For example, an IDS may state that every instance of IfcWall must contain the

³¹ <https://www.etim-uk-and-ie.org/the-standard/structure-of-the-etim-data-model/>

³² <https://blcj.or.jp/contents/setsubi/>

property Fire Rating with the data type IfcLabel; during exchange, a computer can validate the architectural model and instantly assess whether fire-rating information is correctly present for all walls.

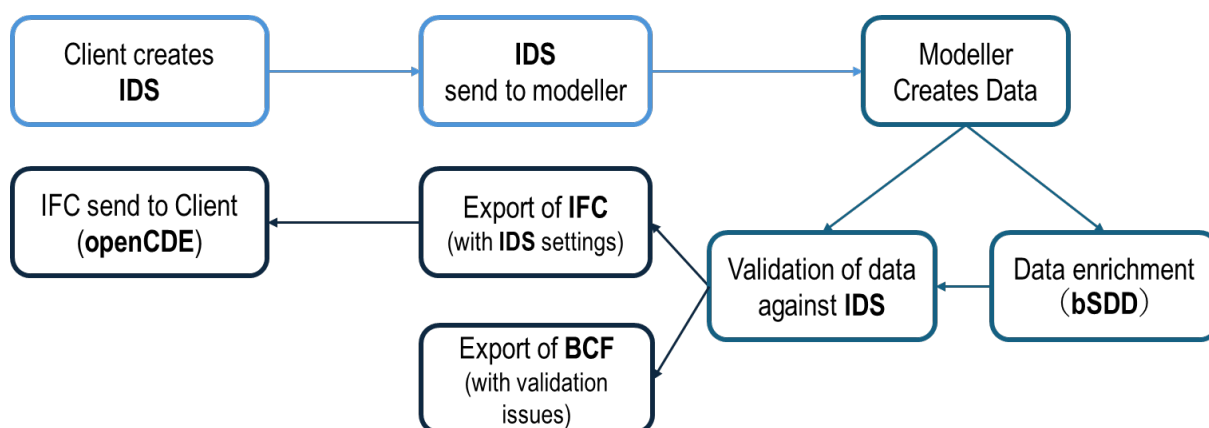
IDS definitions may be authored at the project level and stored in bSDD. Models that meet these requirements, along with the corresponding IDS, can be retained in bSDD as templates for subsequent reuse.

(3) BIM Collaboration Format (BCF)

The BIM Collaboration Format (BCF) is an open format for managing and sharing issues, comments, and review notes related to BIM models, independently of the model data itself. Developed by buildingSMART, BCF stores issue content, the location of the affected objects, viewpoints (camera positions), assignees, due dates, and comment histories in XML or JSON, enabling seamless exchange between different software platforms. This reduces reliance on large IFC file transfers and email-based coordination, thereby improving operational efficiency. For example, if a designer identifies a clash involving walls, the relevant viewpoint and commentary can be recorded in BCF and shared; contractors or other stakeholders can then open the BCF in their own tools, locate the issue in their model, and carry out the necessary corrections.

BCF is supported by a wide range of BIM tools, including Revit, ArchiCAD, Solibri, and Navisworks, and serves as an intuitive, model-based communication mechanism for multi-party projects.

Figure 4-14 illustrates how BCF is utilized within the flow from information production to delivery. As shown in the figure, computers verify whether the deliverables meet the specifications defined in the IDS. If defects are found, a BCF is generated, enabling the exchange of comments and requests for corrections.



Source: Prepared by the JICA Study Team based on buildingSMART International materials

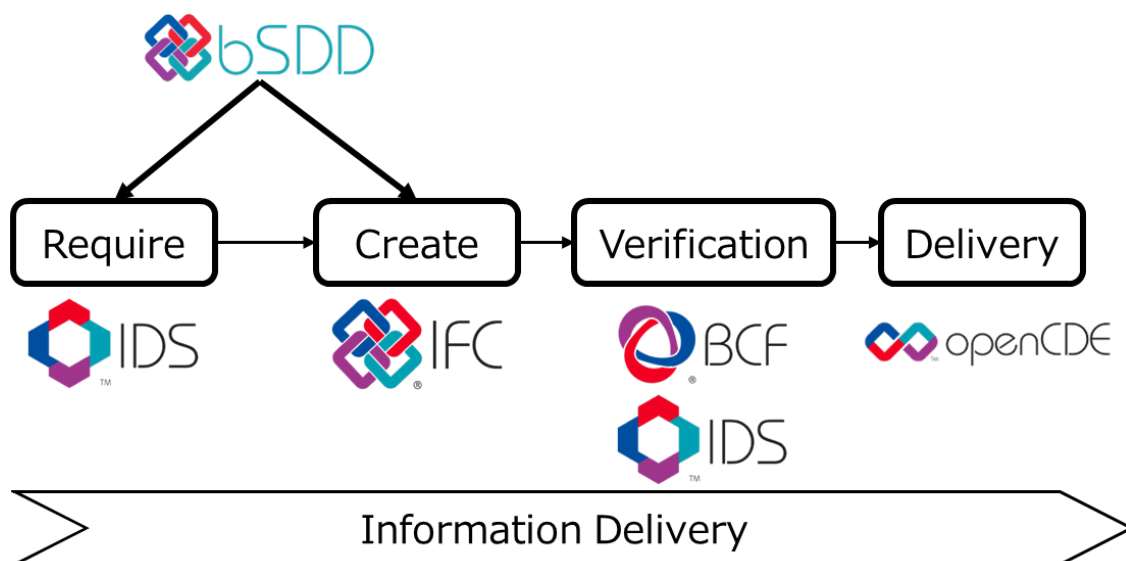
Figure 4-14 Production and Delivery Workflow Using IDS and BCF

(4) Open Common Data Environment (openCDE)

The open Common Data Environment (openCDE) is an open specification and API set that enables interoperable CDE operations across different systems and tools. Standardization is being advanced by buildingSMART.

Conventional CDE implementations are often vendor-specific and closed. Where project participants use differing tools, data exchange, and process control can be labor-intensive and error-prone. openCDE addresses these issues by providing common APIs for document upload, version control, metadata retrieval, and workflow triggers, and by integrating with other buildingSMART standards such as IDS and BCF. This allows smooth information sharing across heterogeneous CDE systems, supports uniform data governance and automation at project level, and ensures that stakeholders can access reliable, real-time information.

Leveraging buildingSMART-standardized components—IFC, IDS, bSDD, BCF, and openCDE—the openBIM Workflow enables all parties in construction and infrastructure projects to collaborate using common rules and data formats, transcending software and organizational boundaries.



Source: Prepared by the JICA Study Team based on buildingSMART International materials.

Figure 4-15 The openBIM Workflow

4.4 COBie

ISO 19650 defines BIM as an information-management approach across the entire lifecycle, from design through construction to O&M. The handover of the substantial information produced up to the construction stage to the O&M phase (FM) is also within scope. At this stage, it is crucial to extract only the information required for the FM phase and to transfer it efficiently, and COBie is a data schema that is useful for this purpose.

4.4.1 Background to COBie

COBie was first introduced in 2007 by the U.S. Army Corps of Engineers, with supported from NASA and the White House Office of Science and Technology Policy. By 2008, major software vendors such as Autodesk and Bentley endorsed the approach, facilitating international adoption. In 2009, buildingSMART officially released COBie as a Model View Definition (MVD; FM Basic Handover) aligned with ISO 10303, the STEP standard for product data exchange. Today, COBie-based MVD is defined within ISO 16739, the IFC standard, and the method is widely recognized as a key approach for information handover to the FM phase.

4.4.2 Overview of COBie

COBie is an information-exchange format used for handing over data to FM. It contains no geometric information, focusing solely on the asset and attribute data required for the operational phase. It is one of the MVDs specialized for FM.

Its main characteristics include:

- Extraction of FM-relevant attributes from design and construction IFC models
- Definition as an MVD (.mvdXML), enabling automated export from IFC data
- A simple, spreadsheet-based structure, typically delivered in Excel
- Organization of essential FM information such as equipment, components, spaces, types, systems, and contacts

Using COBie for project handover can improve efficiency and enhance information quality throughout the asset lifecycle. Key benefits include:

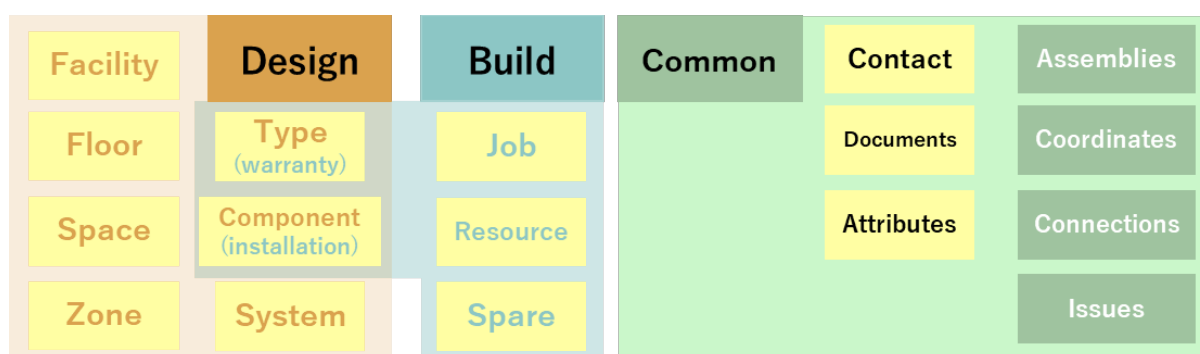
- **Standardization and Interoperability**
By producing models consistent with international standards, information can be exchanged more easily across different software platforms, improving efficiency during information production.
- **Accurate and Streamlined FM Handover**
Because COBie extracts only the information required for FM in a simple, lightweight structure, the resulting dataset is easy to handle. Computer-based export, validation, and completeness checking also reduce omissions and errors.
- **Improved Operational Performance**
Key FM-related data—such as maintenance information and serial numbers—can be clearly structured for handover. Since COBie can integrate with FM software, organizations can implement planned operational strategies from day one.

Although COBie offers substantial benefits, several considerations must be addressed:

- **COBie Requirements Must be Defined from the Modelling and Information-production Stages**
The appointing party must establish a COBie Delivery Matrix—based on the planned FM strategy—and incorporate it into the AIR and EIR. The lead appointed party must then integrate these requirements into the BEP.
- **Data Completeness and Accuracy are Essential during BIM Model Authoring**
Clear standards for attribute sets and input methods are required, typically through a BIM Object Standard (BOS). A BOS defines rules for attributes, classification, naming conventions, and other parameters to ensure model consistency and information quality. Representative examples include the UK's NBS BOS, Japan's BIM Library Technology Research Association (BSCJ) BOS, and the international openBIM Object Standard.
- **Local Regulatory Performance Requirements Must be Reflected**
COBie Type properties include regulatory-performance fields, which are generally configured for UK requirements but may differ by country. Therefore, these fields must be adapted to reflect the relevant local legislation. For example, in Japan, the required fields may include fire resistance and smoke protection defined under the Building Standards Act, as well as requirements related to asbestos, VOCs, PCBs, and compliance with laws such as the Fire Service Act, the Electricity Business Act, and Personnel Authority Regulations. These must be organized according to the intended operational use.

4.4.3 Example of COBie Structure (Excel)

An example of the information typically included in COBie can be represented in a tabular format, such as the one shown in Figure 4-16. Since COBie places emphasis on keeping information simple, well-structured, and easily manageable, it is generally preferable to produce COBie for each building, rather than for an entire multi-building project in a single file.

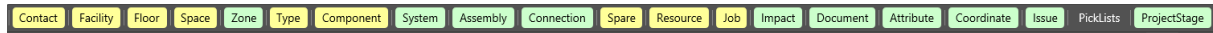


Source: the JICA Study Team

Figure 4-16 Internal Structure of COBie

As illustrated in Figure 4-16, COBie organizes its internal structure by dividing information into three sections: Design Information, Construction (Build) Information, and Common/General Information.

Within each section, the constituent information sets are further organized into separate Excel worksheets, as shown in Figure 4-17. Each sheet manages a specific category of related data, ensuring that the overall COBie deliverable is structured, navigable, and aligned with FM requirements.



Source: Autodesk COBie Sample (Autodesk Interoperability Tools)

Figure 4-17 Example COBie Excel Worksheets

Table 4-16 provides an overview of each internal COBie component introduced in Figure 4-16.

Table 4-16 Internal COBie Components

Design – Information Defined During the Design Stage	
Facility	The overall facility that is the subject of the project.
Floor	The hierarchical floor structure within the facility.
Space	Rooms and defined areas within the building.
Zone	Groupings of spaces (e.g., HVAC zones).
System	Building services systems (e.g., electrical, HVAC).
Type (Type & Warranty)	Equipment or component types and their associated warranty information.
Component (Component & Installation)	Individual assets/components and their installation details.
Build – Information Defined During the Construction Stage	
Job	Records of construction tasks and activities.
Resource	Materials, labor, and other resources used.
Spare	Spare parts and replacement components.
Common – Information Used Across Both Design and Construction	
Contacts	Contact information for project stakeholders.
Documents	Related drawings, specifications, and other documentation.
Attributes	Additional properties for elements (e.g., material, manufacturer).
Assemblies	Assemblies composed of multiple parts.
Coordinates	Location and spatial coordinate data.
Connections	Relationships and connections between elements.

Source: Autodesk COBie Sample (Autodesk Interoperability Tools)

Using the Autodesk COBie Sample—an example dataset provided in Excel format—this section explains several key COBie components (Facility, Floor, Space, Zone).

Each COBie dataset is generally created for a single Facility. As shown in Figure 4-18, the Facility Worksheet contains information describing the overall building that is the subject of the COBie deliverable.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	Name	CreatedBy	CreatedOn	Category	ProjectName	SiteName	LinearUnits	AreaUnits	VolumeUnits	CurrencyUnit	AreaMeasurement	ExternalSystem	ExternalProjectObject	ExternalProjectIdentifier
1														
2	PN 0001	bill.east@p	2011-09-14	11-13 24 14	Medical-De	Default	millimeters	squaremet	cubicmeter	Dollars	Autodesk R	Autodesk R	RlfcProject	3eM8WbY
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
13														
14														
15														
16														
17														

Source: Autodesk COBie Sample (Autodesk Interoperability Tools)

Figure 4-18 COBie Sample: “Facility” Worksheet

As shown in Figure 4-19, when a facility contains multiple floors, the Floor Worksheet is used to record information for each individual floor.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	Name	CreatedBy	CreatedOn	Category	ExtSystem	ExtObject	ExtIdentifier	Description	Elevation	Height				
1														
2	First Floor	bill.east@p	2011-09-14	Floor	Autodesk RlfcBuildings	3eM8WbY	First Floor	0	0					
3	Roof - Mair	bill.east@p	2011-09-14	Roof	Autodesk RlfcBuildings	3eM8WbY	Roof - Mair	9.25	0					
4	Second Flo	bill.east@p	2011-09-14	Floor	Autodesk RlfcBuildings	3eM8WbY	Second Flo	4.57	0					
5	Site	bill.east@p	2011-09-14	Site	Autodesk RlfcBuildings	n/a	Site	0	0					
6	TOF Footin	bill.east@p	2011-09-14	Site	Autodesk RlfcBuildings	3eM8WbY	TOF Footin	-1	0					
7														
8														
9														
10														
11														
12														
13														
14														
15														
16														
17														

Source: Autodesk COBie Sample (Autodesk Interoperability Tools)

Figure 4-19 COBie Sample: “Floor” Worksheet

As shown in Figure 4-20, the Space Worksheet is used to record information about each room or area,

including its intended use and location (such as the floor on which it is situated).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	Name	CreatedBy	CreatedOn	Category	FloorName	Description	ExtSystem	ExtObject	ExtIdentifier	RoomTag	UsableHeight	GrossArea	NetArea	
1	1A01	bill.east@p	2011-09-14	13-11 11 3	First Floor	PATIENT A	Autodesk R	IfcSpace	0ztdC3L1H	n/a	2700	19.767	19.767	
2	1A02	bill.east@p	2011-09-14	13-15 11 3	First Floor	RMO ANAL	Autodesk R	IfcSpace	0ztdC3L1H	n/a	2400	27.693	27.693	
3	1A03	bill.east@p	2011-09-14	13-15 11 3	First Floor	TRICARE O	Autodesk R	IfcSpace	0ztdC3L1H	n/a	2400	8.874	8.874	
4	1A04	bill.east@p	2011-09-14	13-15 11 3	First Floor	TRICARE O	Autodesk R	IfcSpace	0ztdC3L1H	n/a	2400	9.545	9.545	
5	1A05	bill.east@p	2011-09-14	13-15 11 3	First Floor	TRICARE O	Autodesk R	IfcSpace	0ztdC3L1H	n/a	2400	8.999	8.999	
6	1A06	bill.east@p	2011-09-14	13-15 11 3	First Floor	TRICARE O	Autodesk R	IfcSpace	0ztdC3L1H	n/a	2400	10.492	10.492	
7	1A07	bill.east@p	2011-09-14	13-15 11 3	First Floor	TRICARE O	Autodesk R	IfcSpace	0ztdC3L1H	n/a	2400	8.73	8.73	
8	1A08	bill.east@p	2011-09-14	13-15 11 3	First Floor	PHARM. O	Autodesk R	IfcSpace	0ztdC3L1H	n/a	2400	10.45	10.45	
9	1A09	bill.east@p	2011-09-14	13-41 11 1	First Floor	W. TOILET	Autodesk R	IfcSpace	0ztdC3L1H	n/a	2400	10.854	10.854	
10	1A10	bill.east@p	2011-09-14	13-51 11 2	First Floor	LOUNGE	Autodesk R	IfcSpace	0ztdC3L1H	n/a	2400	10.272	10.272	
11	1A11	bill.east@p	2011-09-14	13-75 11 1	First Floor	JAN.	Autodesk R	IfcSpace	0ztdC3L1H	n/a	2400	2.037	2.037	
12	1A12	bill.east@p	2011-09-14	13-41 11 1	First Floor	M. TOILET	Autodesk R	IfcSpace	0ztdC3L1H	n/a	2400	9.91	9.91	
13	1A13	bill.east@p	2011-09-14	13-41 11 1	First Floor	STAFF TOIL	Autodesk R	IfcSpace	0ztdC3L1H	n/a	2400	4.468	4.468	
14	1A14	bill.east@p	2011-09-14	13-15 11 3	First Floor	SUPER / NC	Autodesk R	IfcSpace	0ztdC3L1H	n/a	2400	7.23	7.23	
15	1A15	bill.east@p	2011-09-14	13-41 41 9	First Floor	COUNSELIN	Autodesk R	IfcSpace	0ztdC3L1H	n/a	2400	6.398	6.398	
16	1A16	bill.east@p	2011-09-14	13-75 11 1	First Floor	PHARM. DI	Autodesk R	IfcSpace	0ztdC3L1H	n/a	2400	67.549	67.549	

Source: Autodesk COBie Sample (Autodesk Interoperability Tools)

Figure 4-20 COBie Sample: “Space” Worksheet

As shown in Figure 4-21, the Zone Worksheet is used to record properties that organize rooms or spaces into functional groups. Examples include fire-protection zones, HVAC zones, and patrol/inspection zones.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	Name	CreatedBy	CreatedOn	Category	SpaceNames	ExtSystem	ExtObject	ExtIdentifier	Description					
2	Administra	bill.east@p	2011-09-14	Occupancy	1A01	n/a	IfcProperty	n/a	Administration Department					
3	Administra	bill.east@p	2011-09-14	Occupancy	1A02	n/a	IfcProperty	n/a	Administration Department					
4	Administra	bill.east@p	2011-09-14	Occupancy	1A03	n/a	IfcProperty	n/a	Administration Department					
5	Administra	bill.east@p	2011-09-14	Occupancy	1A04	n/a	IfcProperty	n/a	Administration Department					
6	Administra	bill.east@p	2011-09-14	Occupancy	1A05	n/a	IfcProperty	n/a	Administration Department					
7	Administra	bill.east@p	2011-09-14	Occupancy	1A06	n/a	IfcProperty	n/a	Administration Department					
8	Administra	bill.east@p	2011-09-14	Occupancy	1A07	n/a	IfcProperty	n/a	Administration Department					
9	AdultMedi	bill.east@p	2011-09-14	Occupancy	1D02	n/a	IfcProperty	n/a	Adult Medicine Department					
10	AdultMedi	bill.east@p	2011-09-14	Occupancy	1D04	n/a	IfcProperty	n/a	Adult Medicine Department					
11	AdultMedi	bill.east@p	2011-09-14	Occupancy	1D05	n/a	IfcProperty	n/a	Adult Medicine Department					
12	AdultMedi	bill.east@p	2011-09-14	Occupancy	1D06	n/a	IfcProperty	n/a	Adult Medicine Department					
13	AdultMedi	bill.east@p	2011-09-14	Occupancy	1D07	n/a	IfcProperty	n/a	Adult Medicine Department					
14	AdultMedi	bill.east@p	2011-09-14	Occupancy	1D08	n/a	IfcProperty	n/a	Adult Medicine Department					
15	AdultMedi	bill.east@p	2011-09-14	Occupancy	1D09	n/a	IfcProperty	n/a	Adult Medicine Department					
16	AdultMedi	bill.east@p	2011-09-14	Occupancy	1D10	n/a	IfcProperty	n/a	Adult Medicine Department					
17	AdultMedi	bill.east@p	2011-09-14	Occupancy	1D11	n/a	IfcProperty	n/a	Adult Medicine Department					

Source: Autodesk COBie Sample (Autodesk Interoperability Tools)

Figure 4-21 COBie Sample: “Zone” Worksheet

In addition to the information described above, COBie allows you to record, for each component, details such as the responsible manager, manufacturer, installer, dates of associated tasks, warranty periods, and maintenance intervals. This enables the systematic organization of information that supports effective facilities management.

4.4.4 COBie (MVD) and Supporting Software

COBie is defined as a Model View Definition (MVD) compatible with the IFC standard, allowing BIM authoring tools to export COBie data directly from a three-dimensional (3D) model into an Excel file.

Furthermore, several FM platforms can then import COBie files and use them to create maintenance schedules, link data with 3D models, and centralize asset information for effective O&M.

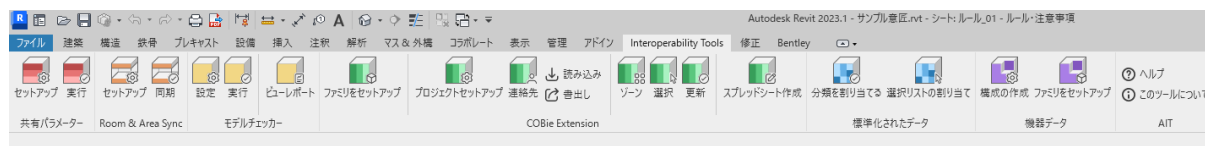
(1) Tools for Exporting COBie Data (Examples)

One example of a COBie export tool is Autodesk's Interoperability Tools for Revit, provided as an add-in for the Revit BIM authoring platform.

Using this tool, users can define:

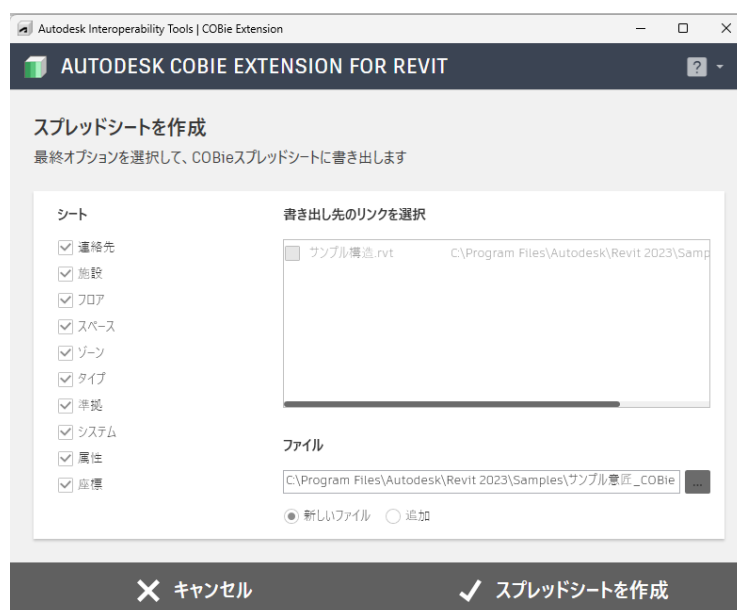
- What information should be exported to each COBie worksheet;
- The units to be used; and
- The construction classification systems that should be applied.

By assigning the correct properties to the model in accordance with these definitions, users can generate COBie files that meet client requirements.



Source: the JICA Study Team

Figure 4-22 Interoperability Tools for Revit Operation Tab



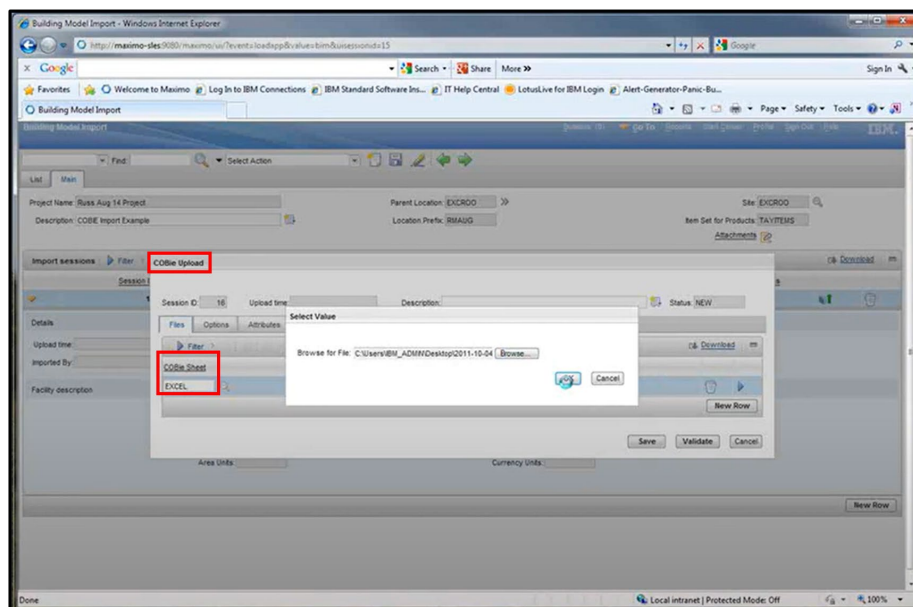
Source: the JICA Study Team

Figure 4-23 Interoperability Tools for Revit COBie Export Screen

(2) Tools for Importing COBie Data (Examples)

For the FM phase, IBM Maximo is an example of software capable of importing and using COBie to support asset maintenance, inspections, and reliability management.

Through the add-in Extensions for BIM, Maximo can import COBie datasets and integrate them into a comprehensive, lifecycle-based asset management environment.



Source: Extract from BIM MAXIMO DEMO33

Figure 4-24 Maximo Extensions for BIM COBie Import Screen

4.5 LOIN (ISO 7817)

4.5.1 Background of LOIN and Prerequisites

The concept of LOD (The Level of Development)³⁴, defined by the American Institute of Architects (AIA) and others, has been widely used as a term to indicate the level of geometric information in a BIM model. From LOD100 (basic model) to LOD500 (detailed model), the level of detail of geometric information was defined according to the purpose, such as analysis, estimation, design, and construction scheduling. The attribute definition is also included, but it supplements the reliability and definition of geometric information according to the purpose and use.

In the UK, where BIM was defined as an information management tool, PAS 1192-2 explicitly separates geometric information and attribute definitions to align with the BS/PAS 1192 framework, which considers the entire asset lifecycle, including the operation and maintenance stage. It defines this separation as:

Level of Model Definition = Level of Model Detail (LOD, geometric information) + Level of Model Information (LOI, attribute information).

Following the international standardization of the BS/PAS 1192 framework as ISO 19650, the terminology defining geometric and attribute information was redefined as LOIN and standardized in the European standard EN 1741235.

This standard was later revised by removing content specific to the UK/European context, terminology, and information, and generalized with an explicit emphasis on supporting operation and maintenance use cases. It was harmonized with ISO 19650 and the exchange information requirements of the above-mentioned Information Delivery Manual (IDM, ISO 29481-1), and internationalized as ISO 7817-136. With this international standardization, the European standard EN 17412 has been withdrawn.

Traditional LOD requirements focused solely on geometric information, leading to ambiguous specifications for non-geometric information (attributes, documents, etc.). This caused discrepancies with information exchange requirements, such as excessive modeling. Therefore, ISO 7817-1 clearly defines

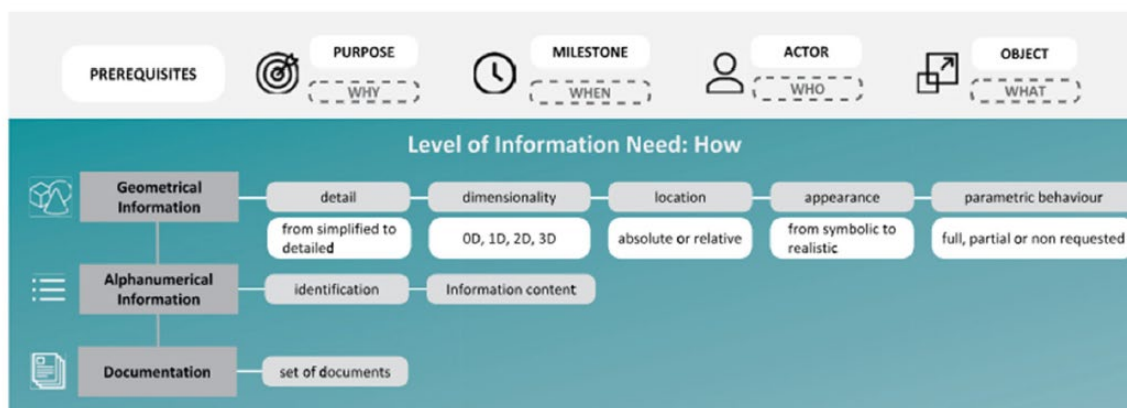
33 YouTube: BIM MAXIMO DEMO Part1: <https://youtu.be/142WRvF7R0k>

34 AIA Document G202-2013: Project Building Information Modeling Protocol Form, AIA

35 BS EN 17412-1: Building Information Modelling, Level of Information Need, 2020

36 ISO 7817-1:2024, Building Information Modelling - Level of Information Need - Part 1 Concepts and principles

purpose-based criteria based on the 5W1H concept: “Why → Purpose,” “When → Delivery Milestone,” “Who → Actor,” and “What → Object.” Furthermore, by defining LOIN settings that specify detailed information for “How → Geometrical Information, Alphanumerical Information or non-geometrical information such as attribute, performance value, standard, and Documentation,” it enables more precise information requirements. Additionally, the framework establishes information requirements that are both human-readable and machine-interpretable (expressible in XML schemas) based on the level of information necessity.



Source: M.Bolpagni, Reference 37

Figure 4-25 Framework of ISO 7817 LOIN

Table 4-17 Framework of LOIN Specification

Prerequisites	Content
Purpose	Consider the purpose of the information and specify it to clarify why the information is needed. The required amount of information is determined by the purpose sought.
Delivery Milestone	Consider the milestones of the information delivery and specify them to clarify when the information will be needed.
Actor	When specifying the LOIN, identify the actors who receive and provide the information.
Object	Specify the objects to be considered within the breakdown structure and identify the semantic, functional, and spatial BS of the project (e.g., identifying components and spaces) and other BSs.

Source: the JICA Study Team

The following is an overview of the information to be specified in LOIN: How (geometric information, non-geometric information, documents) in ISO 7817-1.

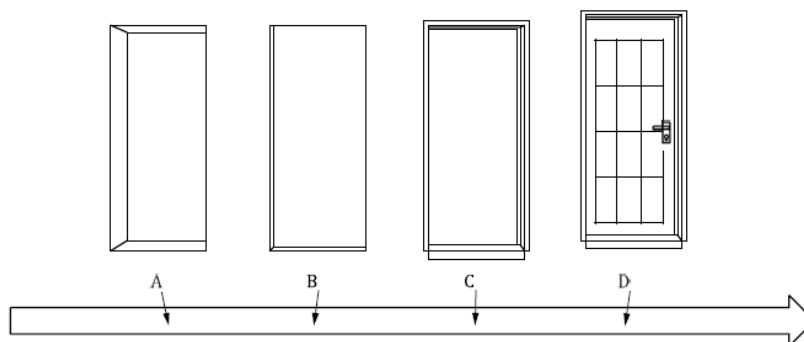
4.5.2 Geometrical Information

Geometrical information specifies detail, dimensionality, location, appearance, and parametric behavior.

(1) Detail

The specification of the level of detail corresponds to the level designation in the conventional LOD/LOG, and it should be defined according to the information milestone, that is, the stage level of the project (FS, basic design, detailed design, etc.). As a reference example, the door example shown in ISO 7817-1 is presented below. In a project, door details may vary depending on the purpose and information milestones. For instance, during basic design, the door is represented as a hole in the wall to aid in structural analysis (see Figure 4-26 A) or as a simplified box representing a door panel for asset management during operation (see Figure 4-26 B). In more detail, additional parts are added, such as thresholds and casings for crash detection (see Figure 4-26 C), as well as door handles and glass for visualization (see Figure 4-26 D).

37 R.Sacks, G.Lee, L.Burdi, M. Bolpagni: BIM Handbook 4th Edition, Wiley, 2025



Source: ISO 7817-1

Figure 4-26 Level of Details According to ISO 7817 Information Milestones

(2) Dimensionality

An object is defined by multiple spatial dimensions: 0D (e.g., position points), 1D (e.g., lines, curves, paths), 2D (e.g., surfaces, planes), or 3D (e.g., volumes). This means that even if the same pipe is used, it can be specified in 1D for the quantity calculation and used in 3D for crash detection.

(3) Location

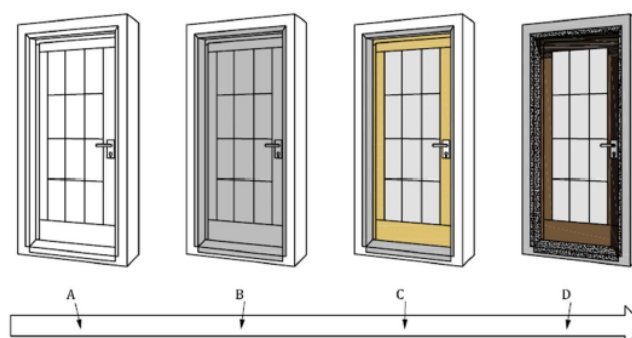
Location describes the position and orientation of an object. Location can be absolute, based on a reference point, or relative, based on another object.

Example 1: The absolute location of an object can be expressed by its position and orientation in a reference system, such as grids, alignment, or reference point (e.g., a survey point in a coordinate reference system).

Example 2: The relative location of an object can be expressed by its position and orientation in terms of topological relationships with other objects (e.g. a window can be positioned at a specified distance along the length of a wall).

(4) Appearance

Appearance represents the visual representation of an object, which can range from symbolic to real compared to the real world. Appearances that require detailed specifications in architectural design may include more shading characteristics (e.g., diffuse color, transparency, reflectivity, and emissivity), which better approximate the visual features of real-world objects. On the other hand, it may be explicitly designated as “not applicable” where visual appearance is irrelevant (e.g., for piping).



Source: ISO 7817-1

Figure 4-27 Exterior Example of Architectural Design (e.g., Door)

(5) Parametric Behavior

Parametric behavior indicates whether an object's shape, position, and orientation are designed to change based on other information or the surrounding context. In other words, it represents whether:

- The object can be recalculated and reconfigured based on certain parameters (such as dimensional

constraints or placement conditions).

- The object exists solely as a fixed shape.

When exchanging information (e.g., via IFC), this parametric behavior can be fully inherited, partially inherited, or not inherited at all. The choice depends on the application and the required level of information.

For example, if the original shape in Figure 4-28 is designated as Shape A, the possible operations vary depending on the status of each parametric geometry.

- **Explicit Geometry (Fixed Shape, Figure 4-28 B)**

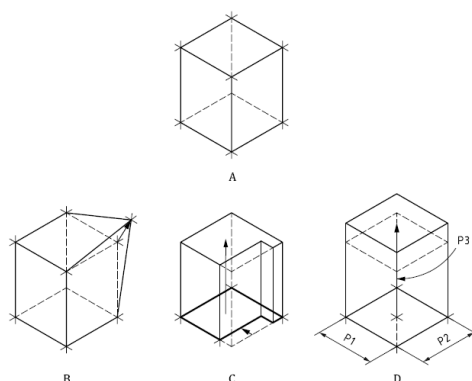
This represents a fixed description of the shape using points, lines, and surfaces (boundaries). The shape cannot be changed by parameters, so the object contains "only the result" and cannot be reconstructed using dimension conditions or calculation formulas. In other words, only the completed shape data is passed.

- **Constructive Geometry (Parametric Shape, Figure 4-28 C)**

This type retains the dimensional parameters used to creating shapes by combining primitives (cuboids, cylinders, etc.) and sweeps (extrusions, rotating bodies). It is possible to modify the shape (e.g., adjusting the extrusion distance changes thickness, changing the angle to alters the shape of a revolved body). In other words, the shape can be modified later because the "original dimension information" used to calculate it remains.

- **Parametric Geometry (Parametric Shape with Equation/Constraint, Figure 4-28 D)**

This defines shapes with equations and constraints, allowing them to be automatically adjusted based on other objects and contexts (e.g., wall thickness, room size, level criteria). The shape itself is parameter-dependent, and when the relevant conditions change, the shape is automatically reconstructed. In other words, the shape is generated from a calculation formula and automatically updates when other elements change (like a Revit family).



Source: ISO 7817-1

Figure 4-28 Different Parametric Behavior (B: Explicit, C: Constructive, D: Parametric)

4.5.3 Alphanumerical Information (Non-geometrical Information)

Non-geometrical information requires the data for an object or set of objects be created in a data template or link that conforms to the ISO23387: Data Template Principles and Data Exchange Standards.³⁸

(1) Identification

Identification tags are used to locate objects within the breakdown structure (BS).

Examples: name, type name, classification, encoding, reference structuring, indexing, numbering.

³⁸ ISO 23387 BIM Data templates for construction objects used in the life cycle of any built asset (Concepts and principles), design template structures in accordance with the dictionary framework ISO12006-3 and define how to work with IFC and taxonomy

(2) Information Content

The information content is a list of all the necessary properties, which can be grouped to facilitate the management of non-geometric information.

Example 1: The non-geometric information of an object in the initial design can specify the information content, including the existence of only the object identified as the outer wall, the type name, classification, and the property indicating whether it supports a load.

Example 2: The alphanumeric information of an object at the final handover for operational purposes can specify the presence of all objects identified as requiring maintenance, including detailed information such as product, manufacturer, and warranty information.

4.5.4 Document

Documents associated with an object—or a set of objects—serve to support processes, decisions, approvals, and the verification of information deliverables, and are therefore specified as required documents. This approach means that certain specifications, such as those for items like doorknobs, are not handled entirely within the model but are instead recorded in external documentation. These documents may include reports (e.g., calculations, geotechnical reports), specifications, manuals, test certificates, photographs, and even hand-drawn sketches. They may relate to construction elements, spaces, construction entities, and more. Documents must reference the information model using defined classification and identification methods, enabling direct linkage to geometrical and alphanumeric information and ensuring interoperability and machine interpretability.

4.5.5 Ongoing Developments and Related Concepts for LOIN (ISO 7817)

As of 2025, LOIN has established its fundamental concepts and principles as ISO 7817-1. Detailed application methods are being developed primarily by buildingSMART. The following outlines the international standards currently under development.

(1) ISO 7817-2 Guidance for application

ISO 7817-2 is a technical specification that provides practical guidance on applying the information requirements (LOIN) defined in ISO 7817-1 (Concepts and principles) within projects and programs. The planned content includes:

- Specify the LOIN application process:
Clarify how to handle the prerequisites and concepts outlined in ISO 7817-1 in practical use. Include details regarding geometrical information, alphanumeric information (non-geometrical information), and document specifications.
- Provide a practical format:
Includes plain-language explanations, decision trees, examples from both building and infrastructure sectors, and examples of LOIN expressed in template formats (tabular and spreadsheet formats).
- Classification System, Software, and Data Format Independent Design:
Provides a structural approach that enables consistent LOIN configuration in the international market, independent of classification-system-agnostic, software-agnostic, and data-format-agnostic (such as IFC formats).
- Design Leading to Future “Part 3 (Machine-Readable LOIN)”:
The structured approach defined in this Part 2 forms the foundation for developing Part 3 (the machine-readable schema for LOIN).
- Enhanced Verification and Validation Capabilities:
Extends the concepts presented in Part 1 to organize methods to verify whether information deliverables (models, documents, etc.) conform to information requirements (LOIN). However, verification of compliance with design requirements, building codes, regulations, or building programs is outside the scope.

- Relationship and Alignment with ISO 19650:
LOIN is linked to the detailed requirements for Exchange Information Requirements (EIR) and BIM Execution Plans (BEP) as defined by ISO 19650. This section explains how LOIN relates to ISO 29481 (IDM) and ISO 16739-1 (IFC).

(2) ISO 7817-3 Data Model and Schema

ISO 7817-3 defines the official UML data model and XSD exchange schema required for software-based handling of LOIN. It is aligned with the data template principles of ISO 23387 and translates the concepts and guidance defined in ISO 7817-1 and ISO 7817-2 into fully machine-readable structures. It also incorporates Linked Data principles—such as unique identifiers and semantic relationships—and ensures interoperability with ISO 12006-3 (data dictionary) and IFC (ISO 16739-1).

This creates the foundation for internationally consistent digital management of information requirements, integrated with EIR, BEP, and IDM workflows.

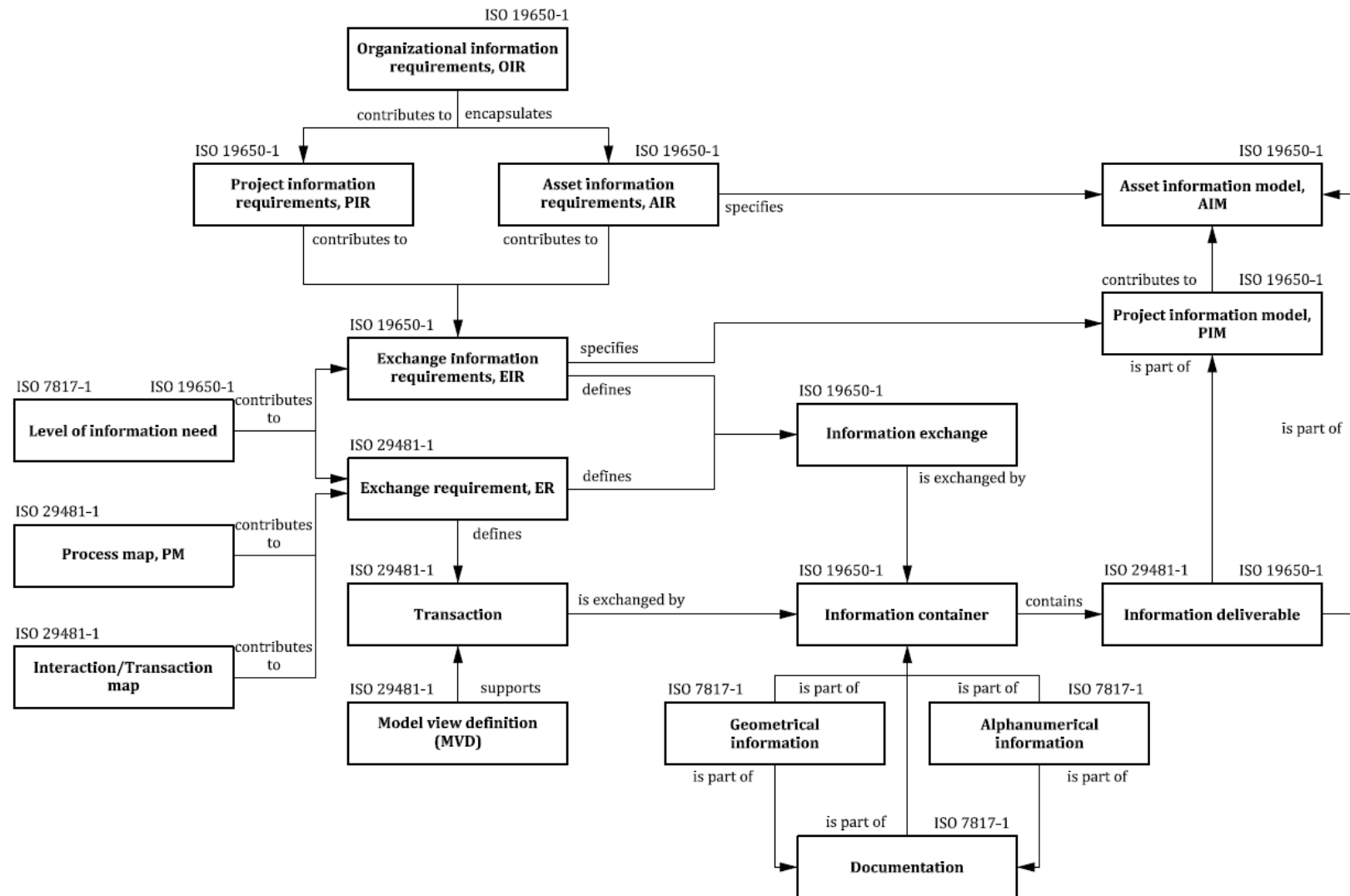
ISO 7817-3 is a technical specification that defines the official data model (UML) and exchange schema (XSD) for handling LOINs in software. Its content conforms to the data template principles of ISO 23387, translating the concepts and guidelines outlined in ISO 7817-1 and 2 into a machine-readable format. Furthermore, it incorporates Linked Data principles and ensures interoperability with the data dictionary defined in ISO 12006-3 and the IFC (ISO 16739-1). This provides a foundation for achieving internationally consistent digital management of information requirements, while linking with EIR/BEP/IDM, etc.

The relationship between ISO 7817-3 and other standards, along with a conceptual diagram of related standards such as ISO 7817-1, ISO 19650, and ISO 29481, is shown.

Table 4-18 Relationship Between ISO 7817-3 and Other Standards

Standard	Role	Relation with ISO 7817-3
ISO 7817-1	Concept and principles of LOIN	Data modeling the Approach from Part 1
ISO 7817-2	Application guide for LOIN	Converts the process in Part 2 into a machine-readable format
ISO 23387	Data template structure	Structuring of alphanumerical information (non-geometric information) (mandatory for XSD/UML in 7817-3)
ISO 12006-3	Data dictionary	Foundation for vocabulary, concept, and ID management
ISO 16739-1 (IFC/MVD)	BIM data exchange format	When mapping LOIN requirements to an IFC model, MVD serves as the implementation mapping specification (consistent with 7817-3).
ISO 29481 (IDM)	Process of data transfer	Integration with EIR/BEP Information Requests

Source: the JICA Study Team



Source: ISO 7817-1

Figure 4-29 Concept of Relationship Between ISO 19650-1, ISO 29481-1, and ISO 7817-1

4.6 Common Data Environment (CDE)

4.6.1 CDE Functions Required by ISO 19650

Under ISO 19650-2, the CDE must support several key functions during the design and construction phases. These include:

- Version control
- Centralized information management
- Access rights and permissions management
- Workflow and approval management
- Audit trail / traceability
- Provision of a collaborative working environment
- Improved information visibility and searchability

Together, these capabilities enable the CDE to serve as the project’s “single source of truth” during design and construction.

In contrast, a CDE used during the operations and maintenance phase must function as a single source of truth in coordination with the organization’s FM systems and other enterprise platforms. This ensures that asset information remains consistent across all systems, avoiding discrepancies between datasets. Because of these differing requirements, the functions needed for O&M are not identical to those required during design and construction. As discussed later, the literature commonly notes that no single CDE platform currently available on the market can support all project phases—design, construction, and operations—in a fully integrated and seamless manner.

This section summarizes the current state of CDE solutions available on the market, based on published references, to support informed decision-making when implementing the ISO 19650 framework.

4.6.2 CDE in the Design and Construction Stages

In the current Architecture, Engineering, and Construction (AEC) market, a large number of CDE solutions are available, including platforms that aim to comply with ISO 19650 requirements. When including general-purpose shared data environments that are not specifically tailored for AEC workflows, the number becomes even greater.

However, comprehensive cross-platform evaluations comparing these systems are extremely limited. Likewise, only a small number of design and construction organizations—or individual practitioners—have direct experience working with multiple CDE platforms, making broad, evidence-based comparisons difficult.

In this context, NBS conducted a survey³⁹ targeting professionals in the UK and internationally, gathering information on BIM usage—including the CDE platforms they employ. Building on this, an EU-funded study⁴⁰, based on this survey, carried out interviews with experts across Europe who have practical experience using CDEs, particularly in the UK market.

Drawing on these publications, together with the survey team’s own experience, the following section outlines the current state of CDE utilization in the design and construction stages.

(1) NBS Survey on CDE Usage³⁹

To understand BIM adoption trends, NBS conducted a large-scale survey that included organizations of various sizes—from micro-firms to large enterprises—and participants from multiple roles, such as clients,

³⁹ 10th Annual BIM Report 2020, NBS

⁴⁰ K.Jaskula, E. Papadonikolaki, D. Rovas, Comparison of Current Common Data Environment Tools in the Construction Industry, 2023 European Conference on Computing in Construction 40th International CIB W78 Conference

designers, contractors, engineers, BIM managers, and others. Although the respondents were predominantly based in the UK, approximately 25% of responses were received from outside the UK.

The survey specifically included several questions on CDE utilization. The findings relevant to CDE use are summarized in Table 4-19 and Table 4-20. By addressing fundamental questions about CDE usage, the survey analyzed both adoption rates and overall patterns of use.

Table 4-19 NBS Online Survey Items (CDE-Related Extract)

Item	Survey Content
Survey period	Dec 2019 – Mar 2020
Survey method	Online questionnaire
Target regions	Mainly UK, with approx. 25% responses from outside the UK
Respondent roles	Predominantly design professionals (27% architects), engineers, architectural technologists, BIM managers; others include contractors, project managers, cost consultants, manufacturers, surveyors, clients, etc.
Organization size	Ranging from micro-firms (1–2 people) to large enterprises with more than 500 staff
Number of respondents	1,061 construction professionals
Main CDE-related questions	- “Do you use a CDE on all projects?” - “Do you use a CDE on most projects?” - “Do you use a CDE on only some projects?” - “Do you not use a CDE at all?” - “Which CDE platform(s) do you use?” (multiple responses allowed) - “Do you manage information in accordance with BS EN ISO 19650 or PAS 1192?” - “Do you use naming conventions or classification systems (e.g., Uniclass2015)?”

Source: Prepared by the JICA Study Team based on Reference 39

Table 4-20 NBS Online Survey Results (CDE-Related Extract)

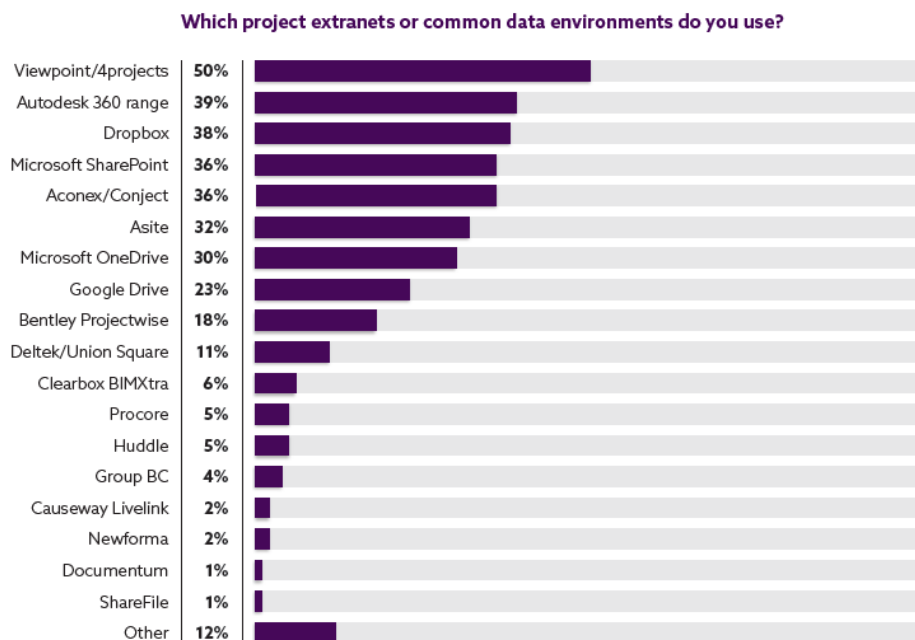
Item	Response Rate (%)
CDE usage (all respondents, including non-BIM users)	
Use on all projects	21%
Use on most projects	23%
Do not use at all	28%
Other (not listed; assumed “use on some projects” or no answer)	28%
Respondents using BIM	73%
Among BIM users:	
Use a CDE on BIM projects	67%
Share information using naming conventions	68%
Exchange information in IFC format	62%
Specify the purpose of information (e.g., for review, for construction)	61%
Use revision codes to indicate changes	46%
Classify information using Uniclass2015	38%
Exchange information in COBie format	33%
Produce a BIM Execution Plan (BEP)	67%
Define Information Standards	58%
Define Exchange Information Requirements (EIR)	56%
Define Information Production Methods and Procedures	54%
Use Information Protocols	46%
Prepare a Responsibility Matrix (e.g., RACI)	42%
Prepare a TIDP (Task Information Delivery Plan)	38%
Prepare a MIDP (Master Information Delivery Plan)	32%

Source: Prepared by the JICA Study Team based on Reference 34

The findings indicate that CDE adoption is notably higher in large organizations and on large-scale projects. This trend reflects the critical need for reliable and coordinated information management in contexts involving complex datasets and diverse stakeholders—conditions under which a CDE becomes essential as

the project's "single source of truth."

Figure 4-30 shows the usage rates of different CDE platforms. The tools in use range from basic file-sharing systems, which do not fully comply with ISO 19650-2, clause 5.1.7 requirements (e.g., information container records, approval workflows, access controls) to highly sophisticated platforms with complex workflows and the capacity to scale to large user bases. This suggests that CDE usage varies depending on project requirements, complexity, and organizational maturity.



Source: Reference 39

Figure 4-30 NBS Survey Results on the Usage of Different CDE Platforms

(2) Literature Review: Expert Interviews on CDE40

This publication presents a comparative study of CDE tools conducted at University College London with EU funding, following up to the NBS BIM survey. The study examined CDE solutions currently used in industry and the issues associated with them. Data was collected through web searches, review of existing literature, and interviews with industry experts.

Twelve CDE tools were identified, and their strengths and weaknesses were compared. The study concluded that no single CDE performs exceptionally well across all requirements even during the design and construction phases. Furthermore, no tool on the market can provide all the functions needed throughout the entire project lifecycle. As a result, multiple CDEs are typically required to manage different aspects of project information.

1) CDE Maturity Assessment

The authors identify key functional expectations for CDEs and propose a maturity assessment matrix, focusing on two main aspects:

- **CDE Solution:** Functional capabilities, including cloud or on-premises information storage, document management, transmittals, issue tracking, access control, and BIM-integrated collaboration.
- **CDE Workflow:** Processes for managing information states across the information lifecycle (work in progress, shared, published, archived).

Table 4-21 CDE Maturity Indicators

Evaluation	Level 1	Level 2	Level 3
Document Management	Basic storage and sharing	Workflow control, version management	Immutability, approval, and review functions
BIM Integration	Storage of BIM files only	IFC/BCF support, viewing/markup	Real-time multidisciplinary collaboration
Security	Unstructured file server	Structured file server	Object-level access control, data ownership protection
Lifecycle Coverage	None	Covers PIM or AIM only	Covers both PIM and AIM

Source: Prepared by the JICA Study Team based on Reference 40

2) Main Experts Interviewed for the CDE Evaluation

The study conducted interviews with construction-industry experts, supplemented by analyses of online comparison platforms and review of NBS documentation. For CDEs that certain experts had not personally used, additional interviews were carried out to ensure comprehensive evaluation.

Table 4-22 Key Interviewees for CDE Maturity Assessment

No.	Role	Specialism	Years of Experience	Country	BIM Competency	CDE Tools Used
1	Consultant	Standards, regulation, BIM implementation	20+	UK	Expert	-
2	BIM Manager / Researcher	Project management, research	15+	UK	Expert	BIM 360, Aconex, SharePoint
3	BIM Manager	Project management, architectural practice	5+	UK	Expert	BIM 360, Aconex
4	Consultant	MEP, HVAC design	15+	Sweden	Very good	-
5	Blockchain Developer / Researcher	Blockchain application development	<5	UK	N/A	-
6	Consultant / Researcher	IT implementation in construction	30+	Denmark	Very good	-
7	Consultant	Smart buildings, sustainable construction, general contracting	30+	Sweden	Very good	-
8	BIM Manager	Project management, main contractor	20+	Ireland	Expert	Autodesk Glue, Viewpoint
9	Construction Manager	Digital/Design management	10+	Ireland	Expert	BIM 360, Autodesk Glue, Viewpoint
10	Consultant / Researcher	IT implementation in construction	20+	Sweden/Denmark	Very good	-
11	BIM Manager	Project management, architectural practice	5+	UK	Expert	BIM 360, Aconex
12	Consultant / Researcher	Asset management (infrastructure owner perspective)	10+	Estonia	Very good	-
13	Facilities Manager	Public-sector asset management	5+	Ireland	Expert	Autodesk Glue, Cylon
14	Department Head	Digital construction in project management, general contracting	15+	Sweden	Expert	-
15	Development Director	Facilities management	20+			BIM 360 Ops, CAFM

Source: Prepared by the JICA Study Team based on Reference 40

3) Maturity Evaluation of Key CDEs in the Market

Table 4-23 summarizes the CDE maturity evaluation conducted in the study. In addition, four major CDE platforms with significant adoption in Japan—BIM 360/ACC, Aconex, ProjectWise, and Viewpoint for Projects—are described in Table 4-24, combining published findings with the survey team's practical experience. The assessment confirms that no existing product can serve as a fully integrated, lifecycle-wide CDE suitable for O&M. This limitation stems from the substantial differences in functional requirements between the design/construction stages and asset operation, making full integration difficult. Even within the design and construction stages, each CDE exhibits particular strengths and weaknesses. For large or complex projects, it is common to deploy multiple CDEs in parallel, depending on the type of information and project workflow. Therefore, selecting and configuring a CDE must be done in alignment with project scale, technical needs, and intended usage.

Table 4-23 CDE Maturity Evaluation (from Reference 40)

Tool Name	Vendor	Monthly Cost (GBP)	NBS Usage (%)	Document Management	BIM Integration	Security	Lifecycle Functions	Remarks
BIM360/ Autodesk Connected Cloud	Autodesk	£48-£155	39%	Level2	Level3	Level3	Level2	See Table 4-24
Viewpoint 4 project	Trimble	£15-£50	50%	Level3	Level2	Level3	Level2	See Table 4-24
Aconex	Oracle	£53-£87	36%	Level3	Level2	Level3	Level2	See Table 4-24
Asite	Asite Solutions	Min. £375	32%	Level3	Level2	Level3	Level2	Widely used in UK
ProjectWise	Bentley	£49-145	18%	Level3	Level2	Level3	Level2	See Table 4-24
Deltek/Union Square		n.a.	11%	Level3	Level2	Level3	Level2	
Procore	Procore Technology	Min. \$375 USD	5%	Level3	Level2	Level3	Level2	Popular in US construction
BIMcollab	KUBUS BV	£5-£14	n.a.	Level2	Level3	Level3	Level2	IFC/BCF-focused collaboration
Dropbox		£14-£40	38%	Level1	Level1	Level1	Level1	Low cost; insufficient for ISO 19650 except small projects
SharePoint	Microsoft	£4.10-£22	36%	Level1	Level1	Level1	Level1	
Google Drive	Google	£5-	23%	Level1	Level1	Level1	Level1	
One Drive	Microsoft	£8.20-£36	30%	Level1	Level1	Level1	Level1	

Source: Prepared by the JICA Study Team based on Reference 40

Table 4-24 Key Features of Major CDE Solutions

CDE	Vendor	Key Functions and Characteristics
BIM 360 / ACC	Autodesk	Strong BIM integration; synchronizes with Revit and Navisworks. Includes clash detection, design coordination, and RFI management. Document management is less sophisticated; compliance codes often require manual input. BIM 360 Ops exists but is limited as an FM-ready solution.
Viewpoint for Projects	Trimble	Strong document management with robust approval/sign-off workflows. Limited BIM integration; commonly used alongside BIM 360. Trimble Connect and Quadri now available as complementary CDE options. Trimble Unity ALM available for GIS-based public-infrastructure asset management.
Aconex	Oracle	Strong version control and metadata immutability. Supports classification and tracking of compliance status. Reliant on clear file naming; poor naming reduces searchability. Highly capable for construction-phase correspondence. Limited integration with FM systems.
ProjectWise	Bentley	Integration with Microsoft 365; automated design-review workflows. Powerful document control, data sharing, and versioning. Highly customizable but requires significant admin effort and training. Less seamless than BIM 360 for Autodesk-focused BIM workflows. AssetWise ALIM is available as an O&M-oriented CDE.

Source: Prepared by the JICA Study Team based on Reference 40

4) Summary of CDEs Used in Design and Construction

CDE tools currently available for the design and construction stages each provide only partial support for the functional requirements defined in ISO 19650. However, no single platform is capable of acting as a “single source of truth” across the entire asset lifecycle, including the O&M phase. This limitation arises because the functions required during design and construction differ significantly from those needed during asset operation, making it difficult for any single tool to accommodate all lifecycle requirements in a fully integrated manner.

Consequently, real-world projects typically rely on multiple CDE platforms, selected according to project scale, complexity, and intended use. The transfer and integration of information into the O&M stage often require manual effort due to mismatches between systems and the absence of fully interoperable lifecycle-wide solutions. Looking ahead, a practical approach is likely to involve linking phase-specific tools via APIs and interoperability services, enabling data continuity without forcing a single platform to fulfill all lifecycle requirements.

(3) CDEs Certified Under the BSI Kitemark Scheme

The British Standards Institution (BSI), which manages UK Standards (BS), provides a range of third-party certification schemes that verify whether products, services, or organizations conform to specific standards. Among these schemes, the BSI Kitemark is widely recognized as a mark of trust, demonstrating that the claims made about a product or service have been independently and repeatedly tested and evaluated by experts.

In the field of BIM and information management, BSI offers certifications such as the Kitemark for BIM Design and Construction and the Kitemark for BIM Software, which are increasingly used to demonstrate reliability in the management, sharing, and operating information.

To obtain the BSI Kitemark for BIM Software, a product must satisfy the following requirements:

- User functionality within the software must comply with the process requirements defined in the ISO 19650 series.
- The organization must implement a security-focused approach to information security and risk management.
- User support and customer-satisfaction processes must operate in accordance with the frameworks defined in ISO 9001 and ISO 10004.

Meeting these requirements provides independent verification that the software complies with internationally recognized information-management standards, ensuring high levels of reliability, quality, and user satisfaction.

Several CDE products have obtained the BSI Kitemark, which are summarized in Table 4-25 for reference.

Table 4-25 CDEs Certified with the BSI Kitemark

Company	Country	Certificate Number	Product / Brand Name
Asite Solutions Ltd.	UK	KM 740457	Asite Common Data Environment
Autodesk, Inc.	US	KM 823075	Autodesk Construction Cloud
Llewellyn and Partners Co. Ltd.	Hong Kong	KM 744907	AutoBIM
Procore Technologies, Inc.	US	KM 817099	Procore Construction Management Software
Zutec Inc. (Ireland) Ltd.	Ireland	KM 741560	Zutec Cloud

Source: Prepared by the JICA Study Team based on Reference⁴¹

4.6.3 CDEs for the Operations and Maintenance Phase

As discussed in the evaluation of design- and construction-phase CDEs, no single CDE solution currently on the market can be used consistently across the entire asset lifecycle. Some platforms, however, are specifically positioned as CDEs for operations and maintenance (O&M).

In the UK, the government provides the G-Cloud Framework⁴², a digital marketplace established to simplify procurement of cloud-based services. Through this online catalogue, public-sector organizations can acquire products such as CDEs without conducting individual tenders or direct negotiation with vendors, as long as the services are listed and approved under G-Cloud.

Within this system, two CDE products are listed specifically for public-sector O&M use, as shown in Table 4-26.

⁴¹ [Product Directory Results - Validation, Verification | BSI](#)

⁴² <https://www.gov.uk/guidance/g-cloud-suppliers-guide->

Table 4-26 CDEs for Operations and Maintenance Listed on G-Cloud

Item	Glider BIM	Bentley AssetWise ALIM
Vendor	Glider Technology Ltd	Bentley Systems UK Ltd
Primary Focus	Buildings, facilities management, FM	Infrastructure, public assets, engineering
API Integration	APIs available (integration with CAFM, BEMS, IoT, etc.)	Integrates with ProjectWise and enterprise systems

Source: Prepared by the JICA Study Team

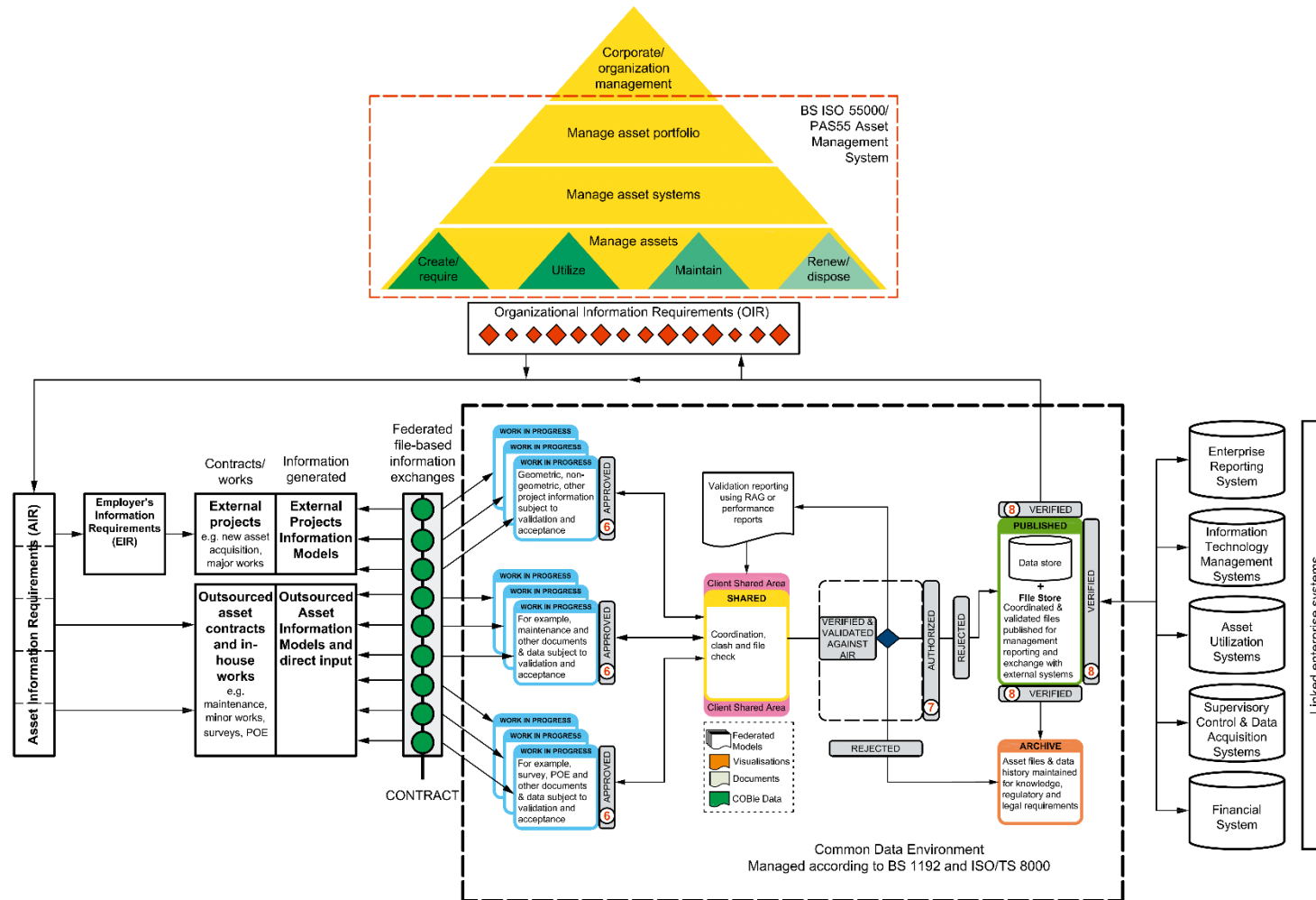
The study cited in Reference 40 notes that Glider BIM could only be evaluated on the basis of publicly available information, as detailed client-side documentation was not accessible. Consequently, the publication does not provide a full functional assessment. Similarly, although several vendors promote O&M-focused CDEs that can connect with design- and construction-phase CDEs, publicly available technical information is limited, making independent evaluation difficult. Therefore, a detailed investigation is required at the time of adoption, particularly for public-sector organizations.

A CDE used during the O&M stage must serve as a “single source of truth” across an organization’s enterprise systems (e.g., FM systems, CMMS, IoT platforms). This implies that:

- asset data must remain consistent between the CDE and all downstream systems; and
- the CDE must operate as a central data hub, supporting synchronization and eliminating discrepancies across platforms used for daily operations.

The conceptual relationship between an O&M-phase CDE and enterprise systems is presented in PAS 1192-3, the foundational framework that informed ISO 19650-3 (the international standard for information management during the operational phase).

An illustrative diagram is shown in Figure 4-31, where the dashed box represents the CDE and the systems linked on the right-hand side (e.g., CMMS) represent enterprise applications that integrate with the CDE.



Source: PAS 1192-3:2014

Figure 4-31 Illustration of the CDE and Enterprise-System Integration Concept as Presented in PAS 1192-3

4.7 Enterprise Systems (e.g., FM Systems)

Across corporate operations, a wide variety of enterprise software systems are deployed, each designed for different purposes and developed independently over time. As a result, enabling these systems to function in a coordinated or parallel manner is highly challenging.

To avoid inconsistencies in asset information across these systems, a CDE capable of operating as a “single source of truth” is required, as discussed in the previous section.

Enterprise systems range widely—from ERP systems used for finance and human-resource management, to CMMS and CAFM systems dedicated to facilities and asset management.

Because these systems continue to evolve and increasingly overlap in functionality, system names no longer reliably indicate their functional scope.

For reference, Table 4-27 and Table 4-28 provide an overview of enterprise systems and the functions typically associated with each. These categories reflect the types of systems that may be used to manage buildings, equipment, infrastructure, and organizational assets in ODA loan projects.

Table 4-27 Functional Comparison of Enterprise Systems

Functional Area	IWMS	EAM	CMMS	CAFM	ERP	CREM	SCADA BAS BMS	BEMS
1. Facility and Space Data								
Facility information (name, location, area, floors, etc.)	✓	✓	✓	✓		(✓)		
Floor plans / BIM-based spatial data	✓	(✓)	(✓)	✓				
Space usage and occupancy (e.g., meeting rooms)	✓			✓				
2. Equipment and Asset Data								
Equipment specifications, locations, operational status	✓	✓	✓				✓	
Asset registers	✓	✓	✓		✓			
Maintenance history and schedules	✓	✓	✓				(✓)	
3. Workforce and User Data								
Staff allocation, desk booking	✓			✓	(✓)			
Facility use / access control	✓						(✓)	
4. Real Estate Data								
Lease management	✓				(✓)	✓		
Property valuation, transactions, operating cost	✓				(✓)	✓		
5. Finance, Procurement and HR								
Financial indicators, procurement, HR information	(✓)				✓			
6. Operational Monitoring								
Energy consumption	✓			✓			✓	✓
Environmental performance (e.g., green building KPIs)	✓	✓		✓			✓	✓
7. Project Management								
Budget and schedule management	✓				(✓)			
Document management (contracts, drawings, reports)	✓			(✓)	(✓)			
Note: (✓) indicates partial support or available in some products)								

Note: (✓) indicates partial support for some products or features

Source: Prepared by the JICA Study Team based on Reference 43

Table 4-28 Overview of Enterprise Systems

System	Main Roles and Scope of Application	Key Features	Related Materials and Examples
Integrated Workplace Management System (IWMS)	Overall facility management, integrated management of assets, space, energy, maintenance, and real estate, and improvement of employee productivity	Property management, lease management, space management, workspace booking, flexible work support, maintenance management, energy management, sensor data integration	IBM TRIRIGA (needs to be combined with Maximo), Archibus (USA), Planon (Netherlands), MainManager (Iceland), etc., has integrated CAFM and EAM with CMMS functions
Computer-Aided Facility Management (CAFM)	Management of buildings, spaces, and facilities (relatively emphasis on drawing and ledger linkage, visually digitized)	Derived from CAD, drawing-based space management (frequency of use, occupancy, work progress, etc.), facility management, relocation management	AutoCAD-linked CAFM, IBM Maximo (there are examples including CMMS functions)
Enterprise Resource Planning (ERP)	Integrated management of corporate resources such as finance, purchasing, asset management, and human resources	Integrated management of assets and maintenance costs, not exclusive to FM, and integration of EAM, CREM, and ERP (accounting and purchasing) to enable integrated asset management and finance	SAP, Oracle ERP
Enterprise Asset Management (EAM)	Optimal management of corporate assets (equipment, infrastructure, vehicles, IT assets, etc.) at the company-wide level	Strategically manage the entire CMMS high-level concept and lifecycle. Maximo, SAP EAM, etc.	Concepts that encompass CMMS such as IBM Maximo and SAP EAM and integrate financial, risk, and lifecycle optimization (including strategic asset management, renewal, and disposal planning)
Computerized Maintenance Management System (CMMS)	Planned management of equipment, maintenance, support for work execution	Work orders and preventive maintenance, asset ledger, spare parts management, cost management	IBM Maximo , Infor EAM, etc.
Corporate Real Estate Management (CREM)	Real estate asset portfolio management, investment strategy, lease management	Specializing in the strategic management of real estate (portfolio management, resource optimization, asset profitability assessment, etc.)	Many of them are now built into IWMS.
Supervisory Control and Data Acquisition (SCADA)	Industrial version of BAS for monitoring and control, especially in public infrastructure	Central monitoring, automatic control of equipment, anomaly detection and alarms, SCADA specializes in controlling industrial equipment and works with BAS	For use in large-scale installations and public infrastructure (similar to BAS), Real-time data management , GE SCADA, Schneider SCADA
Building Automation/Management System (BAS/BMS)	Control and monitoring of building equipment (air conditioning, electricity, disaster prevention, etc.)	Central monitoring, automatic control of equipment, anomaly detection and alarm	Honeywell, Johnson Controls Metasys, Azbil Real-time data management
Building Energy Management System (BEMS)	Monitoring and optimizing energy use	Energy data measurement and analysis, peak cutting, and CO ₂ emissions management	Domestic: NEC BEMS, Fujitsu BEMS, Overseas: Siemens Desigo CC, Real-time data management
IoT Platform	Real-time collection and analysis of sensor and equipment data	Linked with BAS, BEMS, and CMMS/EAM to provide data for predictive maintenance and asset performance analysis	Azure IoT, IBM Watson IoT

Source: Prepared by the JICA Study Team

4.8 GIS

4.8.1 Background and Significance of GIS

A Geographic Information System (GIS) is a technology for integrating and analyzing geospatial data to support location-based decision-making. GIS manages large-scale information such as topography, land use, transport networks, and environmental conditions, and playing a vital role in urban planning and infrastructure development. In recent years, GIS has increasingly incorporated real-time data from IoT devices and sensors, enabling applications in operational management and disaster response. This allows cities and infrastructure operators to monitor changing conditions dynamically and make timely, informed decisions. For infrastructure projects, BIM and GIS provide valuable but distinct types of information. BIM delivers highly detailed 3D models for design, construction, and asset management, with rich attribute information for buildings and structures. GIS integrates spatial information related to urban planning, transport, terrain, and environmental conditions, supporting decision-making from a broader geographic perspective.

In large-scale infrastructure such as railways and airports, it is essential to consider detailed structural information and geographical context simultaneously. BIM alone cannot fully account for geographic constraints or surrounding conditions, while GIS alone cannot provide the detailed structural information required for engineering and maintenance. When BIM and GIS are applied in isolation, discontinuities in information commonly arise—particularly in site selection during the planning stage, access and logistics planning during construction, and asset management in maintenance and operation. These information gaps can lead to design delays, cost increases, and inefficiencies in long-term maintenance.

To address these issues, BIM and GIS must be used in an integrated manner, enabling consistent use of information from planning through operations. By combining wide-area geospatial information with detailed structural data, integrated BIM–GIS workflows support more rational planning, efficient construction, and effective long-term asset management.

Although BIM and GIS originate from different technical domains, their integration creates value that neither can deliver independently. Moreover, this integration serves as a core enabling technology for digital twins and smart city initiatives and is becoming indispensable for future infrastructure development.

Table 4-29 Characteristics of BIM and GIS

Indicator	BIM	GIS
Scope	Detailed representation of buildings and structures	Regions, cities, and large-area environments
Coordinate System	Local/model-based coordinates	Geographic coordinates (latitude/longitude)
Data Structure	Object-oriented formats such as IFC	Raster and vector data
Information Types	Materials, dimensions, equipment, construction data	Terrain, land use, transport, population, hazard data
Primary Uses	Design, construction, asset maintenance	Urban planning, asset management, disaster response
Representation	High-precision 3D models	Map-based 2D/3D visualization (overview perspective)
Analysis Functions	Clash detection, quantity take-off, scheduling	Spatial analysis (distance, range, routing, risk assessment)
Standards	IFC, COBie	CityGML, GeoJSON
Strengths	Detailed design, construction, and maintenance	Large-scale planning, spatial analysis, operations, disaster response

Source: Prepared by the JICA Study Team

4.8.2 International Trends and Standardization

The integration of BIM and GIS is being supported by the development of international standards. Because

BIM and GIS originate from different technical domains—with differing data structures, coordinate systems, and intended uses—interoperability frameworks are essential. To address these challenges, organizations such as ISO and buildingSMART International have advanced various standardization initiatives⁴⁴.

While full, practical BIM–GIS integration remains limited in real-world projects, international efforts can broadly be categorized into two directions

(1) Information-Management Standards Supporting Advanced BIM–GIS Use

To leverage BIM and GIS effectively across the entire lifecycle, a consistent information-management framework is required. The CDE defined in ISO 19650 provides a common environment where spatial information and design information can be shared across design, construction, and operations.

On the BIM side, IFC serves as the open standard for representing detailed asset attributes, forming the foundation for GIS integrations such as location alignment or terrain-based extraction⁴⁵.

On the GIS side, CityGML allows urban-scale spatial information to be modelled at multiple Levels of Detail (LODs). When combined with BIM, it enables both broad spatial analysis and detailed design coordination.⁴⁶

CityGML is notable for supporting:

- 3D geometry
- Semantic information
- Attribute information
- Structured hierarchical relationships

It covers urban elements such as buildings, terrain, transport facilities, vegetation, and water bodies, and allows LOD selection depending on the analytical or operational purpose.⁴⁷

Notably, as discussed later, caution is required as the definitions of LOIN/LOD in BIM and LOD in GIS differ.

Table 4-30 Structure of Semantic and Attribute Information in CityGML

Category	Semantic Information	Attribute Information
Attribute Information	Types of urban objects (buildings, terrain, roads, vegetation, water bodies, bridges, tunnels, etc.)	IDs, names, external references
Hierarchical structure	Building → rooms → components (walls, floors, roofs, windows, doors)	Room numbers, component IDs
Semantic attributes	Class, function, usage	Zoning information, regulatory constraints
Geometric information	Geometry, LOD (0–4)	Coordinates, area, volume, height
Appearance	Meaning and role of textures/materials	Texture files, colors, reflectance
Relationships	Connections and aggregations (e.g., road networks)	Related IDs, parcel numbers, addresses

Source: Prepared by the JICA Study Team

During the operations and maintenance phase, the COBie standardizes asset information exchange, supporting GIS-enabled facility management and renewal planning.⁴⁸ Together, these standards form an integrated framework for leveraging information at different spatial scales and across the entire asset

⁴⁴ <https://www.esri.com/content/dam/esrisites/en-us/media/ebooks/gis-bim-integration-report.pdf>

⁴⁵ [Industry Foundation Classes \(IFC\) - buildingSMART International](#)

⁴⁶ [CityGML Standard | OGC Publications](#)

⁴⁷ [OGC City Geography Markup Language \(CityGML\) Part 1: Conceptual Model Standard](#)

⁴⁸ [Construction to Operations Building Information Exchange \(COBie\) V3 – National Institute of Building Sciences](#)

lifecycle.

(2) Standardization Aimed at BIM-GIS Integration

Key international initiatives promoting integration include ISO 19166 and ongoing research and development by buildingSMART International.

ISO 19166 defines a conceptual reference model that enables BIM information to be used within GIS environments.⁴⁹ The standard focuses primarily on one-way integration from BIM to GIS, reflecting the need to incorporate detailed BIM models into broader geospatial contexts.

ISO 19166 defines three conceptual mechanisms:

- Perspective Definition: specifying which information is to be extracted (view definition).
- Element Mapping: linking BIM elements to corresponding GIS elements.
- LOD Mapping: converting BIM levels of detail to GIS LODs.

However, ISO 19166 does not define coordinate-transformation or attribute-mapping details. These are supplemented by other ISO standards and buildingSMART guidelines.

Table 4-31 Standards and Guidelines Complementing ISO 19166

Standard	Purpose and Role
ISO 19111	Defines coordinate reference systems (CRS), geodetic datums, and transformation models. Enables accurate geolocation of BIM models within GIS. Essential for spatial alignment and data reuse.
ISO 19109	Specifies general principles for application-schema design using UML and the General Feature Model (GFM). Forms the design rules for GIS data models (e.g., CityGML), providing a structured framework for receiving BIM information.
Information Delivery Manual ⁵⁰ , ISO 29481	Defines process models and Exchange Requirements (ER) for BIM. Supports BIM–GIS integration by identifying required information and exchange points. A key complement for defining GIS-side information requirements derived from BIM.

Source: Prepared by the JICA Study Team

buildingSMART is advancing several initiatives related to GIS integration, including:

- Enhancements to IFC to support georeferencing directly.
- Development of APIs for data exchange with GIS.⁵¹
- Promotion BIM–GIS interoperability through their shared BIM-GIS Integration Strategic Roadmap⁵². (buildingSMART and OGC jointly).

⁴⁹ ISO/TS 19166:2021- Geographic Information BIM to GIS Conceptual Mapping (B2GM)

⁵⁰ [What is an Information Delivery Manual \(IDM\) ? | NBS](#)

⁵¹ [Annual Report bSI 2023 v4.pdf](#)

⁵² [bSI-OGC-BIM-GIS-Strategic-Roadmap_Industry_Insight_bSI_v2.pdf](#)

Table 4-32 Overview of the buildingSMART × OGC “BIM–GIS Integration Strategic Roadmap”

Background and Purpose	Although BIM and GIS have traditionally evolved as separate domains, their integration has become essential for urban planning, transport, environmental assessment, digital twins, and related fields. The roadmap aims to advance sustainable development, lifecycle management, and smart cities through strengthened information interoperability based on open standards.
Strategic Pillars	Address high-value use cases (environmental assessment, transport planning, urban models) Provide standardized toolkits (data models, APIs, metadata) Demonstrate the benefits of adopting open standards Foster collaboration between BIM and GIS communities Train next-generation data practitioners in standards-based information modelling
Working Group Activities	G1 (Use-case definition): Identify and organize priority use cases such as environmental assessment, transport planning, and digital twins. G2 (Standards WG coordination): Integrate buildingSMART and OGC working groups to establish the joint Geo+BIM WG. G3 (Toolkit development): Develop data-standard toolkits using IFC, CityGML, LOD frameworks, and metadata standards. G4 (Vendor collaboration): Embed toolkits into existing software and provide APIs and validation tools. G5 (Training and dissemination): Promote adoption of standardized tools and develop educational programs.
Application Domains	Infrastructure (roads, railways, airports); urban planning (digital twins, environmental simulation); buildings (design, construction, maintenance); sustainability (energy efficiency, disaster resilience).
Implementation Plan	A 3–4-year agile process: prioritizing use cases → toolkit development → pilot implementation → iterative refinement. Standardization activities and software implementation progress in parallel.

Source: Prepared by the JICA Study Team

Although these international initiatives do not yet provide full technical integration, detailed specifications continue to evolve. By supporting the advanced use of BIM and GIS today and establishing a foundation for future interoperability, these efforts enable data exchange across different tools and platforms and facilitate consistent information utilization from planning through to O&M.

4.8.3 Use of BIM and GIS

Because BIM and GIS play different roles across the lifecycle of an infrastructure project, using them in combination enhances decision-making accuracy and efficiency from planning through O&M. This section summarizes their benefits at each project phase and identifies the technical challenges that must be addressed to achieve deeper integration.

(1) Use and Benefits by Project Phase

Planning

BIM enables spatial studies and design-condition simulations using 3D models of structures, while GIS provides wide-area information such as topography, land use, transport networks, and environmental conditions.

When used together, planning proposals can be evaluated against geographical constraints, leading to optimized infrastructure siting. For large assets such as railways or airports, GIS allows early understanding of geological conditions and clashes with existing infrastructure, thereby improving decision accuracy.

Design

BIM supports detailed design, clash detection, and quantity take-off, whereas GIS analyses connectivity with surrounding infrastructure and the distribution of public facilities.

Their combined use enables design models to be validated at the urban scale and ensures alignment with wider planning policies. This integration reduces design-change risks and supports effective cost management across the project.

Construction

BIM supports construction-sequence simulations and material-delivery planning. GIS manages site-access routes and traffic-management information.

By using both systems, construction planning can account for geographic constraints, reducing risks such as congestion and environmental impact. In urban areas, GIS can predict traffic effects, while BIM adjusts the construction schedule, improving both efficiency and safety.

Operations & Maintenance

BIM manages information related to equipment, asset histories, and renewal planning, while GIS manages the spatial locations of assets and supports the analysis of hazard impact areas.

Their combined use enables asset management to incorporate geographic context, strengthening disaster response and long-term planning. This leads to reduced lifecycle costs and more accurate preventive maintenance.

Table 4-33 Example of BIM–GIS Use by Lifecycle Phase

Phase	Use of BIM	Use of GIS	Integrated Benefit
Planning	Spatial studies using 3D models	Topography, transport networks, environmental data	Siting optimization incorporating geographic constraints
Design	Detailed design, clash detection	Analysis of connectivity with surrounding infrastructure	Urban-scale design validation and consistency
Construction	Construction sequencing, material planning	Access routes, traffic-restriction data	Construction plans aligned with geographic conditions; risk reduction
O&M	Asset management, renewal planning	Asset location data, hazard-impact analysis	Enhanced disaster response, improved long-term planning

Source: Prepared by the JICA Study Team

(2) Technical Challenges

• Differences in Coordinate Systems:

BIM generally uses a local, model-based coordinate system focused on precision, whereas GIS uses geographic coordinate systems designed for wide-area spatial data. Standardized coordinate-transformation rules are required to reconcile these differences. At present, many projects rely on custom scripts or intermediate formats, and the lack of standardization remains a significant challenge.

• LOD Alignment:

BIM and GIS adopt different concepts of Level of Detail (LOD). In BIM, LOD refers to the maturity and reliability of model information according to design, construction, and asset-management needs, whereas in GIS, LOD (0-4) denotes increasing levels of geometric and semantic detail for urban-scale modelling. Clarifying the correspondence between these two definitions is essential. Efforts to formalize LOD mappings are currently underway through ISO 19166 and guidelines developed by buildingSMART.

Table 4-34 Comparison of LOD Concepts

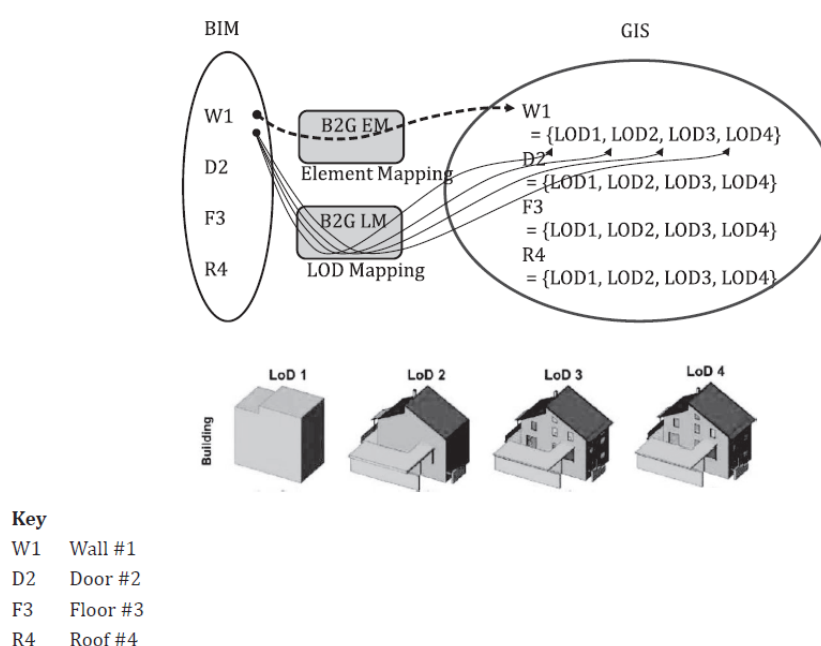
Perspective	BIM	GIS
Meaning of LOD	Indicates model maturity and information reliability. Defines the required detail and attribute completeness for each lifecycle phase.	Indicates the geometric and semantic resolution required at urban scale, defining levels of simplification.
Basis	Information completeness and attribute richness (LOD100–LOD500).	Geometric detail and spatial hierarchy (LOD0–LOD4).
Target Representation	Detailed modeling down to component level (walls, slabs, beams, MEP equipment), performance, cost, including attributes such as materials.	Hierarchical modelling of urban features (buildings, roads, terrain, vegetation, water bodies), with semantic information such as use and zoning.

LOD Examples	LOD100: Concept LOD200: Schematic LOD300: Detailed design LOD400: Fabrication/Construction LOD500: As-built/Operations	LOD0: Terrain + building footprints LOD1: Block model LOD2: Roof shapes and external detail LOD3: Openings and façade detail LOD4: Interior rooms and furniture
Purpose	Managing information reliability across the project lifecycle.	Simplifying geometry and structuring semantics for urban-scale analysis.

Source: Prepared by the JICA Study Team

Attribute-Information Mapping:

BIM models detailed detailed physical and performance attributes, such as materials and dimensions, while GIS datasets include planning-related attributes such as land use, ownership, and zoning. Establishing standardized attribute-mapping rules is essential for integration. At present, mappings are often customized per project, which make interoperability difficult.⁵³



Source: Extracted from Reference 49

Figure 4-32 Conceptual Example of Mapping BIM Elements and LOD to GIS in ISO 19166

4.8.4 Examples of GIS Utilization

In large-scale infrastructure projects, the combined use of BIM and GIS plays a central role in improving decision-making accuracy from the planning stage and ensuring spatial consistency throughout design, construction, and operations. In urban environments—where geographic conditions are complex and the risk of clashes with existing infrastructure is high—it is essential to work with both wide-area geospatial data and detailed structural information.

In recent years, an increasing number of projects have applied BIM and GIS together in a more advanced and integrated manner, achieving significant benefits across all lifecycle phases, from planning to O&M. At the same time, several technical challenges remain—such as coordinate transformation, attribute mapping, and differences in LOD definitions—but these are gradually being resolved through project-level operational design and standardization efforts.

This section highlights representative examples from the railway and aviation sectors, summarizing how BIM and GIS were applied and the outcomes achieved.

⁵³ [CityGML in the Integration of BIM and the GIS: Challenges and Opportunities](#)

Table 4-35 Overview of GIS Utilization in Major Projects

Project	Purpose of Use	Utilized Phases	Outcomes
Crossrail (UK)	- Wide-area asset management - Integrated management of construction, cost, and assets through linkage of 3D/4D/5D data with GIS - Avoidance of clashes with ground conditions and existing structures	- Planning - Design - Construction - O&M	- Faster decision-making - Improved efficiency of land and boundary verification through mobile GIS - Smoother handover for O&M
HS2 (UK)	- Automatic updates and sharing of 3D geological models based on survey data - Integrated management of environmental, geological, and archaeological information for use in design and construction	- Planning - Design - Construction - O&M	- Reduced impacts and improved quality of conservation decisions in early design - Spatial integration to support heritage protection - Reduced time and cost through use of a shared 3D geological model
Heathrow Airport (UK)	- Visualization of airport-wide asset management - Operational optimization and efficiency improvements - Integration with BIM for expansion planning - Strengthened safety and regulatory compliance - Energy-management support via digital twin	- Planning - Design - Construction - O&M	- Faster decision-making through mapping of 1.4 million m² of assets - Maintenance of safety and compliance - More efficient stakeholder coordination - Improved decision-making for access-route and signage planning - Demonstrated CO₂-reduction effects
Schiphol Airport (Netherlands)	- Operational optimization by integrating BIM, GIS, and IoT within a digital twin - 3D visualization to support stakeholder consensus-building - Unified visualization of above- and below-ground assets	- Planning - Design - Construction - Operations	- Delay prevention and cost reduction through incident simulation - Faster preventive maintenance and incident response - More efficient management of 80,000+ assets

Source: Prepared by the JICA Study Team

4.8.4.1 Crossrail 54, 55, 56, 57

Crossrail is a major east–west railway project in London in which the integration of BIM and GIS was essential from the planning stage, due to the complexity of underground urban conditions and the high risk of clashes with existing infrastructure. Traditional, siloed information management approaches made it difficult to handle large-scale geospatial data and detailed design information simultaneously, increasing the risk of delays in decision-making and design changes. To address these challenges, the project established a CDE in which BIM models and GIS data could be centrally managed.

(1) How BIM and GIS Were Used

Crossrail connected document, CAD, BIM, scheduling, and cost-management applications with GIS through the CDE. BIM models were extended to 4D (schedule) and 5D (cost), with asset and construction-site location data linked to GIS to support construction management and visualization. In parallel, GIS layers representing underground utilities, geological data, and environmental conditions were continuously updated and visualized. This integration enabled stakeholders to evaluate design options and

54 [Crossrail Project: Application of BIM \(Building Information Modelling\) and Lessons Learned - Crossrail Learning Legacy](#)

55 [Crossrail BIM](#)

56 [Crossrail's Information System - Crossrail Learning Legacy](#)

57 [Boyes_Thesis.pdf](#)

construction sequences using a consistent spatial context. In addition, the project referenced the 3D geological models from the British Geological Survey (BGS), improving predictions of subsurface conditions for station and tunnel excavation and supporting more informed design and construction risk assessments.

(2) Use by Lifecycle Phase

Planning

GIS integrated geological conditions, subsurface infrastructure, and environmental constraints, which were combined with BIM-based alignment studies. This enabled the project to present highly defensible route and construction proposals, even under severe constraints, accelerating early stakeholder agreement.

Design

The combined use of BIM and GIS together within the CDE allowed underground spatial conflicts and relevant environmental conditions to be incorporated directly into the design model. This improved consistency and enabled rapid tracing of the impacts of design changes.

Construction

GIS managed access routes, material-delivery paths, and spatial restrictions, which were linked to 4D/5D BIM models. Construction sequences, cost implications, and safety measures were evaluated in an integrated manner, enabling simultaneous monitoring of progress and site conditions.

Operations & Maintenance

Asset locations and conditions were visualized continuously in GIS and combined with BIM attribute data to support renewal and inspection planning. This established a spatially grounded basis for lifecycle decision-making.

(3) Outcomes and Remaining Challenges

Centralized information management reduced discrepancies and duplication, enabling faster decision-making and improving shared understanding among stakeholders. At the same time, several technical challenges—such as coordinate-system differences, attribute alignment, and model simplification—required ongoing optimization. These were progressively addressed through CDE operation, ETL design, and the application of standards.

Despite the constrained urban environment, the ability to move seamlessly between wide-area GIS context and detailed BIM models during day-to-day operations proved to be one of the project's greatest achievements, optimizing both construction-risk management and stakeholder alignment.

4.8.4.2 High Speed 2 58, 59, 60

HS2 (High Speed 2) is a high-speed railway extending from London to Birmingham and further north. Given the extensive route length and the complex geological and environmental conditions, the project adopted an early-stage strategy to ensure design and construction consistency and scalability through integrated use of BIM and GIS. Because large-area datasets were frequently updated and constraints related to geology, environment, and cultural heritage emerged concurrently, it was essential to provide designers with a mechanism that delivered the latest information as a single, authoritative source.

(1) How BIM and GIS Were Used

HS2 established an integrated framework in which GIS data—including topography, geology, and environmental layers—could be directly reflected in the design process through a GIS platform and the

58 [Soils, Landscape and Woodland: How HS2 is using integrated asset information management in a BIM environment. - HS2 Learning Legacy](#)

59 [Incorporation of digital ground investigation data and geological model into the 3D BIM environment - HS2 Learning Legacy](#)

60 [The role of BIM and GIS in HS2 historic environment data management, an overview of HS2 Phase One, UK. Aryankhesal. Internet Archaeology 65.](#)

CDE, interoperating with BIM models such as IFC.

A rule-based workflow was created to automatically update borehole data and geological models, version-controlled within the CDE, ensuring that design teams always had access to an up-to-date single source of truth.

Within the Historic Environment Programme, GIS was used to centrally manage the locations, metadata, and document links for cultural-heritage assets. These were linked with BIM attributes, creating an operational workflow that enabled heritage-protection requirements to be reconciled with design coordination.

(2) Use by Lifecycle Phase

Planning

GIS supported route selection and environmental impact assessment (EIA), while BIM enabled structural alternatives to be evaluated against spatial constraints, supporting consensus-building based on wide-area conditions.

Design

GIS managed constraint layers, such as heritage sites, environmental zones, and land-acquisition data. BIM supported clash detection and construction-scenario analysis, ensuring design quality and consistency.

Construction

GIS controlled site-access routes, traffic restrictions, and temporary-works planning. These were linked to BIM-based scheduling, material planning, and safety management optimizing construction from both progress and spatial-constraint perspectives.

Operations & Maintenance

The combination use of BIM and GIS provided unified management of asset locations, attributes, and histories, enabling integrated long-term maintenance strategies across civil, environmental, and structural domains.

(3) Outcomes and Challenges

The dynamically updated geological model improved design consistency, update efficiency, and overall quality. ETL automation reduced the burden of data updating and produced direct time and cost savings.

By managing cultural-heritage and environmental layers within GIS, design coordination and stakeholder alignment were significantly accelerated, enabling decision-making based on shared geographic context, even in a large, multi-stakeholder project.

However, several operational challenges remained, including coordinate alignment, data-volume management, and the need for cross-disciplinary BIM/GIS expertise. Continued advancement in ETL standardization, CDE governance, and training and role definition is required to ensure effective long-term utilization.

4.8.4.3 Heathrow Airport ^{61, 62, 63}

Since 2015, Heathrow Airport has been working to digitize asset information and establish an operations-focused CDE to support the efficient management of both existing facilities and future expansion areas. GIS now functions as a core platform for managing spatial information across the airport and is integrated with document-management systems, the AIM, and the CMMS as part of the overall CDE environment.

⁶¹ [BIM Project Management at Heathrow Airport | Symetri.co.uk](https://www.symetri.co.uk/bim-project-management-at-heathrow-airport)

⁶² [New technology to allow Heathrow to prioritize emission targets - NATS](#)

⁶³ [Heathrow Airport Ltd - Esri UK Customer Success Awards 2024](#)

(1) How GIS Was Used

The airport developed a GIS-based management framework covering approximately 26,000 units of internal spaces, equipment zones, and leasable areas (around 1.4 million m²), implementing a true operational single source of truth.

As part of the major expansion programme, a new CDE strategy was defined, and information requirements and information-supply processes were standardized.

The existing GIS platform was migrated to ArcGIS, and interoperability with Autodesk tools was enhanced through Autodesk–Esri integrations, improving exchange of geometric and attribute data and strengthening information-container management within the new CDE.

A digital twin for arrivals operations (NATS DCB) was also developed to model demand and capacity in real time, achieving an annual reduction of approximately 47,000 minutes of delays. This capability has since been expanded into environment-focused performance optimization, targeting a reduction of up to 30,000 tonnes of CO₂ per year.

(2) Use by Lifecycle Phase

Planning

Established the new CDE strategy at the outset of the expansion programme and migrated legacy GIS systems to ArcGIS. Alignment was ensured with wider spatial-planning frameworks shared with surrounding local authorities.

Design

Civil 3D / Revit models were connected with ArcGIS, enabling visual applications for layout verification, impact analysis, and stakeholder engagement. Design-data standards and workflows were standardised across the programme.

Construction

Under the new CDE, documents, drawings, models, and attribute data were centrally controlled. Service Clearance & Permits monitored construction clearances geographically, and Active Works were monitored through operational dashboards.

Operations & Maintenance

Indoor GIS supported space and equipment management. Operational visualization tools were used for Winter Resilience, real-time monitoring, and optimization of arrivals operations using NATS DCB, reducing delays, fuel use, and CO₂ emissions.

This operational model effectively implements the ISO 19650 O&M approach to information utilization.

(3) Outcomes and Challenges

The indoor GIS platform unified space, leasing, and equipment information, accelerating decision-making across multiple departments and improving the passenger experience (wayfinding and navigation).

The integration of planning and design enhanced stakeholder alignment and supported long-term standardization through a 25-year roadmap.

Operational dashboards enabled real-time situational awareness of conditions (stands, vehicles, works, clearances, winter operations), improving efficiency.

Remaining challenges include ongoing maintenance of the integrated CDE environment—including GIS, document management, BIM, and operations/maintenance systems—as the airport continues to expand its digital ecosystem.

4.8.4.4 Schiphol Airport 64, 65, 66

Schiphol Airport is one of Europe's major hub airports and has established a CDE to support facility renewal, operational optimization, and asset management. The airport has developed an integrated BIM–GIS framework for managing approximately 80,000 indoor and outdoor assets. Because the airport operates with dense infrastructure and frequent operational changes across a wide area, a consistent spatial platform was required—built around BIM-to-GIS ETL processes and web-based 3D visualization, combined with operational and sensor data to enable predictive maintenance.

(1) How GIS and BIM Were Used

Schiphol processes BIM models delivered by contractors using FME and publishes them as web-based 3D GIS scenes, enabling spatial management of asset locations, attributes, and conditions through operational dashboards.

A workflow was also developed to continuously update high-density equipment spaces using mobile scanning and automated modelling, reducing modelling costs by approximately 68% per m² and avoiding operational disruption during updates.

The airport's BIM–GIS digital twin connects to sensor systems and operational platforms through APIs, enabling spatial decision-making for refurbishment planning, operational optimization, preventive maintenance, delay mitigation, and construction coordination.

(2) Use by Lifecycle Phase

Planning

GIS was used to manage asset locations, refurbishment targets, and impact areas at a wide-area scale, while BIM enabled comparison of new and renewal design options within the same spatial context. This improved early identification of priority works and potential clashes.

Design and Construction

BIM models were shared through the CDE for quantity take-off and scheduling, while GIS visualized construction impacts, including movement routes, safety constraints, and spatial occupancy. This supported shorter construction timeframes and improved on-site safety.

Operations & Maintenance

GIS combined with sensor data enabled real-time management of asset locations and conditions, while BIM provided detailed equipment information. Together, they supported efficient preventive maintenance and renewal planning, minimizing passenger impacts and ensuring operational continuity.

(3) Outcomes and Challenges

Efficient BIM-to-GIS ETL workflows and accelerated modelling processes improved the accuracy of refurbishment planning, reduced costs, and minimized delays. The integrated digital-twin environment demonstrated its value by simultaneously optimizing airport operations and construction coordination.

However, ongoing challenges include the workload of converting heterogeneous datasets, ensuring scanning accuracy, and promoting organizational adoption of data-driven workflows. Continued focus on CDE governance, application of standards, and staff training/role definition has been identified as essential for sustaining the system.

64 [Digital Twin Helps Airport Optimize Operations](#)

65 [Schiphol Airport and Allinq Digital Transform Scan to BIM to Realize Ambitious Sustainability Goals](#)

66 [Innovative Design Approach Speed Up Bridge Replacement Process](#)

5 NATIONAL GUIDELINES RELATED TO ISO 19650

This chapter reviews Building Information Modelling/Management (BIM) guidelines established by various countries which are based on the ISO 19650 series. It outlines their institutional background, structural framework, and practical applications, and clarifies the characteristics of international efforts towards the standardization of information management. These guidelines are closely aligned with real-world practices in public works and infrastructure projects, addressing key elements such as the definition of information requirements, operation of the Common Data Environment (CDE), integration with contractual documentation, and consistency with asset management processes.

Throughout this chapter, the aim is to extract insights that supports the development and adoption of BIM guidelines for official development assistance (ODA) loan projects, taking into account the institutional frameworks and evaluation methodologies implemented in different countries.

5.1 Selection of Guidelines

5.1.1 Criteria for Selecting Guidelines

The guidelines reviewed in this chapter were selected based on the criteria shown in Table 5-1.

Table 5-1 Criteria for Selecting Guidelines

Criterion	Description
Region	Countries recognized as BIM leaders, such as the UK, the USA, EU Member States, Australia, and Hong Kong
Alignment with ISO 19650	Guidelines that directly reference or apply the ISO 19650 series
Public Availability	Documents published by government bodies or industry organizations
Practical Influence	Actively used in public procurement or contractual processes

Source: Prepared by the JICA Study Team

5.1.2 List of Selected Guidelines

Table 5-2 lists the guidelines and policies reviewed in this chapter.

Table 5-2 List of Guidelines and Policies Reviewed

Country/Region	Guideline/Policy	Year of Publication	Scope of Application
UK	IMI BIM Framework	2023	Buildings and infrastructure
Hong Kong	CIC BIM Standards	2019	Buildings and infrastructure
EU	EU BIM Handbook	2016	Construction sector
Australia	NATSPEC National BIM Guide	2011	Buildings
	AS-7739	2022	Rail sector
US	AIA BIM Standards	2022	Buildings
	BIM Workflows and Centralized BIM Transportation Library for Bridges and Roadways	2024	Roads and bridges
Peru	Plan BIM Perú	2019	Construction sector

Source: Prepared by the JICA Study Team

5.2 Overview of the Selected Guidelines

5.2.1 IMI BIM Framework (United Kingdom)

(1) Overview

The IMI BIM Framework is a structured framework developed to advance digital transformation and BIM implementation across the United Kingdom (UK) construction sector. It was originally published in October 2019 through a collaboration between the British Standards Institution (BSI), the Centre for Digital Built Britain (CDBB), and the UK BIM Alliance (now known as nima). Following the conclusion of CDBB activities in 2022, BSI and nima have taken responsibility for the maintenance and updating the framework.

The IMI BIM Framework aligns with the UK government's BIM Level 2 policy and provides practical guidance on the application of the ISO 19650 series within the UK's operational and contractual environment.

(2) Positioning

The framework is positioned primarily as a technical guidance resource. However, many of the process documents and templates included within the framework—such as information protocols and information-management matrices—can be incorporated into contractual documentation, thereby providing legal enforceability as part of a suite-based approach.

The framework is referenced in major UK policy documents, including the Construction Playbook, Trust and Productivity, and the TIP Roadmap to 2030, demonstrating its recognized authority within industry practice.

(3) Intended Scope and Use

The framework is applicable to a broad range of construction projects, covering both buildings and infrastructure, including roads, rail, airports, and other large-scale assets.

Its scope spans the entire project lifecycle—from planning and design through construction and operations and maintenance—and is intended for use by a wide range of stakeholders, including clients, designers, contractors, and operators.

(4) Structure and Content

The IMI BIM Framework consists of a main framework document supported by a suite of practical guidance documents.

The main document provides an overview of the framework, the purpose and key characteristics of the guidance, and the relationship with the ISO 19650 series.

The guidance documents support the implementation and are organized as follows:

- Guidance 0: The need for information management
- Guidance 1: Core concepts and the background to digital transformation
- Guidance 2: Project delivery phase
- Guidance 3: Operational phase
- Guidance 4: Methods for information exchange
- Guidance A–F: Detailed topics, including information-management functions, open data, CDE operation, and development of information requirements

(5) Templates and Tools

Guidance A–F functions as a set of implementation tools, providing standard templates such as, COBie, Information Protocols, and Information Management Assignment Matrices.

These templates are designed to be incorporated into contracts and used directly in practice. The framework

also provides supplementary learning materials, including instructional videos and example databases

5.2.2 CIC BIM Standards (Hong Kong)

(1) Overview

The CIC BIM Standards are a set of BIM implementation standards published by the Construction Industry Council (CIC) of Hong Kong.

These standards emerged following the publication of the Roadmap for the Strategic Implementation of BIM in Hong Kong's Construction Industry in 2014, which identified the need for locally rooted BIM standards. The first edition of the standards was issued in 2015 and has been periodically updated.

(2) Positioning

These standards form the core reference documents for BIM adoption throughout the Hong Kong construction industry. They establish a framework for defining project phases and also underpin Hong Kong-specific BIM-related professional qualifications.

In the field of asset management, the standards are complemented by the BIM-AM Standards and Guidelines issued by the Electrical and Mechanical Services Department (EMSD), reflecting a coordinated, cross-agency approach to standard development.

(3) Intended Scope and Use

The CIC BIM Standards are applicable to a broad range of construction projects, including buildings and civil engineering works, and are designed for use in major infrastructure projects such as roads, railways, and airports.

Their coverage extends across the entire asset lifecycle, from planning through design and construction to operations and maintenance. The standards are structured to enable multiple stakeholder groups, including clients, designers, contractors, and operators, to use them effectively.

Although the standards reference international frameworks, they are customized to align with Hong Kong's regulatory environment and industry practices, reflecting a locally adapted implementation of global BIM principles.

(4) Structure and Contents

As of December 2021, the standards consist of a core "General" standard, supplemented by discipline-specific standards that establish Level of Information Need (LOIN) definitions and provide implementation guidelines consistent with local regulations. The series includes the following:

- CIC BIM Standards General
- CIC BIM Standards for Architecture and Structural Engineering
- CIC BIM Standards for Underground Utilities
- CIC BIM Standards for Mechanical, Electrical, and Plumbing
- CIC BIM Standards for Preparation of Statutory Plan Submissions

(5) Templates and Tools

The CIC BIM Standards—General include comprehensive templates in the appendices covering, Operational Information Requirements (OIR), Asset Information Requirements (AIR), Project Information Requirements (PIR), and Exchange Information Requirements (EIR). These templates ensure that all tiers of information requirements are clearly defined.

Additional materials are also published, such as evaluation criteria to support clients during tendering process, and special contract conditions specifying information-management responsibilities. These resources are intended to support practical implementation of BIM and its integration into contractual frameworks.

5.2.3 EU BIM Handbook (EU)

(1) Overview

The EU BIM Handbook is a guideline developed to promote the digitalization and adoption of BIM in public-sector construction projects across the European Union. It was published in 2017 by the EU BIM Task Group, with support from the European Commission.

The handbook aims to stimulate economic growth and enhance competitiveness by encouraging the use of BIM, while maximizing the value of public investment.

(2) Positioning

The EU BIM Handbook is positioned as a policy-level guideline, rather than a technical standard or specification.

Its purpose is to provide a unified, strategic framework for BIM adoption across Europe. It outlines the leadership roles that governments and public clients should play, as well as offering practical recommendations for organizations implementing BIM at the project level.

As such, it functions as a foundational reference for EU member states in formulating national BIM policies and initiatives.

(3) Intended Scope and Use

The handbook is primarily directed towards public-sector construction projects across Europe. It provides strategic recommendations for national, regional, and public-works policy development, while also providing practical implementation guidance for procurement and project-level delivery.

It is therefore used both as a resource for high-level policy design and as a tool for operational decision-making in public-sector construction program.

(4) Structure and Content

The handbook consolidates examples and principles of BIM utilization across EU member states and is structured into the following chapters:

Chapter 1: Introduction

- Definition of BIM and its significance.
- Purpose and target audience of the handbook.
- The need for digitalization in the construction sector.

Chapter 2: General Principles

- Value of BIM for the public sector and public clients.
- Why public-sector organizations must take a leadership role.
- Benefits of adopting a common European approach to BIM.
- Strategic examples of government-led BIM implementation.
- Establishing a framework that supports information continuity from design to operations.

Chapter 3: Recommendations for Action

- High-level strategic recommendations.
- Implementation-level guidance on organizational policy, processes, technology, and skills development.

(5) Templates and Tools

The EU BIM Handbook does not provide standard contractual documents or information-requirements

templates. However, it presents a wide range of best practices and implementation case studies from EU member states that public clients can refer to when developing BIM procurement strategies or defining contractual requirements. It therefore serves as a practical reference document for governments and public procurers when designing BIM-related policies, procedures, and contractual frameworks.

5.2.4 NATSPEC National BIM Guide (Australia)

(1) Overview

The NATSPEC National BIM Guide is a BIM implementation guideline published by National Specification System for Building (NATSPEC), a non-profit organization in Australia focused on improving quality and productivity in the building industry. The first edition was released in 2011, based on the VA BIM Guide (2010) published by the U.S. Department of Veterans Affairs. The guideline was reaffirmed in 2016, and the current latest edition was published in 2022.

Its content aligns with AS ISO 19650, which provides the overarching framework for BIM. However, the NATSPEC guide is positioned as a complementary document that translates the standard into practical, project-level implementation guidance.

(2) Positioning

The main body of the guide is positioned as guidance, rather than a mandatory standard. However, the accompanying templates—such as PIR, AIR, EIR, and BEP—can be incorporated into contractual documentation, thereby providing legal validity as part of a suite-based approach.

The guide was developed with contributions from key industry bodies including buildingSMART, the Australian Institute of Architects, Consult Australia, and the Facility Management Association of Australia, making it a widely recognized reference for BIM best practices in Australia.

(3) Intended Scope and Use

While the guide is primarily intended for building projects, its principles can be applied to horizontal infrastructure such as roads and bridges.

To maximize the benefits of BIM, the guide covers the entire project lifecycle, such as planning, design, construction, and operations, and is intended for use by diverse stakeholders including clients, designers, contractors, and operators.

(4) Structure and Content

The guide consists of a main document, multiple appendices, and a suite of templates.

The main document provides high-level information, guidance, and recommendations for BIM implementation, written for stakeholders involved in strategic planning and management, including those who may be less familiar with BIM.

Normative or compliance-related content—particularly material concerning AS ISO 19650—appears in the appendices, which include:

- Appendix A: Glossary
- Appendix B: Overview of AS ISO 19650 and its relationship to the guide
- Appendix C: BIM uses and supporting technologies
- Appendix D: Defining Information Requirements

(5) Templates and Tools

In addition to the main text and appendices, the guide includes AS ISO 19650-aligned templates, such as:

- AIR (Asset Information Requirements)
- PIR (Project Information Requirements)

- EIR (Exchange Information Requirements)
- Project BIM Brief

These resources support project teams in implementing BIM in a consistent and standardized manner.

5.2.5 AS-7739 (Australia)

(1) Overview

AS-7739 is a Digital Engineering (DE) standard developed by the Rail Industry Safety and Standards Board (RISSB), which is recognized by Standards Australia as the sole Standards Development Organization (SDO) for the Australian railway industry.

In this context, Digital Engineering (DE) refers to a broad strategic concept that integrates BIM as the core technology while incorporating related domains such as GIS, IoT, real-time sensor data, and digital twins. DE also encompasses the wider processes required for data-driven decision-making across the full infrastructure lifecycle, including a Common Data Model (CDM), data governance, procurement and contract workflows, and quality assurance.

The Australian government actively promotes the adoption of DE.

AS-7739 serves as the principal reference standard for implementing DE in railway contracts and operations, defining concepts, data-management rules, procurement and delivery requirements, and interoperability principles.

The standard aligns with the fundamental concepts of the ISO 19650 series while being tailored to the specific context of the Australian and New Zealand rail sectors.

(2) Positioning

RISSB standards, including AS-7739, are classified as Australian Standards but are generally voluntary, unless referenced in legislation or contracts.

- Part 1 (conceptual content; see Section (4)) is not intended to be contractually binding.
- Part 2 (technical requirements) can be incorporated into contracts, providing legal enforceability as part of a suite-based structure.

Contractually, AS-7739 references well-known general conditions such as:

- AS 4000: General Conditions of Contract
- AS 2124: General Conditions of Contract
- GC 21: NSW Government General Conditions
- NEC4: Engineering and Construction Contract

(3) Intended Scope and Use

RISSB, as a non-governmental, member-based, non-profit organization, develops standards and guidelines collaboratively with the railway industries of Australia and New Zealand. Accordingly, AS-7739 applies to railway projects in both countries.

As indicated by its title, Digital Engineering for Fixed Rail Infrastructure, the standard covers DE use across planning, design, construction, and operations and maintenance for fixed railway infrastructure.

Its content reflects industry-specific characteristics, including the scale of railway projects, the volume of assets to be managed, and the legacy systems already used by railway operators.

(4) Structure and Content

AS-7739 “Digital Engineering for Fixed Rail Infrastructure” is structured into two main parts:

- Part 1: Concepts and Principles (published on 30 January 2023)

- Part 2: Technical Requirements (published on 31 January 2024)

Part 1 Covers

- DE concepts and definitions
- Organizational and programme structures
- Project planning
- Project delivery approaches

Part 2 Technical Specifications such as:

- Common Data Model (CDM)
- Common Data Dictionary (CDD)
- Document requirements
- Survey requirements
- CAD requirements
- BIM requirements

Part 2 is supplemented by three appendices:

- Appendix A: Common Data Dictionary (CDD)
- Appendix B: Bibliography
- Appendix C: RISSB Hazard Register

5.2.6 AIA Digital Documents Guide (United States)

(1) Overview

The AIA Digital Practice Documents, revised and issued by the American Institute of Architects (AIA) in 2022, constitute a suite of documents that systematically govern the contractual and practical management of BIM and other digital project information in building projects.

These documents address legal and technical issues associated with BIM use, including information sharing among project participants, allocation of responsibilities, reliability and authority of digital models, and treatment of BIM models as contract documents.

(2) Positioning

These documents form part of the AIA Contract Documents, the standard set of contractual forms widely used in U.S. architectural practice. As such, they provide a formal mechanism for determining whether BIM models are considered official contract documents, and how risks associated with model sharing and data exchange are to be managed.

For example:

They may be appended to standard AIA contracts, such as B101-2017 (Owner-Architect Agreement) and A101-2017 (Owner-Contractor Agreement), to provide contractual force.

They may also be added after contract execution using modification documents, such as G802 (Amendment to the Owner-Architect Agreement) or G701 (Change Order).

(3) Intended Scope and Use

The documents apply broadly to participants in building projects, including owners, architects, contractors, consultants and subconsultants, subcontractors, and fabricators.

Depending on the project delivery arrangement, BIM managers or similar specialists may also be involved.

The documents support agreement-making on responsibilities and protocols for digital information.

Typical uses include defining rules for treating BIM models as contract documents, establishing protocols for model sharing and version management, developing project-specific BIM Execution Plans (BEPs), defining model element LOIN/LOD requirements, and managing licenses and intellectual property rights for digital data.

They serve as the institutional foundation for integrating BIM into U.S. architectural contracting practice, supporting risk management and information reliability.

(4) Structure and Content

The AIA Digital Practice Documents (2022 edition) consist of the materials shown below.

Table 5-3 AIA 2022 BIM and Digital Practice Contract Documents

Document Code	Description
BIM Exhibits	
E201-2022	Allows shared use of models among all participants and permits selected model versions to serve as contract documents.
E202-2022	Allows shared use of models among all participants but does not permit models to be contract documents.
E401-2022	Model sharing within the design team only.
E402-2022	Model sharing within the construction team only.
Execution Plan and Model Element List	
G203-2022	Template for the BIM Execution Plan (BEP).
G204-2022	Detailed Model Element Table: defines LOD and responsibility allocation.
G205-2022	Simplified Model Element Table: streamlined LOD and responsibility management
License Agreement	
C106-2022	License agreement for digital data (intellectual-property management).

Source: Prepared by the JICA Survey Team

5.2.7 BIM Workflows and Centralized BIM Transportation Library for Bridges and Roadways (United States)

(1) Overview

This document, issued by the Federal Highway Administration (FHWA) under the United States Department of Transportation, provides guidance for promoting BIM within the roadway and bridge sectors.

FHWA positions BIM as a method to enable improved information visualization and more efficient project management across the design, construction, and maintenance phases of transport infrastructure.

The document focuses on two key themes: the development of BIM-enabled workflows and the establishment of a centralized BIM library dedicated to bridges and roadways.

Through BIM adoption, data can be visualized, shared, and analyzed consistently across the entire lifecycle, supporting effective communication among stakeholders, faster decision-making, and improved operational efficiency.

(2) Positioning

This document serves as a guidance for advancing BIM implementation within the roadway and bridge sectors, and presents best practices specific to these asset types.

FHWA emphasizes that BIM contributes to improved design accuracy, reduced project durations, cost savings, and more effective information exchange in complex infrastructure projects.

By institutionalizing BIM, the guideline aims to mitigate risk and enhance project outcomes for public-sector transportation projects.

(3) Intended Scope and Use

The intended audience includes a wide range of stakeholders, such as roadway and bridge designers, contractors and construction managers, project managers, public-sector officials, and researchers and academic practitioners.

Expected use cases include the introduction or improvement of BIM workflows for roadway and bridge projects, the utilization of a centralized BIM library for efficient information management, the promotion of consistent and analyzable data usage throughout the entire lifecycle, and facilitation of information sharing and decision-making among all project participants.

(4) Structure and Content

The document consists of the following sections:

- Introduction: Significance and objectives of BIM
- Current state of BIM adoption in roads and bridges projects
- BIM workflow steps: Planning, design, construction, and maintenance
- Design and operation of the centralized BIM library
- Case studies demonstrating successful BIM implementation
- Future outlook: Emerging technologies and the future of BIM

Each section provides both conceptual guidance and practical examples derived from actual transport infrastructure projects.

(5) Templates and Tools

To support BIM implementation, the guidance includes a suite of templates and tools, such as:

- Workflow templates: Frameworks for visualizing and managing each stage of a BIM-enabled project
- Data-management tools: Software functionalities to support creation and operation of the centralized BIM library
- Construction-management tools: Applications enabling real-time monitoring of site progress
- Analytical tools: Tools for structural analysis, cost analysis, and other engineering evaluations based on BIM data

These resources are intended to enhance project efficiency by enabling the consistent and structured application of BIM throughout the lifecycle.

5.2.8 Plan BIM Perú (Peru)

(1) Overview

Plan BIM Perú is a national digitalization initiative led by the Ministry of Economy and Finance (MEF) of Peru, designed to promote the phased adoption and implementation of BIM within public-sector infrastructure investment projects.

The plan positions BIM not solely as a technical tool but as a method for managing information in public investment, aimed at enhancing the reliability and efficiency of information throughout the entire asset lifecycle—from planning and design to construction, operations, and maintenance.

Plan BIM Perú was launched in 2019 as part of the National Competitiveness and Productivity Plan, with the goal of improving efficiency through the modernization and digitalization of public investment processes.

(2) Positioning

The plan is a government-led policy framework, rather than a technical standard. It provides the institutional

and strategic foundations for integrating BIM across all public-investment processes.

Plan BIM Perú is supported by a series of Supreme Decrees (*Decreto Supremo*) and Directive Resolutions (*Resolución Directoral*) that progressively mandate BIM use in public works.

To support implementation, the National BIM Guide (*Guía Nacional BIM*) defines BIM processes, roles, and information-management requirements.

Plan BIM Perú is aligned with national competitiveness strategies and public-investment reform programmes, constituting a major pillar of Peru's construction-sector digital transformation.

(3) Intended Scope and Use

The plan covers all public-investment projects, including both building and civil-engineering works. It envisions full lifecycle digitalization and the consistent use of BIM across planning, design, construction, and operations/maintenance—improving efficiency through coherent information management.

The initiative is being introduced in stages up to 2030:

- 2021-2025: Foundation-building phase
- 2026 onward: Expansion and consolidation phase

In addition, the government collaborates with educational institutions and professional bodies to develop BIM curricula and enhance the country's BIM capability through training programmes and workforce development initiatives.

(4) Structure and Content

Plan BIM Perú consists of the following key documents:

- National BIM Guide (*Guía Nacional BIM*) (2021; updated 2023)
 - The central document defining BIM-based information-management methods for public investment.
 - Content includes concepts for information-management, BIM processes, stakeholder roles, and requirements for information deliverables (models, documents).
 - The second edition (2023) enhances consistency with the ISO 19650 series and other international standards, updating terminology and definitions related to BIM use.
- Technical Guide (*Guía Técnica BIM para Edificaciones e Infraestructura Pública*) (2023)
 - Provides technical guidance for buildings and public-infrastructure projects.
 - Covers modelling standards, data requirements, and specifications for information deliverables.
 - Aligns with the national investment-system framework Invierte.pe.
- Other policy documents

Several additional decrees and resolutions support BIM implementation, including:

- *Decreto Supremo* N.º 289-2019-EF: Introduces phased BIM adoption in public investment.
- *Resolución Directoral* N.º 007-2020-EF/63.01: Defines BIM guidelines across the investment lifecycle.
- *Decreto Supremo* N.º 108-2021-EF: Updates BIM definitions, expands scope, aligns with international standards.
- *Resolución Directoral* N.º 0002-2021-EF/63.01: Approves the implementation plan and roadmap for Plan BIM Perú
- *Resolución Directoral* N.º 0005-2021-EF/63.01: Approves the “*Nota Técnica de Introducción BIM*”

and the National BIM Guide.

- *Resolución Directoral* N.º 0001-2022-EF/63.01: Sets guidelines for selecting, implementing, and evaluating BIM pilot projects.
- *Resolución Directoral* N.º 0007-2022-EF/63.01: Defines staged BIM deployment across investment-cycle phases.
- *Resolución Directoral* N.º 0001-2023-EF/63.01: Establishes criteria for selecting public institutions and companies to support BIM deployment.
- *Resolución Directoral* N.º 0003-2023-EF/63.01: Updates the National BIM Guide.
- *Resolución Directoral* N.º 0005-2023-EF/63.01: Approves the Technical BIM Guide for buildings and public infrastructure.
- *Resolución Directoral* N.º 0004-2025-EF/63.01: Approves the standard BIM curriculum for higher-education institutions.
- *Resolución Directoral* N.º 0007-2025-EF/63.01: Defines requirements for BIM-related software, hardware, CDEs, and digital infrastructure.

(5) Templates and Tools

Plan BIM Perú provides a wide range of practical tools to support BIM adoption.

The National BIM Guide and Technical Guide include information-exchange formats, naming conventions, information-requirements templates, CDE configuration examples, and deliverable specifications.

Training programmes, pilot-project case studies, manuals, and implementation guides are also publicly available online, supporting capacity building for both public-sector staff and private-sector practitioners.

6 ISO 19650 INFORMATION-REQUIREMENTS TEMPLATES

This chapter organizes the set of information requirements templates that were collected and analyzed with the objective of developing an information management framework for Official Development Assistance (ODA) loan projects, based on the ISO 19650 series.

6.1 Importance of Information Requirements and Standardization

(1) Fundamental Concepts for BIM Adoption

For effective utilization of BIM, it is essential to identify the specific information required throughout the entire asset lifecycle.

The value of this information is maximized through the establishment of standardized requirements. These standards define the format, precision, and level of detail of information—such as “provide in Format A”, “record with ± 5 mm accuracy”, and other similarly explicit criteria.

Such definitions improve information quality assessment, searchability, and reusability, ultimately contributing to greater operational efficiency.

For BIM implementation to be successful, the appointing organization must clearly articulate its information needs and requirements. In the early stages of adoption, the following three questions are pivotal in clarifying the required information and determining the direction of implementation:

- What is the purpose of adopting BIM?
- What outcomes are intended to be achieved with BIM?
- What information is required to achieve those outcomes?

The ISO 19650 series adopts a top-down approach to facilitate the clarification of information requirements. By establishing information requirements at the strategic level and cascading them down to both the asset and project levels, organizations can identify the information they actually require based on first principles.

This approach clarifies the purpose of information collection and reduces the risk of accumulating unnecessary data simply due to established habit. As a result, wasteful effort can be eliminated, helping organizations realize tangible benefits from the initial stages of BIM adoption.

(2) Hierarchy of Information Requirements

A thorough understanding of information needs begins with comprehending the flow of information.

Figure 6-1 illustrates the hierarchical structure of information requirements based on ISO 19650-2 and ISO 19650-3. In this structure, the demand for information flows from the higher layers to lower layers, while the supply of information flows upward from the lower layers back to the higher layers.

The hierarchy comprises four layers:

- Organizational / Corporate Management
- Asset-Portfolio Management
- Asset Management
- Creation and Acquisition of Assets

Corresponding to these layers, the following information requirements are defined:

- Organisational Information Requirements (OIR)
- Asset Information Requirements (AIR)
- Project Information Requirements (PIR)

These requirements serve to gather and structure the necessary information from lower layers in order to address strategic questions at the higher layers.

In addition, the Exchange Information Requirements (EIR) define the specific requirements needed at the point of information exchange to meet the needs identified in the PIR and AIR.

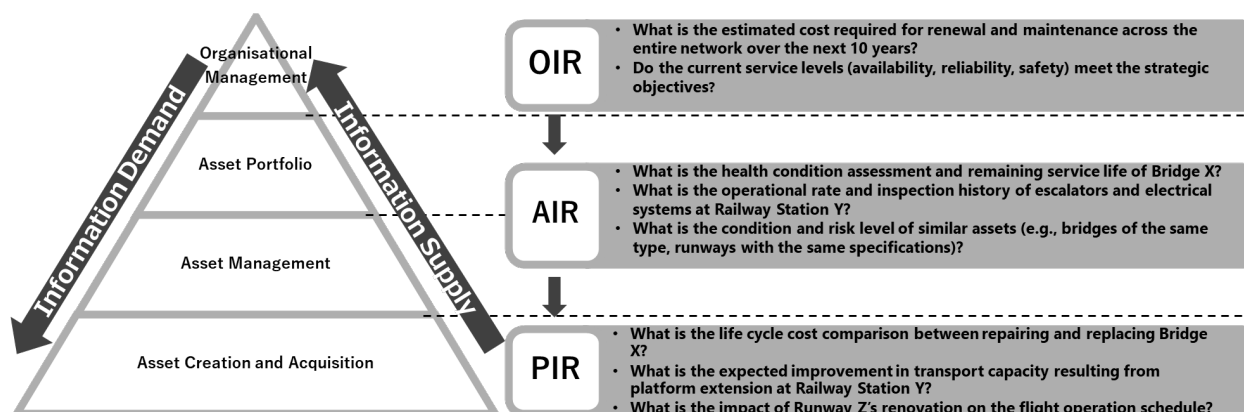
The EIR specifies “who must provide the information”, “when it must be provided”, and “what information is required”.

This clarity enables efficient information handover and enhances the effectiveness of information management during both project delivery and asset operations.

To ensure effective information flow across the hierarchy, three key points must be considered:

- Clear identification of the required data and information
- Establishment of common data and information standards
- Understanding of how information is exchanged within and across hierarchical layers

A structured approach to information management clarifies the purpose of data collection and reduces the risk of unnecessarily data accumulation. This results in more efficient operations and improved decision-making quality.



Source: The JICA Study Team

Figure 6-1 Hierarchical Structure of Information Requirements (ISO 19650-2, 3)

In the next chapter, these concepts will be applied to systematically organize and analyze ISO 19650-aligned information-requirements templates. The objective is to establish a practical foundation for developing an information-management framework for ODA loan projects.

6.2 ISO 19650 Information-Requirements Templates Considered

The templates examined in this chapter include the Organizational Information Requirements (OIR), Asset Information Requirements (AIR), Project Information Requirements (PIR), Exchange Information Requirements (EIR), and Security Information Requirements (SIR).

Table 6-1 presents the list of templates collected for analysis. These materials reflect best practices from the United Kingdom, Australia, Hong Kong, and other leading regions, and serve as foundational references for standardizing and aligning information-requirements frameworks in ODA loan projects.

Table 6-1 Collected ISO 19650 Information-Requirements Templates

	Template Name	Issuing Organization	Year of Publication
OIR	BIM Toolkit (UK)	CDBB (Centre for Digital Built Britain)	2018
	CIC BIM OIR (Hong Kong)	CIC (Construction Industry Council)	2021
	CIBSE OIR (UK)	CIBSE (Chartered Institution of Building Services Engineers)	2017
	Plan BIM Perú (Peru)	MEF (Ministry of Economy and Finance, Peru)	2021
AIR	BIM Toolkit (UK)	CDBB (Centre for Digital Built Britain)	2018
	CIC BIM AIR (Hong Kong)	CIC (Construction Industry Council)	2021
	CIBSE AIR (UK)	CIBSE (Chartered Institution of Building Services Engineers)	2017
	Plan BIM Perú (Peru)	Plan BIM Perú	2021
	NATSPEC AIR Template (Australia)	NATSPEC	2022
PIR	BIM Toolkit (UK)	CDBB (Centre for Digital Built Britain)	2018
	CIC BIM PIR (Hong Kong)	CIC (Construction Industry Council)	2021
	CIBSE PIR (UK)	CIBSE (Chartered Institution of Building Services Engineers)	2017
	Plan BIM Perú (Peru)	Plan BIM Perú	2021
	NATSPEC PIR Template (Australia)	NATSPEC	2022
EIR	BIM Toolkit (UK)	CDBB (Centre for Digital Built Britain)	2018
	CIC BIM EIR (Hong Kong)	CIC (Construction Industry Council)	2021
	CIBSE EIR (UK)	CIBSE (Chartered Institution of Building Services Engineers)	2017
	Plan BIM Perú (Peru)	Plan BIM Perú	2021
	NATSPEC EIR Template (Australia)	NATSPEC	2022
SIR	CIC BIM SIR (Hong Kong)	CIC (Construction Industry Council)	2021

Source: The JICA Study Team

6.3 Method for Organizing and Analyzing the Templates

This section outlines the method used to organize and analyze the information-requirements templates presented in Sections 6.4 to 6.7.

The analysis was conducted using the relevant clauses of the ISO 19650 series as the primary reference point, systematically comparing how each template structures, describes, and operationalizes information requirements.

The analysis focused on the following three perspectives:

Structural Alignment

Assessment of how each template reflects the hierarchical relationships among OIR, AIR, PIR, EIR, and SIR, and the extent to which the templates conform to ISO-based information-management structures.

Level of Detail and Format of Description

Comparison of how information requirements are expressed—for example, attribute definitions, deliverable formats, and the presence or absence of guidance on levels of detail.

Practical Applicability and Contractual Integration

Evaluation of real-world usability, including deliverable timelines, acceptance criteria, responsibility allocation, and CDE operations, as well as the ways in which these elements support contractual processes.

In addition, applicability across different infrastructure sectors—such as rail, road, and aviation—was also considered.

6.4 Organizational Information Requirements (OIR)

The Organizational Information Requirements (OIR) define the information an organization needs about its assets and serve as the starting point for information management.

The OIR provides a foundation for systematically collecting and utilizing information to support ongoing operations and the achievement of strategic objectives.

The scope of information addressed in the OIR is comprehensive and may include:

- Information about the asset itself (e.g., structure, materials, condition, and other assets)
- Information about asset utilization (e.g., usage frequency, traffic volume, and similar data)
- Information about the asset's surrounding context (e.g., environmental, social, and political factors)

The development of OIR begins by defining the strategic questions faced by the organization.

For example, “If a specific road section becomes unusable, how will this affect operations or finances?”, various types of information are required, such as:

- Road structure and condition
- Traffic volume and availability of alternative routes
- Estimated repair costs
- Potential impacts on public perception
- Requirements for coordination with authorities and local communities

Therefore, the OIR is not limited to technical data collection; it covers a broad range of information related to asset operation. This enables organizations to accurately assess risk, evaluate possible responses, and make well-informed decisions.

Once the strategic questions are defined, the required information is identified and documented as the OIR. This document establishes the organization's direction for information management and provides a common foundation for shared understanding among project participants.

ISO 19650-3 Annex A recommends classifying organizational activities relevant to OIR into strategic, tactical, and operational purposes.

This helps clarify, “at which level the need for information arises (executive decision-making, business planning, and site-level operations)”, “how frequently that information is required”, and “who the relevant stakeholders are”.

Table 6-2 provides example activities and corresponding OIRs, as illustrated in ISO 19650-3 Annex A.

Table 6-2 Examples of Activities and OIR Items (ISO 19650-3 Annex A)

Example Activities	Examples of OIR
Cost control, estimating, budget planning	Cost control, estimating, budget planning
Budgeting, asset-renewal planning	Cost-benefit analysis of renewals; lifecycle-cost comparison; performance forecasting
Managing requirements of the appointing organization	Service-level targets; quality objectives
Equipment renewal and refurbishment planning	Lifecycle-cost comparison; economic-life assessment
Coordination with authorities and regulators	Information for regulatory changes; compliance-related data
Information disclosure for public projects	Asset-performance information; quality and safety data
Maintenance activities (inspection, repair, renewal)	Failure history and prediction; asset criticality ratings; risk-management indicators
Disaster-response planning, business-continuity planning (BCP)	Risk assessments and mitigation measures; emergency information-update requirements
Environment-friendly design and operation	Energy-efficiency and environmental-impact assessments; identification and management of environmental risks
Health and safety management, risk assessments	Occupational health and safety risk management; impact assessment of asset failures

Source: Prepared by the JICA Study Team based on ISO 19650-3

6.4.1 Overview of the Collected OIR Templates

Before developing an OIR template suitable for ODA loan projects, this section examines four reference OIR templates, along with the OIR items listed in ISO 19650-3:2020 Annex A.

The structure and content of these templates were compared and analyzed to understand how each defines organizational information needs. Based on this analysis, an integrated OIR template reflecting international best practices will be designed, with particular attention to application in major infrastructure sectors relevant to ODA projects, such as railways, roads, and airports.

Table 6-3 provides a list of the OIR templates collected for review.

Table 6-3 List of Collected OIR Templates

Template Name	Issuing Organization	Year of Publication
BIM Toolkit (UK)	CDBB (Centre for Digital Built Britain)	2018
CIC BIM OIR (Hong Kong)	CIC (Construction Industry Council)	2021
CIBSE OIR (UK)	CIBSE (Chartered Institution of Building Services Engineers)	2017
Plan BIM Perú (Peru)	MEF (Ministry of Economy and Finance, Peru)	2021

Source: The JICA Study Team

(1) BIM Toolkit (United Kingdom)

The BIM Toolkit is based on an information-management structure aligned with the ISO 19650 series and explicitly presents the hierarchical relationships among OIR, AIR, PIR, and EIR.

It systematically organizes strategic goals, information-management roles, responsibilities, and information requirements.

Its structure is as follows:

Structure
1. Introduction Purpose of the OIR and overview of information management based on the ISO 19650 series Hierarchical structure of information requirements

2.	Goals and Policies
	High-level information-management goals and existing organizational policies
	Links to external factors, such as regulations
	Table 2.1: Goals, Strategic Policies, and Influences
	- Goals - Objectives - Internal policies - Regulatory standards
3.	Information Requirements and Activities
	Organizational activities related to information-management goals and the associated information requirements
	Table 3.1: Information Requirements Schedule
	- Goals - Objectives - Policy or influencer - Information requirements - Information containers - Group/department - Project stage/information-delivery milestone
4.	Information Management Structure and Responsibilities
	Organizational structure (internal and external)
	Roles of groups/departments participating in information management
4.1	Internal Organizational Groups
	Table 4.1: Internal Organizational Groups
4.2	External Organizational Groups
	Table 4.2: External Organizational Groups
5.	Governance
	Change control processes for OIR
	Review and continuous improvement mechanisms (e.g., annual review, lessons learned)

(2) CIC BIM OIR (Hong Kong)

Developed for the Hong Kong construction industry, this template aligns with the ISO 19650 series while conforming to the CIC BIM Standards.

It provides a policy-driven framework for defining organizational information exchange requirements.

It covers a wide range of organizational domains, including environment, safety, asset operations, human resource development, and other key areas, and defines detailed information requirements with a high level of granularity for practical use.

Structure	
0.	Introduction
	Purpose of OIR: defining information requirements that support strategic decision-making
	Decision support through digital approaches
1.	General Structure of the OIR
1.1	General Information
	Basic organizational data: organization name, contacts, responsible units
	Roles and persons involved in preparing the OIR
	Systems and data formats used (e.g., FM systems, file formats, and other relevant tools)
1.2	Quality Assurance Procedures
	Quality management processes such as ISO 9001 and ISO 27001
	References to related documents
2.	Organizational Policies
	Background and purpose for defining information requirements for each policy area
	Includes:

2.1	Capital investment and lifecycle costing policy
2.2	Health and safety
2.3	Security management
2.4	Emergency response and contingency planning
2.5	Environmental management
2.6	Sustainability
2.7	Supply chain management
2.8	Space utilization
2.9	Risk assessment and management
2.10	Maintenance and repair
2.11	Asset refurbishment
2.12	Asset operations
2.13	Training and competency
2.14	Technology adoption
2.15	Value management
3.	Organizational Information Requirements
	For each policy domain, detailed information requirements are provided, including:
-	Requirement ID
-	Information owner
-	Data format
-	Acceptance criteria
-	Supplementary notes
	Example: Required capacity of an asset; "ID: 2.12.001, Format: m ² , Source: extracted directly from a BIM model."

(3) CIBSE OIR (United Kingdom)

Developed by Chartered Institution of Building Services Engineers (CIBSE), this OIR template is highly specialized for the building services and FM sector.

It organizes information requirements into structured tables, with emphasis on financial, technical, maintenance, and performance evaluation aspects.

Structure
Table 1 – Organization
- Organization name, contacts, departments
Table 2 – Legal
- Land parcel information, legal references, contract-related elements
Table 3 – Commercial
- Net lettable area and other commercial metrics
Table 4 – Financial
- Rental unit rates (£/m ²), financial indicators
Table 5 – Technical
- Building performance metrics, environmental ratings, and technical specifications

(4) Plan BIM Perú (Peru)

Developed under the national BIM program, this OIR is highly detailed and directly linked to public investment policy goals.

It articulates information requirements across the entire investment cycle and defines clear connections between organizational goals and information needs.

Structure	
A	Strategic Data (<i>Datos Estratégicos</i>)
	- Goals, outcomes, and drivers related to investment management Examples: Improving educational infrastructure quality, disaster-risk management, cost reduction, improving BIM maturity External factors: ISO standards, UNESCO guidelines Internal factors: POI (Institutional Operating Plan), National BIM Guide - Organizational Information Requirements (<i>Requisitos de Información Organizacional</i>) Detailed OIRs linked to each objective Examples include: - Technical files (drawings, specifications, budgets, maintenance manuals) - Maintenance plans - Risk management plans - Quantity and cost information extracted from BIM - Clash-detection reports - TDR-BIM templates and CDE definitions Each information requirement is linked to: - Information container(s) (file formats: .doc, .pdf, .dwg, .xls, .indd, IFC, and other file formats) - Responsible unit/team - Investment cycle phase (e.g., technical-file preparation, physical works, and operation)
B	Responsibilities (<i>Responsabilidades</i>)
	- Internal responsibilities Procurement, finance, HR, IT, maintenance, design, construction, and relevant departments. - External responsibilities Designers, contractors, supervisors, Ministry of Education, audit bodies, and other external stakeholders.
C	Feedback Mechanisms (<i>Mecanismos de Retroalimentación</i>)
	- Documents governing continuous improvement - Documents establishing lessons-learned processes

6.4.2 Comparative Analysis of the OIR Templates

This section provides a detailed comparative analysis of the OIR templates introduced previously, using the item categories listed in ISO 19650-3 Annex A as a reference point.

The analysis evaluates each template from the perspectives of structure, descriptive format, level of detail, treatment of lifecycle phases, and responsibility allocation.

(1) Format and Level of Detail of Information Requirements

Significant differences were observed in how each template describes information requirements and the level of granularity adopted.

BIM Toolkit

Uses high-level, conceptual descriptions focusing on strategic direction and the organizational framework for information management. It does not provide detailed operational requirements.

CIC OIR

Provides moderately detailed descriptions, structured around organizational policies. More actionable and practical for real-world implementation.

CIBSE OIR

Specialized for building-services and FM. Although it is structured in Excel format, it contains relatively limited depth in its descriptions.

Plan BIM Perú

Offers highly detailed information, including warranty periods, inspection requirements, manual formats, file types, and explicit required attributes.

This reflects the needs of public-sector project governance and supports practical, compliance-driven information management.

(2) Information Format and Degree of Structuring

The formats used to describe and deliver information requirements have direct implications for practical usability.

Plan BIM Perú

Specifies exact file formats for each required deliverable (e.g., .pdf, .dwg, .xls, .indd, and IFC).

This approach reflects a strong structuring and standardization.

CIBSE OIR

Highly structured within Excel, making it well suited to operational data collection.

CIC OIR

Primarily narrative and document-based, with limited specification of required data formats.

BIM Toolkit

Employs an abstract structure and provides minimal instructions on file formats.

(3) Treatment of the Asset Lifecycle Phases

The handling of lifecycle phases differs significantly across the templates.

Plan BIM Perú

Explicitly classifies information requirements according to investment cycle phases (technical file development, procurement, construction, operations, among others).

It clearly defines when information is generated and how it should be used.

CIC OIR

Includes phase-related content but lacks a structured or formally defined lifecycle classification.

BIM Toolkit

Introduces the concept of the information delivery cycle, though its direct linkage to OIR is limited.

CIBSE OIR

Contains minimal references to lifecycle phases; the emphasis is on static, FM-oriented information collection.

(4) Information Flow and Integration with Other Requirements

The OIR shall operate in connection with AIR, PIR, and EIR.

BIM Toolkit

Clearly articulates the hierarchical structure from OIR → AIR → PIR → EIR, positioning the OIR as the strategic upstream driver.

Plan BIM Perú

Provides clear definitions of information creation, transfer, and coordination at each lifecycle phase, ensuring operational clarity.

CIC OIR

Mentions linkages, yet provides limited procedural detail on information flow.

CIBSE OIR

Focused on FM; however, it does not provide extensive treatment of information flow across requirement layers.

(5) Organizational Structure and Responsibility Allocation

Clear allocation of responsibilities is essential to ensure effective information management.

Plan BIM Perú

Specifies responsible internal units and external stakeholders for each information requirement, demonstrating a high level of clarity.

CIC OIR

Similarly provides detailed descriptions of internal and external organizational structures and role allocations.

BIM Toolkit

Illustrates an information-management structure, but the linkage to individual OIR items remains abstract.

CIBSE OIR

Assumes an FM-centric organizational context but includes limited detail regarding responsibility allocation.

(6) Updating and Change Control of Information Requirements

The OIR shall be reviewed regularly as organizational policies evolve.

Plan BIM Perú

Includes explicit mechanisms for annual lessons-learned reviews and continuous improvement, positioning OIR as a dynamic, evolving document.

CIC OIR

Indicates the existence of change control processes, including review and approval steps.

BIM Toolkit

Mentions change management conceptually, however, it lacks prescriptive detail.

CIBSE OIR

This does not provide explicit descriptions of update or change control processes.

6.4.3 Structure of the OIR Template for ODA Loan Projects

Based on the comparative analysis of national OIR templates using the classification defined in ISO 19650-3 Annex A, notable differences were observed among the templates in terms of format and granularity of information requirements, responsibility allocation, information handover, and linkage with other requirements, change control mechanisms, and degree of structuring.

Taking these findings into account, the development of an OIR template for ODA loan projects must ensure alignment with international standards, while also achieving an appropriate balance between practical applicability and flexibility for diverse project contexts.

(1) Design Principles

The following principles are adopted in designing the OIR template:

- Base the structure on ISO 19650-3 Annex A:
Organize information requirements according to the activity groups related to asset and facility management, ensuring a structure that reflects both strategic and operational objectives.
- Ensure structured information and explicit formats:
Allow each information requirement to specify file formats (e.g., .pdf, .dwg, .xls, and IFC) and information container types, thereby facilitating efficient information handover and verification.
- Enable adjustable levels of detail:
Provide a flexible structure that can accommodate both simple and highly detailed descriptions, depending on the characteristics and complexity of the project.
- Clarify responsibility and stakeholder relationships:
Include fields for identifying responsible departments, external stakeholders, and accountable individuals for each information requirement, thereby strengthening the effectiveness of information management.
- Embed change control and continuous-improvement mechanisms:
Incorporate structures for managing revision history, review frequency, and improvement actions to ensure that the OIR remains a living, evolving document.

(2) Proposed Structure of the OIR Template

The proposed OIR template for ODA loan projects is organized into the following four primary sections:

Structure	
1.	Strategic Objectives and Policies
-	Description of organizational objectives
-	Target outcomes (e.g., KPIs)
-	External factors (regulations, international standards, and related requirements)
-	Internal factors (organizational policies, operational plans, and internal guidelines)
-	Related policy documents
2.	Organizational Information Requirements
-	Requirement ID
-	Linkage to relevant strategic objective(s)
-	Description of the information requirement
-	File format (e.g., .pdf, .dwg, .xls, and IFC)
-	Responsible department or team
-	Applicable asset-lifecycle phase (e.g., technical-file preparation, construction, operations)
-	Acceptance criteria and verification method
3.	Organizational Responsibilities
-	Department or team name
-	Type (internal or external)
-	Organization or agency name
-	Specific responsibilities
-	Timing and role in the information-management process
4.	Feedback and Governance
-	OIR change-management process, revision history, and justification for changes
-	Mechanisms for continuous improvement and periodic review
-	Related documents

(3) Application and Potential Use

This template can be implemented in Excel or database formats, allowing each organization to describe and update its OIR and utilize it as a foundational input for developing the AIR, PIR, and EIR.

In ODA projects and public-infrastructure programs, the template functions as a means for the appointing organization to clearly articulate its information strategy.

This approach supports information consistency from the contracting stage through operations and maintenance, ensuring coherence and continuity across the entire asset lifecycle.

6.4.4 Application of OIR to Large-Scale ODA Infrastructure Projects (Railways, Roads, and Airports)

The development and implementation of OIR can significantly contribute to enhanced information management and improving decision-making quality in large-scale infrastructure projects financed through ODA loans, particularly in the railway, road, and airport sectors. These projects involve highly complex structures in which multiple countries and organizations participate, requiring consistent and transparent information management across the entire asset lifecycle.

(1) Characteristics of ODA Loan Projects and the Importance of Information Management

In ODA loan projects, contracting, design, construction, and operations responsibilities are shared between Japan and the recipient country. This often results in challenges, including information asymmetry and uncertain management responsibilities.

Furthermore, because the project involves diverse stakeholders—including international agencies (such as JICA), national governments, consultants, and contractors—standardizing and sharing information requirements becomes essential.

The OIR provides a foundation framework for overcoming these challenges. By clearly expressing the strategic information needs of the implementing agency, OIR establishes a unified direction for project-wide information management, thereby supporting consistent governance across the entire project lifecycle.

(2) Complexity of Information Requirements in Large-Scale Infrastructure Sectors

Railway, road, and airport projects require a broad and diverse range of information due to variety of assets involved, such as structures, systems, equipment, operational processes, maintenance regimes, environmental conditions, and disaster-response requirements.

Information is generated and used in multiple formats and varying levels of detail at each project phase—from design and construction through to operations and maintenance.

Key categories of information include:

- Design deliverables and specifications (.dwg, .pdf)
- Quantity take-offs and cost/budget data (.xls)
- Maintenance plans and O&M manuals (.doc, .pdf)
- Risk assessments and disaster-response plans
- Operational data and performance-monitoring information
- Compliance with international standards

By structuring and organizing these information elements within the OIR, it becomes possible to improve project transparency, enhance quality, and support long-term sustainability. OIR acts as a strategic anchor, ensuring that all subsequent information requirements (AIR, PIR, and EIR) are aligned with the needs of large-scale and complex infrastructure projects.

6.5 Asset Information Requirements (AIR)

The Asset Information Requirements (AIR) define and structure the information needed for a specific infrastructure asset, which is derived from the Organizational Information Requirements (OIR). AIR serves as the framework for information management that supports decision-making related to asset operation, maintenance, and renewal.

For example, in the maintenance of road infrastructure (including pavements, bridges, retaining walls, and other road infrastructures), determining the appropriate timing for repair or renewal requires information such as the types and specifications of materials used, design service life, expected traffic conditions (traffic

volume, vehicle composition, and other traffic conditions), allowable deterioration thresholds (crack ratio and rut depth), deterioration forecasts. When this information is integrated with condition data obtained from site inspections or sensor-based monitoring systems, rational and evidence-based decisions regarding the timing of asset renewal.

For example, if pavement resurfacing is delayed by one year, the structural damage risk may increase substantially—particularly in locations where no alternative routes exist—leading to severe impacts on traffic functionality and service continuity. To avoid such risks, preventive renewal measures may be selected even when deterioration condition have not yet reached critical levels.

ISO 19650-3 provides a framework for information management during the operational phase and introduces the concept of “Trigger Events”.

Trigger events are planned or unplanned occurrences that change the condition or performance of an asset and require the collection, verification, storage, or sharing of information.

Representative examples include asset performance evaluations (failure trends of similar assets, user feedback, and other relative evaluations), planned or emergency maintenance activities, minor repairs, parts replacement, small-scale refurbishments, major repairs or renewals, and full asset replacement. For each trigger event, it is essential to define the information required, and the AIR serves as the reference standard for this purpose.

Additionally, information-management rules must be established for creation, maintenance, and utilization of asset information throughout the entire asset lifecycle.

ISO 19650-3 Annex A provides illustrative examples of information that should be stored in the Asset Information Model (AIM). These examples constitute the specific information elements that form the AIR.

The information is categorized into the following five groups:

(1) Managerial Information

Includes essential information required for asset operation and management, such as:

- Asset identification and location (asset ID and spatial coordinates)
- Spatial data (area, dimensions, and others)
- Warranty periods
- Work schedules
- Preventive maintenance and service history
- Emergency response plans
- Failure history

(2) Technical Information

Covers the structural and functional characteristics of the asset, including:

- Design parameters
- Technical dependencies
- Commissioning data
- Performance characteristics

(3) Legal Information

Covers legal and compliance-related aspects, including:

- Ownership and maintenance responsibilities

- Relevant legal obligations
- Contract information
- Risk assessments

(4) Commercial Information

Covers information needed for operational planning and commercial management, including:

- Asset functions
- Interdependencies with other assets
- Vendor information
- Utilization data
- Key Performance Indicators (KPIs)
- Spare-parts information

(5) Financial Information

Addresses the economic evaluation of the asset, including:

- Lifecycle cost
- Operational expenditure
- Downtime impacts
- Current asset value
- Acquisition or replacement cost

These categories support comprehensive and structured information management across the entire asset lifecycle.

In developing the AIR, organizations must systematically organize these information elements and establish mechanisms to ensure that they can be updated, maintained, and utilized as required.

6.5.2 Overview of the Collected AIR Templates

Before developing an AIR template suitable for ODA loan projects, this section reviews five reference AIR templates and summarizes their structure and key characteristics.

Table 6-4 lists the AIR templates collected for analysis.

Table 6-4 List of Collected AIR Templates

Template Name	Issuing Organization	Year of Publication
BIM Toolkit (UK)	CDBB (Center for Digital Built Britain)	2018
CIC BIM AIR (Hong Kong)	CIC (Construction Industry Council)	2021
CIBSE AIR (UK)	CIBSE (Chartered Institution of Building Services Engineers)	2017
Plan BIM Perú (Peru)	Plan BIM Perú	2021
NATSPEC AIR Template (Australia)	NATSPEC	2022

Source: The JICA Study Team

(1) BIM Toolkit (United Kingdom)

The BIM Toolkit is based on the United Kingdom government's BIM Level 2¹ program and organizes information requirements around Plain Language Questions (PLQ)². It is characterized by the use of the Uniclass 2015 classification system and the specification of deliverables in COBie format.

The clarity of the information purpose is high; however, the level of descriptive detail remains relatively coarse.

Structure
1. Maintainable Assets
1.1 Schedule of Maintainable Assets
2. Information Requirements
2.1 Data Structure
2.2 Asset Information Requirements (AIR)
2.2.1 Maintenance
2.2.2 Sustainability
2.2.3 Asset Operation Efficiency
3. Information Standards, Production Methods, and Procedures
3.1 Information Standards
3.1.1 Information-management Standards
3.1.2 Asset Identification
3.1.3 Asset Information Model (AIM) Deliverables
3.1.4 Information Classifications
3.2 Information Production Methods and Procedures
3.2.1 Soft Landings

(2) CIC BIM AIR (Hong Kong)

Developed for the Hong Kong construction industry, this AIR template aligns with the ISO 19650 series while complying with the CIC BIM Standards. It provides a structured framework for asset-information exchange requirements.

The template makes extensive use of the OmniClass classification system (Tables 11, 14, 22, and 23), features detailed attribute definitions, emphasizes COBie integration, and places strong emphasis on facility management and operational phases.

Structure
1. AIR Overview
1.1 General Information
1.1.1 Asset Information Management Functions (role distribution)
1.1.2 Asset Information Management Systems (systems used and file formats)
1.2 Quality Assurance Procedures
1.2.1 Quality Systems (QA/QC framework)
1.2.2 Responsibility (RACI-based assignment of responsibilities)
2. Asset Information Requirements

¹ BIM Level 2 is one of the BIM maturity levels defined in the United Kingdom. At this level, discipline-specific 3D models are developed and managed within a Common Data Environment (CDE), and information is exchanged based on standardized processes. The models are not integrated (i.e., a federated model approach is used), and information exchange is carried out using appropriate formats and protocols such as COBie or IFC, depending on the intended purpose. For further details, see: [\[Withdrawn\] Creating a Digital Built Britain: what you need to know - GOV.UK](#)

² A Plain Language Question (PLQ) is defined as a "question expressed in simple, non-technical language" used to clarify the Project Information Requirements (PIR). It is designed to enable the Appointing Party to understand and verify the information required at each stage of the project without the need for specialized technical knowledge. PLQs ensure completeness of required information, facilitate informed decision-making, and maintain consistency with contractual documentation. The concept of PLQs is explained and defined in PAS 1192-3, BS 8536, and related standards. For further details, refer to Section 5.8 of the draft handbook.

2.1	AIR Delivery Formats (e.g., rvt, .dwg., .xlsx., .json)
2.2	Model Breakdown Structure for Asset Management (hierarchical model decomposition for FM purposes)
2.3	Systems Breakdown Information (decomposition of asset-management systems.)
2.4	Nomenclature (standardized naming conventions)
2.5	BIM Object Requirements
2.5.1	Library Requirements
2.5.2	Object Library Types
2.5.3	Symbology Requirements
2.6	Classification (application of OmniClass for element and system classification)
2.7	Schedule of Asset (asset lists and standardized templates)
2.8	Accuracy of Information (required accuracy levels for geometric and non-geometric data)
2.9	Schedule of Information Requirements (structured list of all AIR items)
2.10	Key Compliance Requirements (mandatory compliance conditions and checks)
3.	COBie (Construction Operations Building Information Exchange)
3.1	COBie Requirements – Formats (e.g., XML, XLS, COBieLite)
3.2	COBie Requirements (specifications for each COBie worksheet)
3.3	COBie Deliverables Requirements
3.3.1	Schema Requirements
3.4	COBie Contacts (requirements for contact-information fields)
3.5–3.20	COBie Worksheets (requirements for each COBie tab)
	Facility, Floor, Space, Zone, Asset Type, Asset Component, Asset System, Assembly, Spare, Resource, Job, Document, Attribute, and Issue

(3) CIBSE AIR (United Kingdom)

Given that the Chartered Institution of Building Services Engineers (CIBSE) is the principal professional body for building services engineering in the UK, its AIR template is designed specifically for facility-management (FM) use within the building-services domain.

Information requirements are organized in Excel format based on a hierarchical structure comprising Facility → Space → System → Component, with clearly defined classification rules at each level.

Structure
Table 1 – Facility (Information at the Building or Facility Level) - Project name and identification number - Overview and function of the asset - Owner, address, and geographic coordinates - Classification (Uniclass 2015) - Area information (gross floor area/net internal area) - Cost information (construction, maintenance, operations, occupancy, disposal, and revenue) - KPI information, supplier data, and sustainability information (often provided as link or list formats) - Contract, health-and-safety, and risk-assessment information (typically provided as linked documents) Table 2 – Space (Information at the Room or Space Level) - Space name, identifier, and description - Function, owner, and level/floor - Area information (GFA/NIA) - Theoretical occupancy and links to room data sheets Table 3 – System (Information at the Building Services System Level) - System name, identifier, and description - Function, owner, and location/hierarchy - Classification and major constituent components - Performance data, supplier information, and commissioning data Table 4 – Component (Information at the Component or Equipment Level) - Component name, identifier, and description

- Associated system, owner, location, and coordinates
- Classification, condition, and performance attributes
- Supplier, serial number, and installation date
- Warranty information, barcode, and commissioning data
- Spare parts information (linked format)

(4) Plan BIM Perú (Peru)

This AIR template is optimized for public sector projects under Peru's national BIM strategy.

It integrates IFC models with Excel-based deliverable definitions, offering high flexibility and strong linkage with the OIR.

Structure	
1.	Functional Responsibilities of the Investment (<i>Responsabilidad funcional de la inversión</i>)
-	Function
-	Functional Division
-	Functional Group
-	Responsible Sector
-	Service
-	Type of Investment
2.	Asset Information Generated through Investment Management (<i>Datos de los activos a generar en la gestión de inversiones</i>)
1.	Asset Inventory
-	Asset name
-	Asset type (e.g., architectural element, electrical equipment, IT equipment)
2.	Information Requirements for Asset Maintenance
-	Activities (e.g., preventive maintenance and repair)
-	External/internal factors
-	Required information (installation date, warranty, classification, among others)
-	Information container (e.g., .xlsx)
-	Exceptions and acceptance criteria
3.	Information Requirements for Asset Sustainability
-	Activities (e.g., energy-use monitoring)
-	Factors/required information (e.g., CO ₂ emissions, water consumption, waste generation)
-	Container and acceptance criteria
4.	Information Requirements for Asset Operation
-	Activities (e.g., energy efficiency)
-	Factors/required information (forecast vs. actual energy consumption)
-	Container and acceptance criteria
5.	AIR Requirements for AIM Deliverables
-	IFC-based 3D models
-	COBie parameters
-	Drawings (.dxf)
-	Technical specifications
3.	Information Standards, Methods, and Procedures (<i>Normas de información, métodos y procedimientos de producción de información</i>)
-	Information management standards (e.g., <i>Guía Nacional BIM</i>)
-	Asset identification code standards
-	Information classification standards
-	Methods for capturing data from existing assets (e.g., physical inventory)
-	Processes for creation and approval of new information (including regulatory approval)
-	Information security and distribution procedures (e.g., communication protocols)
-	Requirements for providing information to suppliers (e.g., selection process)

(5) NATSPEC AIR Template (Australia)

This template complies with the AS ISO 19650 series and features classification between Spatial Object and Physical Asset Object, as well as deliverables defined in IFC4 and COBie formats.

It also explicitly defines information management procedures and CDE governance.

Structure	
1.	Document Overview - Alignment with AS ISO 19650 - Purpose and scope (design, construction, and operational phases)
2.	Project Details - Project description - Project objectives (priorities and success indicators)
3.	Commercial Information - Procurement strategy - Project-team structure - Common Data Environment (CDE) - Asset information delivery milestones - Existing conditions information - Purpose of asset information - AIM integration strategy (Asset Information Model) - AIM deliverables: - Formats for deliverables - As-built models - Asset management models - Record drawings - Record documents - Record data - Spatial object properties - Physical asset object properties required in the AIM
4.	Management - AIM quality assurance - Information security and privacy - CDE management
5.	Technical - Asset identification - Model object and project naming conventions (aligned with IFC) - Standards and reference information - o Project Information Standards Directory - o Production Methods and Procedures Directory - o Reference Information Directory - o Shared Resources Directory
6.	Annex - Reference documents (e.g., ABAB, BS 8536, Soft Landings, OBOS, and other relevant documents)

6.5.3 Comparative Analysis of the AIR Templates

This section compares the five AIR templates collected in Section 6.5.1 from the perspectives of information purpose, asset structure, deliverable formats, information-management procedures, and assignment of responsibilities.

The alignment with ISO 19650-3 and the potential for linkage with the OIR are also analyzed.

(1) Information Purpose and Description Method

Each template differs substantially in how it describes information purposes:

NATSPEC

Organizes AIR using the “Asset Information Purposes Table”, which aligns closely with the five categories in ISO 19650-3 Annex A (managerial, technical, legal, commercial, and financial). This approach ensures high level of consistency with the AIM structure.

UK (BIM Toolkit, CIBSE)

Uses Plain Language Questions (PLQs) to clarify the purpose of information; however, the direct linkage to OIR is limited.

Peru (Plan BIM Perú)

Classifies information according to functional responsibilities. This method provides considerable flexibility but may present challenges for standardization across projects.

(2) Differences in Asset Classification Systems and Hierarchical Structures

CIBSE employs a clear hierarchical structure of Facility → Space → System → Component, which is suitable for FM. Classification of spaces, systems, and components is explicitly defined. NATSPEC categorizes assets as Spatial Objects and Physical Asset Objects and maps these to IFC4 property sets.

The UK and Hong Kong employ construction-classification systems such as Uniclass 2015 or OmniClass. However, the linkage between these classification systems and the AIR is primarily attribute-based, with limited structural definition. Peru utilizes a custom classification system designed for public-investment workflows, providing flexibility for project-specific adaptations.

(3) Comparison of Deliverable Formats and Submission Requirements

NATSPEC supports the widest range of deliverable formats, explicitly including IFC, COBie, PDF, Excel, JSON, and others, and clearly specifies delivery milestones and verification procedures. Peru (Plan BIM Perú) employs a hybrid model combining IFC and Excel, which is highly practical for public-sector project delivery. The UK and Hong Kong focus on COBie-based deliverables, typically with relatively coarse granularity. CIBSE uses Excel-based structures, but with comparatively simpler deliverable definitions.

(4) Comparison of Information-Management Procedures and Responsibility Structures

NATSPEC provides the most detailed guidance, including RACI-based responsibility allocation³, CDE management, QA/QC procedures, and information handover and update processes. It aligns closely with ISO 19650-3 Clause 5.1 requirements. Peru defines practical procedures and responsibility structures, particularly suitable for public infrastructure projects. The UK and Hong Kong responsibility structures are primarily included in the BEP, with limited direct linkage to AIR. CIBSE uses table formats to show responsibilities, however, with limited depth.

(5) Alignment with ISO 19650-3

When evaluated against the 13 requirements of ISO 19650-3 Clause 5.1:

NATSPEC shows the highest compliance, with comprehensive coverage of OIR establishment, AIR definition, CDE management, AIM definition, information protocols, and more. Peru provides high alignment while balancing flexibility and practical applicability; however, standardization challenges remain. The UK, Hong Kong, and CIBSE address some elements of Clause 5.1, but direct alignment with ISO 19650-3 requirements is limited.

(6) Linkage with OIR

NATSPEC clearly defines “information purposes,” deliverables, responsibility allocation, and verification methods, facilitating efficient integration with the OIR structure. Peru’s system is designed with explicit

³ Refers to the ISO 19650-2 Annex A: Information Management Assignment Matrix, which clarifies the allocation of responsibilities among the Appointing Party, Lead Appointed Party, and Appointed Parties. The matrix is commonly referred to as RACI, derived from the initials of its key responsibility categories.

linkage to OIR, making it practical for public-sector implementation. The UK, Hong Kong, CIBSE refuse to directly assume integration with OIR, as additional complementary design is required to connect AIR with the higher-level information-requirements hierarchy.

6.5.4 Structure of the AIR Template for ODA Loan Projects

Building on the comparative analysis conducted in the previous sections, this section presents proposed design principles for an AIR template customized to ODA loan projects.

The structure is designed with explicit linkage to the Organizational Information Requirements (OIR) and considers practical application and scalability across major infrastructure sectors such as railways, roads, and airports.

(1) Design Principles

Because ODA loan projects involve the appointing organization, design–construction–operations teams, and diverse multinational stakeholders, the following principles are essential in developing the AIR:

- **Alignment with international standards:**
Structure the AIR on ISO 19650-3 to ensure transparency and reproducibility of information-management processes.
- **Integration with the OIR:**
Link AIR items directly to strategic objectives (KPI, organizational policies), clarifying the purpose of the information and its deliverables.
- **Cross-sector flexibility:**
Design the AIR to be applied across multiple infrastructure sectors (rail, road, airport, utilities, and public buildings).
- **Standardization of deliverables:**
Specify the required formats of deliverables—construction classification codes, IFC, COBie, PDF, Excel spreadsheets—to enforce consistent submission requirements.
- **Clear responsibilities and verification:**
Define responsibility for creation, review, approval, and acceptance criteria to ensure effective information governance.

(2) Linkage with the OIR Template Structure (Proposed)

Assuming the OIR template structure (Sections A–D), the AIR is designed to map directly to each OIR component. Table 6-5 shows the relationship between OIR sections and AIR components. This ensures consistency between OIR goals, AIR deliverables, responsibility allocation, and governance processes.

Table 6-5 Correspondence Between AIR Components and OIR Template Sections

OIR Section	Corresponding AIR Component
A. Strategic Objectives and Policies	Information purpose, linkage to KPIs
B. Organizational Information Requirements	AIR items, deliverable formats, delivery milestones
C. Organizational Responsibilities	RACI matrix, information-management procedures, CDE governance
D. Feedback and Governance	Information-update procedures, review mechanisms, legal basis

Source: The JICA Study Team

(3) Proposed Structure of the AIR Template

Below is the proposed structure of an OIR-linked AIR template for ODA loan projects.

Structure
1. Purpose and Scope of the AIR - Applicable project name and reference number - Asset scope (facilities, infrastructure, equipment, systems, and related elements)

-	Purpose of information management (maintenance, operations, finance, sustainability, safety)
-	Linkage to OIR objective IDs/KPIs
-	Applicable lifecycle phases (design, construction, operations)
2.	AIR Item List
-	AIR ID
-	Description of the required information
-	File format (e.g., .pdf, .dwg, .xls, .ifc)
-	Project milestone/delivery timing
-	Acceptance criteria and verification method
3.	Asset Classification and Deliverable Structure
-	Spatial objects (Space)
-	Physical asset objects (Physical)
-	Asset breakdown structure (ABS)
-	Classification codes (e.g., Uniclass)
-	Deliverable types (models, drawings, documents, data)
-	Level of information need (LOIN) definitions and granularity
4.	Information-Management Structure and Responsibilities
-	RACI matrix (Responsible, Accountable, Consulted, Informed)
-	Department or team responsible
-	External stakeholders (consultants, contractors, operators)
-	Procedures for information creation, review, and approval
-	CDE management responsibilities and access permissions
5.	Information Update, Review, and Governance
-	Information-update procedures and frequency
-	Feedback loop design (e.g., operational feedback reflected back into the OIR)
-	Alignment with relevant legislation and guidelines
-	Method for recording approvals and change rationale

This proposed AIR template adheres to ISO 19650-3 Clause 5.1 while incorporating explicit linkage to the OIR. It is designed to support both standardization and practical implementation of information management for ODA loan projects.

The next chapter examines how this template can be applied to large-scale sector-specific projects such as railways, roads, and airports.

6.5.5 Deployment of AIR Templates for Large-Scale ODA Infrastructure Projects (Rail, Road, Airport)

This section examines the potential application of the OIR-linked AIR template proposed in the previous section to major infrastructure sectors—namely railways, roads, and airports.

These sectors involve large-scale, complex projects where advanced and standardized information management is essential.

(1) Sector-Specific AIR Structure Examples

Railway Sector

Railway projects typically comprise major asset groups such as track, station facilities, signaling and telecommunications, power supply, and depots. According to JICA's Railway Operation and Maintenance Handbook (2022)⁴, asset-management targets and responsibilities are categorized by O&M division.

Examples of representative “trigger events” include:

- Renewal of rolling stock or signaling systems
- Facility refurbishment (e.g., seismic reinforcement of track or station buildings)

⁴ [Project Study on Railway Operation and Maintenance Summary_12373247](#)

- Response to operational incidents or accidents (e.g., injury, derailment, flooding, fire)
- Periodic inspections and preventive maintenance (e.g., routine checks of track and power equipment)

Typical deliverables for railway projects include IFC models (stations and structures), COBie datasets (equipment attributes), PDF drawings (design documents), and Excel files (inspection records).

Road Sector

Road projects encompass pavements, bridges, drainage structures, signage, lighting, tunnels and tunnel-related systems, ITS facilities, and related infrastructure elements.

For example, the Road Operation and Maintenance Plan⁵ prepared for an ODA project in Cambodia categorizes maintenance activities into three groups:

- Routine Maintenance (e.g., road cleaning, signboard repairs, drainage cleaning, tunnel cleaning)
- Periodic Maintenance (e.g., resurfacing, painting of steel bridges, renewal of tunnel equipment)
- Emergency Maintenance (e.g., post-disaster recovery, repairs after traffic accidents)

Likely “trigger events” include natural disasters (floods and earthquakes), sudden increases in traffic, structural deterioration, and accidents. Typical deliverables for road projects include GIS-linked IFC models, PDF drawings, inspection reports, and comprehensive asset inventories.

Airport Sector

Airport projects span multiple disciplines, including buildings, civil works, equipment, aviation systems and may comprise passenger terminals, cargo facilities, runways, taxiways, airfield lighting, fuel systems, and control towers.

Relevant international standards and guidance include:

- ICAO 6 International Standards and Recommended Practices—Annex 14 Aerodromes (including related manuals, mainly covering civil works and utilities)
- ICAO Eco-Airport Toolkit e-Collection (environmental and sustainability topics)
- IATA Airport Development Reference Manual (primarily guidance for building facilities)

Based on these, typical trigger events include:

- Routine inspections: daily, periodic, and detailed inspections
- Disasters: emergency inspections following natural disasters or aircraft accidents; snow removal operations
- Infrastructure renewal: runway-pavement replacement, building and equipment renewal (typically more frequent for equipment); LED conversion of airfield lighting
- Standards revisions: updates to noise or emissions standards, revisions of facility requirements
- Operational changes: expansion of runway, passenger, or cargo capacity; VIP or charter operations; adjustments to operating hours
- Sustainability and environmental initiatives: greenhouse gas reduction, renewable-energy deployment, improved waste management, smart-building integration

Typical deliverables for airport projects include:

- IFC models covering buildings and equipment

⁵ [The feasibility study on the improvement of National Road No.1 \(Phnom Penh-Neak Loueng section\) in the Kingdom of Cambodia 11721644_09](#)

⁶ [ICAO SAF Airports](#)

- COBie datasets for FM attributes
- 3D/2D data for landfill, embankment, and coastal-protection works
- Inspection and construction photos or videos
- Laboratory test results
- Environmental assessment reports

Regarding ICAO Annex publications:

Annexes—including Annex 14—form the basis of national aviation laws in member states that have ratified the Chicago Convention.

However, operational manuals, design guides, and airport procedures may either adhere to ICAO manuals or be developed independently by each country or airport.

For example, Japanese aviation law is based on ICAO Annexes, but design manuals and operational guidelines are developed domestically. Therefore, for ODA airport projects, it is essential to refer to the actual manuals and procedures employed by the target country or airport when developing the AIR.

Airports involve diverse set of stakeholders, including facility operators, air-traffic control (ATC), customs/immigration/quarantine (CIQ), fuel suppliers, communications operators, police, fire services, and government agencies—often managed by separate bodies.

Moreover, airport maintenance requires thorough planning, as stopping aircraft movements or passenger/cargo processing is extremely difficult.

(2) Sector-Specific Asset Classification and Management Structures

Asset classification generally organized according to system-level groupings:

- Railways: track, signaling/communications, power, stations, and depots
- Roads: pavement, bridges, drainage, tunnels, and ITS
- Airports: passenger, cargo, air-traffic services, and utilities

Management structures vary by sector:

- Rail: separation of operations and maintenance
- Road: division between central and local authorities
- Airports: coexistence of private-sector operators and international regulatory requirements

Consequently, the AIR template must explicitly define responsibility allocation and information-flow designs appropriate to each sector's organizational model.

(3) Anticipated Implementation Challenges

Implementing AIR in ODA projects may encounter several challenges:

- Inconsistent classification systems:
Each sector employs different classifications, requiring alignment between engineering/BIM classifications (IFC, Uniclass, and similar standards) and local asset-management classifications.
- Multilingual and multicultural requirements:
Bilingual documentation (English + local language) is often required, along with accurate translation of technical terminology, and interoperability document formats.
- Insufficient information-update frameworks:
Trigger events and responsibility allocation may be unclear, resulting in reduced responsiveness and loss of real-time accuracy during the operational phase.

6.6 Project Information Requirements (PIR)

The Project Information Requirements (PIR) define and structure the information necessary at each stage of a specific project to support appropriate decision-making.

The PIR is developed based on the OIR and AIR, taking into account the project's objectives, scope, constraints, and stakeholder environment. A key function of the PIR is to identify decision points that arise as a project progresses, and to specify the information required at each decision stage in advance.

For example, when transitioning into the design stage, the following types of information may be required:

- Planning drawings and preliminary models, including geometry and attributes
- Outline construction cost estimates and budget allocation proposals
- Technical, environmental, and social risk assessments
- Construction schedule and key milestones
- Status of stakeholder and community consultation

These items support informed decision-making at each project stage. Clearly defining them helps prevent delays or incorrect judgments resulting from missing, incomplete, or insufficient information.

When establishing the PIR, it is desirable to define the required types, levels of accuracy, and timing of information, taking into account project characteristics, stakeholder configurations, and external factors. The PIR should be operated together with the project's information-management structure.

ISO 19650-2 Clause 5.1.2 states that the following factors should be considered when formulating the PIR:

- Project scope
- Purpose for which information will be used
- Project Plan of Work
- Procurement route
- Number and nature of decision points
- Key questions required for each decision (PLQ: Plain Language Questions)

These elements form the foundation for collecting, organizing, and delivering information, and they function as the starting point of the information management process.

The PIR directly influences the subsequent stages of the ISO 19650-2 information-management framework, including establishing information-delivery milestones (Clause 5.1.3), defining information standards (Clause 5.1.4), establishing information-production methods and procedures (Clause 5.1.5), and preparing the Exchange Information Requirements (EIR) (Clause 5.2.1),

In practice, a well-defined PIR enables the appointing organization to set clear expectations regarding project deliverables by formalizing requirements for information quality, timing, and format. The PIR ensures consistency during the design, construction, and operational phases.

This clarity is especially important in international ODA loan projects, where multiple organizations and stakeholders are involved. A well-articulated PIR contributes to improved transparency and traceability of information.

6.6.1 Overview of the Collected PIR Templates

Before developing a PIR template suitable for ODA loan projects, this section reviews five reference templates and summarizes their structures and key characteristics. These templates are based on information-management frameworks aligned with the ISO 19650 series and are designed to support decision-making by the appointing organization through clearly defined information requirements.

Table 6-6 List of Collected PIR Templates

Template Name	Issuing Organization	Year of Publication
BIM Toolkit (UK)	CDBB (Centre for Digital Built Britain)	2018
CIC BIM PIR (Hong Kong)	CIC (Construction Industry Council)	2021
CIBSE PIR (UK)	CIBSE (Chartered Institution of Building Services Engineers)	2017
Plan BIM Perú (Peru)	Plan BIM Perú	2021
NATSPEC PIR Template (Australia)	NATSPEC	2022

Source: The JICA Study Team

(1) BIM Toolkit (United Kingdom)

Based on the UK government's BIM Level 2 initiative, the BIM Toolkit presents the Project Information Requirements (PIR) in the form of Plain Language Questions (PLQ) to support decision-making by the appointing organization.

In addition to clarifying the project purpose and information-delivery milestones, it adopts COBie for deliverable deliverables and Uniclass 2015 for classification, placing emphasis on structured and standardized information.

Structure
1. Project Scope 1.1 Project Purpose Background and rationale for the project (e.g., replacement of aging assets, improved energy performance through new construction) 1.2 Project Objectives Budget compliance, stakeholder engagement, sustainability commitments, and others 1.3 Project Details Project type, location, procurement route, operational start date, and team structure 1.4 Legacy Information List of existing information (models, drawings, specifications, among others) 2. Plan of Works 2.1 Information Delivery Milestones List of information-delivery milestones across project stages Examples: preparation of the brief, feasibility studies, and spatial coordination Each milestone includes the responsible team/discipline and associated dates. 3. Information Requirements 3.1 Project Information Requirements (PIR) Information requirements aligned with each milestone Examples of information requirements: occupancy levels, maintenance budgets, CO₂ emissions, energy consumption Additional information: External influencers (such as the environmental performance of the building and client policies) Deliverable formats (e.g., Excel, PDF) Acceptance criteria (including compliance with project specifications and information standards)

(2) CIC BIM PIR (Hong Kong)

Developed for the Hong Kong construction sector, this PIR template aligns with the ISO 19650 series while conforming to the CIC BIM Standards. It provides a structured framework for project information exchange requirements, with an emphasis on facility management (FM) and the operational phase, and it is designed with the assumption of integration with COBie.

Information requirements are defined in relation to the appointing organization's decision points, with descriptions including attributes, formats, and verification criteria—resulting in a template optimized for practical use.

Structure
1. Project Information Requirements 1.1 General Information - Roles and responsible persons, such as Delivery Manager, Information Manager, and Security Information Manager - Project-management platforms, CDE solutions, and software environments that are used - Supported file formats: .pdf, .dwg, .rvt, .xlsx, .ifc, etc. 1.2 Quality Assurance Procedures - Quality-management processes - References to supporting documents 2. Project Requirements 2.1 Project Scope 2.2 BIM Uses 2.3 Plan of Work 2.4 Procurement Route and Processes 2.5 Milestones and Decision Points 2.6 Appointing Organization Decision and Response Requirements 3. Information Requirements 3.1–3.15 Information Requirements Linked to OIR - Information requirements are structured to correspond to the following policy domains: - Capital investment and lifecycle cost - Health and safety management - Security management - Emergency response and contingency planning - Environmental management - Sustainability - Supply-chain management - Space utilization - Risk assessment and management - Maintenance and repair - Asset refurbishment - Asset operations - Training, skills, and competency - Technology adoption - Value management

(3) CIBSE PIR (United Kingdom)

As the Chartered Institution of Building Services Engineers (CIBSE) is a professional body specializing in building-services engineering, its PIR template is designed specifically for facility-management (FM) applications within the building-services domain.

The template follows the RIBA Plan of Work and organizes PLQs (Plain Language Questions) in Excel format for each project stage. Each question can specify a data type and link to supporting documents, enabling efficient information collection and management.

The level of detail is relatively high, making the template well-suited for practical implementation.

Structure
1. Stage-Based Organization (Aligned with the RIBA Plan of Work) - The template is divided into the following eight stages: - Stage 0: Strategic Definition - Stage 1: Preparation and Brief - Stage 2: Concept Design - Stage 3: Developed Design - Stage 4: Technical Design

- Stage 5: Construction - Stage 6: Handover and Closeout - Stage 7: In Use
2. Items Included in Each Stage Each stage contains a table-based PIR with common columns: - Ref: question reference number (e.g., 1/1, 2/5) - Question: Plain Language Question Example: "What is the building's net usable area?" - Data Type: the format of the required answer e.g., Number, Text, Boolean - Document: related documents e.g., drawings, specifications, and reports
3. Supplementary Sheet: Picklists A separate sheet defines selectable data types such as: Number, Integer, Text, Boolean, and Document This allows the appropriate response format to be assigned to each PLQ.

(4) Plan BIM Perú (Peru)

This PIR template is designed for public-investment projects under Peru's national BIM strategy.

Information requirements corresponding to each stage of the investment cycle are defined alongside activities, deliverables, and verification criteria. It supports multiple deliverable formats—IFC models, PDFs, and native authoring formats—and is structured to integrate with the OIR, achieving both institutional alignment and practical usability.

Structure
A. Investment Data (<i>Datos de la inversión</i>) - Investment code (CUI) - Investment name - Investment objectives (primary objectives and BIM information-management objectives) - O&M handover date, delivery approach - Responsible team (roles, BIM roles, names, e-mail addresses) - Reference information (information containers, formats, URLs)
B. Institutional Framework (<i>Institucionalidad</i>) - Government level (local / central) - Involved organizations (OPMI, UF, UEI) - Names and responsible persons for each organization - Funding sources for the project
C. Functional Responsibilities (<i>Responsabilidad funcional</i>) - Function, department, group, Responsible sector, Service category, Investment type
D. Investment-Cycle Planning (<i>Planificación del desarrollo</i>) - Work Plan (<i>Plan de trabajo</i>) - Phase, milestone, activity, responsible team, deadline - Project Information Requirements (<i>Requisitos de información del proyecto</i>) - Each phase and milestone, activities - External and internal factors (e.g., laws, regulations) - Required information (e.g., drawings, models, manuals) - Container formats (PDF, IFC, native formats) - Acceptance criteria (including compliance with project specifications and applicable standards)

(5) NATSPEC PIR Template (Australia)

The NATSPEC PIR template is a highly structured document aligned with the AS ISO 19650 series. Its distinguishing feature is the organization of information requirements according to information purposes (design, construction, and operation & maintenance).

The template provides detailed descriptions of the Project Information Model (PIM) structure, deliverable formats, and attribute definitions for spatial and physical asset objects.

It also promotes the use of IFC4-compliant property sets, ensuring compatibility with international standards while maintaining practical applicability.

Structure	
1.	Document Overview
-	Alignment with AS ISO 19650
-	Purpose and scope of the PIR
2.	Project Details
-	Project description
-	Project goals and success indicators (Project Goals Table)
3.	Commercial Information
-	Procurement strategy (e.g., Design–Bid–Build, Design and Construct)
-	Project-team structure
-	Provision, access, and use of the Common Data Environment (CDE)
-	Project Information Delivery Milestones Table
-	Existing conditions information
-	Project Information Purposes Table defining:
-	Information purposes (Design, Construction, and Project Management)
-	Specific information requirements for each purpose
-	PIM integration strategy (Project Information Model strategy)
-	PIM deliverables (formats for PIM outputs)
-	Properties for spatial objects
-	Properties for physical asset objects
4.	Management
-	PIM quality assurance
-	Information security and privacy
-	CDE management
5.	Technical
-	Asset identification
-	Model object and project naming conventions (aligned with IFC)
-	Standards and reference information:
-	Project Information Standards Directory
-	Production Methods and Procedure Directory
-	Reference Information Directory
-	Shared Resources Directory

6.6.2 Comparative Analysis of PIR Templates

This section analyzes the characteristics and differences among the PIR templates reviewed in the previous section, with reference to the components defined in ISO 19650-2.

(1) Degree of Alignment with ISO 19650-2

The NATSPEC PIR (Australia), CIC BIM PIR (Hong Kong), and Plan BIM Perú (Peru) templates all clearly address the six elements defined in Clause 5.1.2 of ISO 19650-2.

Among them, NATSPEC demonstrates the strongest alignment with international standards, as it comprehensively covers requirements across Clause 5.1, including information standards, CDE operation, attribute definitions, and deliverable formats.

In contrast, the BIM Toolkit (UK) and CIBSE PIR (UK) rely primarily on Plain Language Questions (PLQs). Although they are excellent at identifying information required for decision-making, their descriptions related to procurement routes and integration with information standards are limited.

(2) Description Method and Level of Detail of Information Requirements

BIM Toolkit and CIBSE PIR

Use PLQs to elicit information directly linked to organizational decision-making. CIBSE is particularly structured, using the RIBA Plan of Work with stage-based PLQs covering information needs from design through to operation.

NATSPEC PIR and CIC BIM PIR

Classify information requirements by information purpose (design, construction, project management, and others) and link these with attribute definitions and deliverable formats, enhancing structured data and verification capability.

Plan BIM Perú

Tailored for public-investment projects, balancing institutional alignment and practical implementation. It includes explicit deliverable formats and acceptance criteria, offering high operational flexibility.

(3) Flexibility and Scalability in Practical Implementation

NATSPEC

Ensures the consistency and reusability of information by adopting international standards, such as IFC4. It also defines CDE usage and establishes information protocols, making it particularly suitable for large-scale infrastructure projects.

Plan BIM Perú

Structures information requirements according to the investment cycle, enabling efficient, phase-specific deliverable management.

BIM Toolkit and CIBSE PIR

Offer lightweight, user-friendly formats that are well-suited for small-scale projects or early adoption phases. However, additional design work is required when integrating them with broader data structures or attribute-based information management systems.

Overall, each template reflects the institutional environment, project scale, and BIM maturity of its target context. For ODA loan projects, both ISO 19650-2 alignment and compatibility with procurement and deliverable-management workflows are essential, making NATSPEC and Plan BIM Perú particularly valuable references.

(4) Linkage with OIR and AIR

NATSPEC

Is clearly separated from the AIR template. The PIR covers information requirements for the delivery phase (design and construction), while the AIR addresses operational-phase asset information. Both are designed to integrate into the EIR, and the structure maintains consistency with the OIR.

Plan BIM Perú

Is based on national policy objectives (OIR-equivalent) and organizes the AIR and PIR according to project phases. This results in a clear hierarchical structure of information requirements that is suitable for public-sector projects.

CIC BIM

Explicitly considers linkage with FM information (AIR). Its use of OmniClass and COBie enables a smooth transition of data into the operational phase.

BIM Toolkit and CIBSE

Use PLQs to extract information needed for organizational decision-making. This approach aligns well

with OIR purposes; however, linkage to AIR or structured asset information is limited and would require complementary design work.

6.6.3 Structure of the PIR Template for ODA Loan Projects

Based on the requirements of ISO 19650-2 and the comparative analysis of international PIR templates, this section presents a proposed structure for a PIR template specifically tailored to ODA loan projects.

(1) Design Principles

To ensure the reliability, transparency, and reusability of information in ODA loan projects, the PIR shall be developed using a systematic approach that is consistent with the ISO 19650 series.

In particular, project-phase information requirements (PIR) must be aligned with the higher-level OIR and AIR, and must remain consistent with contractual specifications and list of deliverables.

The key design principles are as follows:

- **Alignment with international standards**
Ensure full coverage of the elements defined under ISO 19650-2 Clause 5.1.2, including project scope, information purposes, plan of work, procurement route, decision points, and description of required information.
- **Connection with the OIR**
Reflect JICA's project objectives and benefit indicators (KPIs) in the information purposes. Indicate explicitly which policy goal or OIR item each information requirement addresses.
- **Connection with the AIR**
Ensure that information collected during the delivery phase (design and construction) can be used in the operational phase as AIM data by harmonizing attribute definitions, identifiers, and classification systems.
- **Consistency with contract and deliverable management**
Information requirements defined in the PIR must be conveyed through the EIR, and subsequently incorporated into contractual specifications, deliverables schedules, and submission timelines.
- **Integration with the CDE (Common Data Environment)**
Define how information is stored, shared, approved, and submitted within the CDE. Clarify status management (WIP/Shared/Published/Archive) and access-control rules.
- **Flexibility across sectors and project phases**
Structure the PIR so it can be applied to different infrastructure sectors such as railways, roads, and airports, and adapted to the information needs of each project phase (design, construction, and operational readiness).

By adopting these design principles, the PIR template will ensure information consistency, traceability, and reusability, while also supporting transparency and effectiveness within international procurement and contracting processes commonly used in ODA loan projects.

(2) Proposed Structure of the PIR Template

Below is the proposed structure for a PIR template specifically tailored to ODA loan projects.

Each item is designed to align with ISO 19650-2 requirements and maintain firm relationship with both the OIR and AIR.

Structure	
1.	Project Basic Information
-	Project name
-	Location
-	Contract category

-	Procurement route (e.g., Design-Bid-Build, Design-Build)
-	Appointing organization (agency name, responsible department, contact details)
-	Related documents
2.	Project Purpose and Objectives (Linked to OIR)
-	Project objectives
-	Policy objectives/KPIs
-	Linkage to relevant OIR objectives
3.	Information-Delivery Milestones
-	Design phase (e.g., completion of basic design, detailed design, approvals)
-	Construction phase (e.g., commencement, interim inspections, completion)
-	Operational-readiness phase (e.g., handover, commencement of operations)
-	Decision points and submission deadlines corresponding to each milestone
4.	Information Purposes and Information Requirements
-	Information purpose (Design/Construction/Operational Readiness)
-	Information Requirement ID
-	Information content (e.g., design drawings, quantity schedules, construction plans)
-	Deliverable formats (.pdf, .xls, .ifc, native formats, among others)
-	Acceptance criteria (e.g., compliance with IFC4 requirements)
-	Linkage to AIR (asset attributes, identification codes, among others)
5.	Deliverable Definitions
-	Types of deliverables (models/drawings/documents/datasets)
-	Submission formats and verification methods
6.	Information Standards and Naming Conventions
-	Classification system (IFC/Uniclass/OmniClass)
-	Naming conventions (information container IDs, version control, and others)
7.	CDE Operation Policy
-	Platform to be used (e.g., ProjectWise, BIM 360)
-	Access control and status-management rules
-	Information sharing and approval workflows
8.	Information Acceptance and Verification Criteria
-	Review procedures (design review, construction review)
-	Approval processes (responsible persons, deadlines, documentation requirements)
9.	Reference Information and Shared Resources
-	Existing drawings, geotechnical surveys, design standards
-	Templates, libraries, and past deliverables
-	Linkage to AIR (use of existing asset information)

6.6.4 Deployment for Large-Scale Railway, Road, and Airport Projects in ODA Loan Projects

This section summarizes key considerations and application principles for deploying the proposed PIR template structure in the major infrastructure sectors relevant to ODA loan projects: railways, roads, and airports.

Because these sectors differ in asset characteristics, procurement approaches, and operational frameworks, sector-specific factors must be incorporated into the design of PIR information requirements.

(1) Application to the Railway Sector

Characteristics and Challenges

- Coexistence of linear assets (track, power, signaling, telecommunications) and facility assets (stations, depots).
- High level of information granularity required due to integration with operational control and maintenance systems.
- It is essential to ensure smooth handover of information to the railway operator during operational readiness.

Application Principles

- Define separate information purposes for linear and facility assets within the PIR, and organize requirements per design, construction, and operational-readiness stages.
- Strengthen the linkage with the AIR by standardizing equipment identifiers, maintenance cycles, and IFC attributes.
- In the CDE, use asset classification systems (e.g., Uniclass) for track, power, and building-services domains to ensure consistency and data retrievability.

(2) Application to the Road Sector**Characteristics and Challenges**

- Broad asset categories: earthworks, pavements, structures (including bridges and tunnels), roadside facilities (such as signage, lighting, tunnel equipment, and ITS).
- Strong need for GIS integration.
- High connectivity with AIR requirements and the necessity for information sharing with local authorities.

Application Principles

- Define PIR information purposes under three categories: structures, equipment, and geospatial data; identify information that is required for construction planning, quantity calculations, and maintenance preparation.
- Store existing information (e.g., geotechnical surveys and alignment plans) in the CDE for reuse during design and construction.
- Link PIR to the AIR by harmonizing attributes and identification codes for pavements, bridge components, lighting systems, and other related assets, enabling reusability in the operational phase.

(3) Application to the Airport Sector**Characteristics and Challenges**

- Requires integrated management across buildings (terminals), civil works (runways and taxiways), and utilities (fuel supply, power, communications, and water/sewer systems).
- Must align with international standards issued by ICAO and IATA.
- Long-term operational information is essential, especially for maintenance and equipment renewal.
- Involves of diverse stakeholders (airport operators, ATC, CIQ agencies, airlines, tenants, utility providers, police, fire services, and government authorities).
- Many airports implement phased expansions while continuing operations.

Application Principles

- In the PIR, define information purposes for each phase (design, construction, operations) and for each facility category, and organize deliverables, verification criteria, and handover methods.
- Introduce attribute definitions aligned with ICAO/IATA standards (e.g., facility codes, operational categories).
- In linking the PIR with the AIR, define requirements for commissioning data, consumables and spare-parts data, maintenance manuals, equipment maintenance information, and inspection histories, ensuring seamless transfer into the AIM.
- Explicitly define information needs for construction during live airport operations, for example:

- Temporary taxiway closure plans and NOTAM issuance (civil works);
- Restricted-access areas and scheduling constraints (buildings); and
- Measures enabling the safe coexistence of operations and construction.

(4) Common Deployment Principles Across All Sectors

- **Alignment with OIR:**
Ensure project-specific objectives (e.g., safety improvements, service reliability, and environmental performance) are reflected in the PIR for information purposes and are appropriately mapped to KPIs.
- **Connection with AIR:**
Harmonize attribute definitions and identification codes so that information captured during construction is directly reusable in operational phase asset management.
- **Consistency with Contract Documentation:**
Information requirements defined in the PIR must be reflected in the EIR, informs contractual specifications, deliverables lists, and submission schedules.
- **Use of the CDE:**
Apply domain-specific classification and access-control rules to improve information sharing and streamline approval workflows among all stakeholders.

6.7 Exchange Information Requirements (EIR)

The Exchange Information Requirements (EIR) are documents that the asset owner or its representative (the appointing organization) is responsible for preparing at the tender-invitation stage of a project.

The EIR defines the content, standards, and procedures for the information that must be provided throughout the project. It functions as a common standard that all parties are required to follow when submitting information, thereby ensuring information consistency and quality.

In addition, the EIR should ideally include, as appendices, the templates for the BIM Execution Plan (BEP), Master Information Delivery Plan (MIDP), and Task Information Delivery Plan (TIDP)—described in Section 6.8.5—as well as methods for evaluating the capability of the supply chain.

The EIR is generally divided into the following three domains:

- **Technical Requirements:**
Specifies the required level of information detail (geometric and attribute information), types and volume of required information, and required software and data formats.
- **Management Requirements:**
Defines processes and procedures for creating, checking, and sharing information.
- **Commercial Requirements:**
Outlines required deliverables, submission timing, and the intended purposes of information use.

ISO 19650-2 provides a structured list of elements to be considered when preparing the EIR, forming the foundation for effective project information management.

Clause 5.2.1 specifies that the appointing organization must consider the following:

- **Classification of Information Requirements:**
 - Organizational Information Requirements (OIR)
 - Asset Information Requirements (AIR)
 - Project Information Requirements (PIR)
- **Level of Information Need (LOIN):**

- Define the required level of detail for each information requirement, including both geometric and attribute information.
- **Acceptance Criteria:**
 - Project Information Standards
 - Information Production Methods and Procedures
 - Use of reference information and shared resources
- **Supporting Information:**
 - Existing asset information
 - Shared resources
 - Supporting documents and guidelines
 - Applicable international, national, and industry standards
 - Examples of similar deliverables for reference
- **Deadlines, Milestones, and Decision Points:**
 - Delivery deadlines for each information requirement
 - Aligned on information-delivery milestones and decision points
 - Time required for information review and approval
 - Internal assurance processes of the appointing organization

Beyond the ISO-defined elements, it is desirable for the EIR to include explicit descriptions such as:

- Training requirements
- Security requirements
- Work plans, data segregation rules, and standardized naming conventions
- Requirements for coordination and clash detection
- Collaboration rules and methods
- Information to include or exclude in models and datasets
- Technical constraints (file size, formats, and software versions)
- Compliance plans
- Coordinate systems and reference points
- Required software and versions
- Timing, purpose, and format of information exchange
- Strategic purposes of information use
- Initial responsibility matrix
- Modifications to roles, responsibilities, and authorities defined in the contract
- Supply-chain capability assessment criteria

The EIR is a core document within the ISO 19650 information-management framework. By clarifying the information required at each project stage, it supports efficient and secure information workflows.

In multi-stakeholder projects—particularly international ODA loan projects—the establishment of a strong

EIR ensures information consistency, transparency, and traceability, contributing significantly to the overall improvement of project quality.

6.7.1 Overview of the Collected EIR Templates

Before developing an EIR template suitable for ODA loan projects, this section reviews five referenceable EIR templates and summarizes their structure and key characteristics.

Table 6-7 List of Collected EIR Templates

Template Name	Issuing Organization	Year of Publication
BIM Toolkit (UK)	CDBB (Centre for Digital Built Britain)	2018
CIC BIM EIR (Hong Kong)	CIC (Construction Industry Council)	2021
CIBSE EIR (UK)	CIBSE (Chartered Institution of Building Services Engineers)	2017
Plan BIM Perú (Peru)	Plan BIM Perú	2021
NATSPEC EIR Template (Australia)	NATSPEC	2022

Source: The JICA Study Team

(1) BIM Toolkit (United Kingdom)

The BIM Toolkit provides a comprehensive and structured approach to preparing Exchange Information Requirements (EIR) in accordance with the ISO 19650 series. The template distinguishes between “low-maturity” and “high-maturity” BIM contexts and covers a wide range of essential topics, including project purpose, information-management objectives, information-delivery milestones, spatial coordination, information security, model quality, software environments, and data formats.

Each section includes examples and table formats designed for practical completion and operational use.

Notably, the relationship with the BIM Execution Plan (BEP) is clearly defined, enabling the appointing organization to describe its information-delivery strategy, risk management, and responsibility allocation before contract award.

Structure
1. Introduction 1.1 Purpose of the EIR Clarifies the intent, scope, and required outcomes of the EIR. 1.2 Goals and Objectives for Information Management Goals: aligned with the OIR Objectives: aligned with the PIR 1.3 Information-Requirements Hierarchy and Workflow Hierarchy: OIR → PIR → AIR → EIR The supplier is required to develop a pre-BEP and, subsequently, the BEP in alignment with the EIR. 2. Information Requirements 2.1 Information Purpose Defines why information is required (e.g., design coordination, construction sequence, and risk management). 2.2 Plan of Work Aligns information requirements with project stages. 2.3 Information-Delivery Milestones Lists required information outputs for each milestone. 2.4 Information Security Requirements Defines measures in compliance with established security protocols. 2.5 Spatial Coordination Requirements Provides rules for clash detection, spatial checks, and model coordination process. 2.6 Project Information Model (PIM) Specifies requirements for PIM structure, content, and validation. 2.7 Asset Information Model (AIM)

	Requirements for AIM development, handover, and integration with FM systems.
2.8	Information-Management KPIs Defines performance indicators for assessing information quality and delivery.
2.9	Health, Safety, and Design-for-Construction Risk Management Specifies requirements for H&S-related information, risk reporting, and regulatory compliance.
3.	Information Standards, Information Production Methods, and Procedures
3.1	Information Standards Project-specific standards Naming conventions Level of Detail/Level of Information (LOD/LOI) Authoring and exchange formats Software platforms Model-quality expectations
3.2	Information Production Methods and Procedures Information-management functions Collaboration processes Authorization and acceptance processes Spatial-coordination strategy Capture of existing asset information Information container breakdown structure Lessons-learned processes

(2) CIC BIM EIR (Hong Kong)

Developed for the Hong Kong construction industry, this EIR template aligns with the ISO 19650 series while conforming to the Hong Kong CIC BIM Standards.

It provides a comprehensive framework for defining information-exchange requirements and consists of 11 chapters, covering BIM personnel qualifications, CDE operation, contractual documentation, BIM uses, quality assurance, deliverables handover, model and object management, training, technical requirements, and standards.

Each section includes concrete examples and selectable options, enabling flexible adaptation to project characteristics across the design, construction, and operations stages.

Structure	
1.	BIM Personnel - Roles and responsibilities - Qualification requirements - Organizational charts for BIM teams
2.	Common Data Environment (CDE) - Implementation methods - Access permissions - Period of operation and maintenance
3.	BIM Contractual Documents - Pre-BEP and BEP - Information management functions - Risk management plan
4.	BIM Uses Examples include: - Design - Model review - Drawing production - Spatial coordination - Construction coordination - As-built models

-	Asset Information Models (AIM)
5.	Quality Assurance
-	Quality assurance plans
-	Compliance and verification procedures
6.	Handover of Project Deliverables
-	List of BIM deliverables
-	Delivery media (digital formats and storage media)
-	Transmission and record-keeping procedures
7.	BIM Models Management
-	Discipline-specific model structures
-	Model-integration strategies
-	Requirements for level of information need (LOIN)
8.	BIM Objects
-	Classification systems (e.g., OmniClass)
-	Object-sheet requirements
9.	Training
-	Training objectives
-	Training plans and formats
-	Learning outcome requirements
-	Competency requirements for each role
10.	Hardware and Software Requirements
-	Hardware and software specifications
-	Software per BIM use and version requirements
-	File formats (e.g., IFC)
-	Approved viewers and equipment lists
11.	BIM Standards and Guidelines
-	CIC BIM Standards
-	ISO 19650 series
-	Applicable Hong Kong government guidelines

(3) CIBSE EIR (United Kingdom)

This EIR template is aligned with PAS 1192-2:2013 and supports the UK BIM Level 2 framework. It systematically organizes information requirements for the design, construction, and operational phases and is structured on the assumption that it will be used together with the BIM Execution Plan (BEP).

The content is comprehensive, covering project information, technical specifications, levels of definition, applicable standards, roles and responsibilities, model management, security requirements, clash detection, collaboration processes, deliverable handover, asset-information strategy, and BIM capability assessment.

Each section includes input fields or selectable options, making it an exceptionally practical template—particularly for projects in the building-services (FM) domain. It functions as a hands-on tool supporting information management from design through to operations.

Structure	
1.	Project Information Basic project data and overarching requirements.
2.	Technical Requirements Specifications for information types, formats, precision, and modeling rules.
3.	Levels of Definition (LOD/LOI) Requirements defining geometric detail and non-geometric information.
4.	Applicable Standards References to PAS/BS standards and other mandatory guidelines.
5.	Roles and Responsibilities Definitions of task allocation among the project team.
6.	Work Planning and Data Segregation

	Including: - model management - zones and areas - naming conventions - publication processes
7.	Security Requirements Information-security protocols and classification controls.
8.	Coordination and Clash Detection Processes, resolution procedures, technical queries, and tolerance strategies.
9.	Collaboration Processes Sharing formats, model boundaries, exchange frequency, and review-meeting arrangements.
10.	Health, Safety and CDM Requirements related to Construction (Design and Management) regulations.
11.	System Performance Performance criteria and monitoring requirements.
12.	Compliance Plan Approach for ensuring compliance with standards and contractual obligations.
13.	Asset Information Provision Strategy Information required for handover into FM systems and AIM development.
14.	Data Drops and Deliverables Definition of information drops, deliverables, and submission formats.
15.	Client Strategic Objectives High-level goals that drive the project's information needs.
16.	BIM Capability Assessment Assessment of suppliers' BIM maturity, including: - Level 2 compliance - capability and experience - execution plans - workloads and resources - supply-chain roles and evaluation processes
17.	Project Design Parameters Architectural and spatial design parameters relevant to model development.

(4) Plan BIM Perú (Peru)

The Plan BIM Perú EIR template provides a standardized format for recording and managing EIRs in public-investment projects under the national BIM strategy. It organizes investment information, institutional frameworks, functional responsibilities, and BIM-related requirements in detail.

Information requirements, deliverables, security requirements, coordination needs, and PIM-related conditions are structured according to BIM uses and project phases.

The template also covers PIM deliverables, performance indicators, risk management, documents responding to the EIR (such as the BEP and MIDP), information-management standards, file formats, required software, and quality requirements.

Overall, it ensures alignment with the ISO 19650 series as well as Peru's national standards.

Structure	
A.	Investment Data (<i>Datos de la inversión</i>)
1.	Investment code, name, location
2.	Investment objectives and BIM information-management objectives
3.	BIM uses applicable to the project
B.	Institutional Framework (<i>Institucionalidad</i>)
-	Level of government (local / central)
-	Involved organizations (OPMI, UF, UEI, and relevant organizations)
-	Organization names and responsible persons

-	Funding entities
C.	Functional Responsibilities of the Investment (<i>Responsabilidad funcional de la inversión</i>)
-	Function, department, group
-	Responsible sector
-	Service category
-	Investment type
D.	Information Requirements (<i>Requisitos de información</i>)
-	Information delivery requirements (based on BIM uses)
-	Deliverables and deadlines for each project phase
-	Information security requirements
-	Considerations for multidisciplinary coordination
-	PIM deliverables and information-production considerations
-	Performance indicators
-	Risk-management criteria
E.	Documents Responding to the EIR (<i>Documentos de respuesta a los requisitos de intercambio de información</i>)
-	BEP (BIM Execution Plan)
-	Responsibility Matrix
-	TIDP (Task Information Delivery Plan)
-	MIDP (Master Information Delivery Plan)
F.	Information Standards (<i>Normas de información</i>)
-	Information-management standards
-	Naming conventions and identification rules
-	Methods for defining information levels
-	File formats
-	Required software platforms and tools
-	Quality requirements
G.	Information-Production Methods and Procedures (<i>Métodos y procedimientos de producción de información</i>)
-	Information-management activities and RACI allocation per project stage
-	Reference information and shared resources
-	Methods for collecting existing asset data
-	Considerations for coordination and information exchange

(5) NATSPEC EIR Template (Australia)

The NATSPEC EIR template provides a structured definition of Exchange Information Requirements in alignment with the AS ISO 19650 series.

Building on the AIR and PIR, it organizes information purposes, deliverables, formats, and required levels of information need (LOIN). It also covers CDE management, quality assurance, security, meeting structures, and a broad range of technical requirements, such as model geolocation, asset identification, naming conventions, software environments, and reference standards.

Through the required submission of a BEP, suppliers must demonstrate their capability to meet the appointing organization's requirements.

Structure
· Document Overview - Alignment with AS ISO 19650 - Purpose and scope · Project Details 1. Project description 2. Project objectives (priorities and success indicators) · Commercial Information - Procurement strategy (e.g., Design–Bid–Build, Design & Construct)

- Project-team structure
- Provision, access, and use of the Common Data Environment (CDE)
- Project Information Delivery Milestones Table
- Existing conditions information
- Information purposes for asset and project information (Design, Construction, Project management), Information requirements linked to each purpose (Project Information Purposes Table)
- AIM/PIM integration strategy
- AIM/PIM deliverables and formats
- Properties for spatial objects
- Properties for physical asset objects, including geometric and non-geometric LOIN requirements
- Management
 - Information quality assurance
 - Information security and privacy
 - CDE governance
 - Meeting schedules
 - BEP requirements
- Technical
 - Software requirements
 - IT infrastructure
 - Integration resources
 - Combined facilities
 - Interoperability requirements
 - Model geolocation and coordinate alignment
 - Asset identification rules
 - Model-object and project-naming conventions (IFC-compliant)
 - Standards and reference information
 - Project Information Standards Directory
 - Production Methods and Procedure Directory
 - Reference Information Directory
 - Shared Resources Directory

6.7.2 Comparative Analysis of EIR Templates

This section compares the characteristics and differences among the EIR templates reviewed previously, in relation to the structural components defined in ISO 19650-2.

(1) Classification of Information Requirements (OIR/AIR/PIR)

The BIM Toolkit explicitly presents the hierarchical structure of information requirements—OIR → PIR → AIR → EIR—and is the most faithful representation of the principles of ISO 19650.

This structure is particularly effective for maintaining information consistency and transparency from organizational strategic objectives through to project-level information management. In complex, multi-stakeholder ODA loan projects, this hierarchical clarity provides a strong foundation. In contrast, Plan BIM Perú integrates the AIR and PIR within EIR. This simplifies operational usage; however, it weakens the hierarchy and clarity in the allocation of responsibilities.

NATSPEC adopts an intermediate approach by defining AIR and PIR separately, while also reorganizing their elements flexibly within the EIR.

(2) Level of Information Need (LOIN)

NATSPEC and the BIM Toolkit adopt LOIN definitions aligned with EN 17412-1 (now ISO 7817)⁷,

⁷ Refers to the European standard EN 17412-1:2020: Building Information Modelling—Level of Information Need—Part 1: Concepts and Principles. The standard was withdrawn following its internationalization in 2024, since it was superseded by

specifying information granularity for models, drawings, documents, and datasets. NATSPEC, in particular, provides tabulated LOIN requirements for spatial and physical asset objects, offering strong usability across design, construction, and operational phases.

CIBSE uses the BIM Forum's LOD specifications, which are effective for modeling maturity in the design and construction, but are less relevant for operational-phase information. CIC provides model-quality commentary but includes only minimal LOIN definitions, thus requiring supplementary documentation for detailed control.

(3) Acceptance Criteria

The BIM Toolkit clearly specifies information standards, production methods, and shared resource usage based on the UK BIM Framework. This ensures high reliability for pre-contract capability assessment and information consistency checks.

NATSPEC similarly documents information standards, naming conventions, and IFC-compliant requirements in detail, offering clear acceptance criteria for information handover and verification.

CIBSE and CIC place greater emphasis on contractual integration, including submission formats and quality-management references, but lack a fully systematized structure for information standards and procedures.

Plan BIM Perú adopts national guideline-based information standards, though further alignment with international standards remains beneficial.

(4) Supporting Information

The BIM Toolkit provides a highly structured set of supporting materials—existing asset data, reference documents, sample deliverables, PLQ lists—useful for ODA projects where comparisons with past cases and international reporting obligations are important.

NATSPEC also provides supporting documents and existing conditions data in its annexes, reinforcing practical implementation.

CIC includes sample deliverables in appendices, helping stakeholders visualize expectations.

CIBSE contains examples within its Digital Engineering template set, but it lacks a systematic organization.

Plan BIM Perú provides clear classifications based on BIM uses, although the depth of supporting information is limited.

(5) Information-Delivery Milestones

NATSPEC adopts a milestone table directly linked to decision points, enabling clear management of delivery timing and review or approval procedures.

The BIM Toolkit similarly uses MIDP or TIDP structures to indicate deadlines and review timeframes, considering the appointing organization's assurance processes.

CIC includes sample milestone schedules in appendices, serving as a practical reference.

CIBSE places milestone definitions within the BEP, offering flexibility but with limited standardization.

Plan BIM Perú specifies phase-based deadlines but offers weaker linkage to decision points.

Conclusion

For ODA loan projects, EIR development should draw on the strengths of BIM Toolkit and NATSPEC—particularly their systematic treatment of information hierarchies, LOIN definitions, acceptance criteria, and milestone management—while supplementing these with deliverable examples from CIC and CIBSE,

the ISO version: ISO 7817-1:2024: Building information modelling—Level of information need, Part 1: Concepts and Principles.

and their strong alignment with contract documentation.

This hybrid approach enables the appointing organization to maintain compliance with international standards while ensuring practical usability in real-world contract and deliverable management.

Furthermore, the incorporation of PLQs and capability assessments supports both pre-contract information-consistency checks and post-contract deliverable quality assurance.

6.7.3 Structure of the EIR Template for ODA Loan Projects

Based on the components defined in ISO 19650-2 and the comparative analysis of international EIR templates, this section presents a proposed structure for an EIR template tailored to ODA loan projects.

(1) Design Principles

In developing an EIR template for ODA loan projects, the structure shall be grounded in the requirements of ISO 19650-2:2018 Clause 5.2.1, while also integrating international best practices and the specific needs of ODA operations.

The EIR is more than a list of information requirements; it must function as a core governance document that translates the appointing organization's strategic objectives into actionable information-management processes. It must also ensure contractual performance, deliverable quality, information consistency, and accountability—particularly in large-scale ODA projects, where the appointing organization collaborates with multiple design, construction, and supervision teams.

The key principles guiding the proposed EIR template structure are as follows:

- Clarify the hierarchical structure of information requirements
Explicitly distinguish the OIR, AIR, and PIR, and define their relationship to EIR.
This ensures that the purpose of each information requirement and the corresponding responsibility allocation can be systematically managed.
- Classify information purposes and employ Plain Language Questions (PLQs)
Information shall be organized by purpose—design decisions, construction management, asset operations, contractual compliance, and international reporting. PLQs shall be used to concretize the required information in a user-friendly manner.
- Systematize deliverable management through the MIDP and TIDP
Use the Master Information Delivery Plan (MIDP) and Task Information Delivery Plans (TIDP) to clearly specify:
 - Types of deliverables
 - Submission formats
 - Delivery deadlines
 - Responsibility assignments
 This enhances certainty in information delivery and contract administration.
- Introduce the Level of Information Need (LOIN)
Adopt ISO 7817 (formerly EN 17412-1) to define information granularity for models, drawings, documents, and datasets.
This allows deliverable quality to be controlled consistently across project phases.
- Explicitly define standards, procedures, and shared resources
Standardize deliverables through:
 - IFC compliance requirements
 - Naming conventions
 - CDE governance rules

- Guidance on using templates, libraries, and shared resources

This institutionalizes acceptance criteria for information delivery and review.

- Ensure contractual integration
Position the EIR as part of the contractual documentation.
Explicitly define obligations for information submission, acceptance conditions, and dependencies with BEP, MIDP, and TIDP to ensure alignment between contract performance and information management.
- Clarify review and approval processes
Link information delivery milestones to decision points.
Define review periods and approval procedures that align with the appointing organization's internal assurance process.
- Promote the use of existing asset information and past deliverables
Facilitate knowledge transfer and enhance information reusability by incorporating:
 - Asset information collected in past ODA projects
 - Sample deliverables
 - Templates and reference models
- Integrate capability assessment prior to contract award
Use the pre-appointment BEP to evaluate the bidder's information-management capability and their ability to comply with the EIR, ensuring that the selected contractor is fully prepared to meet the project's information requirements.

Based on these principles, the next section presents the proposed chapter structure and content of an EIR template for ODA loan projects.

(2) Proposed Structure of the EIR Template

The proposed EIR template for ODA loan projects reflects the components of ISO 19650-2, while integrating the appointing organization's information-management policies and contractual requirements.

The structure and descriptions of each section are as follows.

Structure	
1.	General Provisions Clarifies the purpose and role of the EIR, defines the scope of applicability, establishes terminology, and explains its relationships with relevant standards and guidelines. This provides the foundation for how information will be managed throughout the project.
2.	Project Overview Describes basic project information—such as the project name, location, and project summary—along with details of the appointing organization, responsible departments, and procurement route (e.g., Design-Bid-Build or Design-Build). This section clarifies the scope and responsible entities for information management, defining the applicability of the EIR.
3.	Information Requirements Summarizes the key elements of the OIR, AIR, and PIR, and classifies information purposes based on Plain Language Questions (PLQs). Project-specific information purposes—such as supporting design decisions, construction management, asset operations, and contractual compliance—are clarified to ensure that required deliverables and their intended uses cases are explicitly defined.
4.	Deliverable Requirements Using the Master Information Delivery Plan (MIDP) and Task Information Delivery Plans (TIDP), this section systematically identifies: - Types of deliverables (models, drawings, documents, datasets) - Submission formats (.pdf, .xls, .ifc, and native authoring formats, among others)

	- Delivery timing - Responsibility allocation Deliverables are categorized by information purpose, and acceptance criteria and submission conditions are defined for each deliverable.
5.	Level of Information Need (LOIN) LOIN defines the required granularity of information for each deliverable. By describing LOIN for models, drawings, documents, and data—and by providing LOIN tables for spatial objects and physical asset objects as annexes—the template ensures appropriate information quality and prevents over- or under-production. Spatial-object LOIN focuses on geometry (shape and dimensions) and functional attributes (use, finishes, and operational conditions), supporting design coordination and construction preparation. Asset-object LOIN focuses on attributes (model number, manufacturing year, maintenance history, warranty conditions) and identifiers (asset IDs, classification, and installation location), and supporting operational and maintenance phases.
6.	Technical Requirements Specifies interoperability requirements, including: - Software interoperability - IFC compliance - Naming conventions - Geo-referencing rules (e.g., coordinate systems, project base points) This ensures information consistency and exchangeability across multiple stakeholders—which is critical in large, multinational ODA projects.
7.	CDE and Information Security Defines: - The organization responsible for providing the CDE - Access permissions - Information classifications (public / restricted / confidential) - Security measures aligned with ISO 19650-5 where necessary It also clarifies methods for storing, sharing, and managing revision histories to mitigate risks of data loss, leakage, or unauthorized access.
8.	Quality Management Specifies: - Model review frequency - QA/QC structures - Acceptance criteria for submitted information Clear definitions of review timing, responsible parties, and acceptance conditions support deliverable quality and ensure contract compliance. This is particularly important for validating model coordination and attribute accuracy during the construction phase.
9.	Delivery, Review, and Approval Links information-delivery milestones to decision points, and establishes review periods and approval workflows. By aligning with the appointing organization's assurance processes, this structure clarifies the sequence from delivery to approval and reduces risks of delays or resubmissions.
10.	Contractual Provisions Positions the EIR as a contractual document. Information requirements and deliverable specifications stated in the EIR become contractually binding, ensuring that the information-management obligations align with contractual performance.
11.	Supporting Materials Includes: - Existing asset information - Sample deliverables - Capability assessment materials for delivery teams - Templates such as the pre-appointment BEP, TIDP, MIDP - PLQ lists - LOIN tables

These materials enhance reusability, promote knowledge transfer across projects, and provide bidders with clear reference points for interpreting EIR requirements.

6.7.4 Deployment for Large-Scale Railway, Road, and Airport Projects in ODA Loan Operations

Based on the EIR template structure and international comparative analysis presented in the preceding sections, this section outlines key considerations and application principles for deploying the EIR across the major infrastructure sectors typical of ODA loan projects.

Because these sectors have distinct asset characteristics, procurement approaches, and operational frameworks, the EIR must be adapted to incorporate sector-specific requirements.

(1) Application to the Railway Sector

Characteristics and Challenges

- Rail systems comprise a complex combination of facility assets (stations and depots) and linear assets (track, signaling, power, telecommunications).
- Information requirements must distinguish spatial objects (stations, platforms, concourses) from asset objects (signaling equipment, substations).
- Attribute information supporting operational control and maintenance planning is crucial.

Application Principles

- Define LOIN separately for spatial and asset objects, with granularity varying by design, construction, and operations phases.
- Use PLQs to articulate information needs related to operational safety, equipment reliability, and maintainability.
- Link deliverable submission and acceptance conditions with contract documents to ensure information accuracy and timely compliance.

(2) Application to the Road Sector

Characteristics and Challenges

- Road projects involve linear assets (roadways), structures (bridges and tunnels), and ancillary facilities (lighting, signage, drainage, and ITS).
- Ensuring georeferencing consistency is essential.
- Construction accuracy often depends on the integration of the design models with terrain and geospatial data.
- Building an asset ledger for the O&M phase is critical.

Application Principles

- Specify georeferencing rules in the technical requirements, ensuring compatibility with survey and coordinate systems.
- Define the LOIN for quantitative information such as earthwork volumes, pavement thickness, and drainage plans, supporting construction stage accuracy control.
- Integrate existing asset information and new deliverables within the CDE to ensure a seamless transition to maintenance workflows.

(3) Application to the Airport Sector

Characteristics and Challenges

- Airports include multiple functional domains: runways, taxiways, terminal buildings, fuel systems, and

air-traffic control facilities, and other domains.

- Ensuring consistency between spatial zoning (departures, arrivals, and security areas) and equipment layouts is essential.
- Deliverables must meet international aviation standards such as the ICAO and IATA.
- Attribute information must be suitable for constructing an AIM for long-term O&M.
- Many airports remain operational during expansion works, requiring thorough coordination.

Application Principles

- Include zoning attributes, functional attributes, and finish specifications in the LOIN for spatial objects.
- Include equipment IDs, warranty periods, and maintenance cycles in the LOIN for asset objects.
- Provide AIM-ready deliverables at handover, ensuring compatibility with the operator's asset management systems.
- Define information requirements for construction during airport operations, for example:
 - Taxiway closure planning and NOTAM issuance (civil works); and
 - Restricted access areas and scheduling constraints (buildings)

(4) Common Deployment Principles Across All Sectors

- **Alignment with the OIR:**
Reflect a sector-specific project objectives (safety, service reliability, and environmental performance) in the PIR and EIR and map them to KPIs.
- **Connection with the AIR:**
Harmonize attribute definitions and identification codes to ensure that information captured during construction can be directly reused in operational phase asset management.
- **Integration into Contract Documentation:**
Include the EIR as part of the contractual documents to institutionalize obligations for deliverable submission and acceptance.
- **Link Milestones with Decision Points:**
Define review and approval processes aligned with information-delivery milestones and internal assurance cycles.
- **Re-use of Existing ODA Knowledge Assets:**
Systematically leverage asset information, templates, and sample deliverables accumulated from past ODA loan projects to strengthen information reusability and promote cross-project knowledge transfer.
- **Consistency with International Standards:**
Ensure full alignment with ISO 19650, ISO 16739-1 (IFC), ISO 7817 (LOIN), and ISO 12006-2 (classification) in order to strengthen credibility and interoperability in international cooperation projects.

6.7.5 Supplementary Materials for the EIR

ISO 19650-2 Clause 5.1.6 requires the appointing organization to establish project reference information and shared resources, which shall be issued to potential lead appointed parties together with the EIR at the tender-invitation stage (Clause 5.2).

These shared resources typically comprise templates for deliverables, information-container templates, and object libraries.

Templates supporting the preparation of information deliverable include:

- BEP (BIM Execution Plan) template
- MIDP (Master Information Delivery Plan) template prepared for the lead appointed party
- TIDP (Task Information Delivery Plan) templates intended for task teams

Providing these materials in advance establishes the information-management framework and expectations from the outset of the project. This approach minimizes inconsistencies, prevents rework in later stages, and ensures alignment among all participants with a common set of procedures.

The provision of object libraries and information-container templates further supports data interoperability and facilitates quality assurance across design, construction, and operations and maintenance phases. This is particularly significant in ODA loan projects, where stakeholders often have different operational practices.

Using standardized templates reduces project-wide risks by ensuring consistency in data structure and enabling effective collaboration.

(1) Pre-Appointment BEP and BEP

The BIM Execution Plan (BEP) is the document that, in accordance with ISO 19650-2 Clause 5.3, must be prepared by a prospective lead appointed party (during tender) or by the appointed lead party (after contract award) to demonstrate to the proposed approach for responding to the appointing organization's EIR.

At the tender stage, the candidate lead appointed party prepares a Pre-Appointment BEP (Pre-BEP). After contract award, the selected lead appointed party develops the full BEP, expanding all proposed items into confirmed and detailed execution plans.

The following provides a summary of the items typically included in each document.

Example Structure	
Pre-Appointment BEP	BEP
1. Project information (overview)	1. Project information (overview)
2. Proposed information-management functions (roles)	2. Information-management functions (roles)
3. Proposed BIM goals, uses, and deliverables	3. BIM goals, uses, and deliverables
4. Proposed organizational structure and delivery-team composition	4. Organizational structure, delivery-team composition, and detailed responsibility matrix
5. Names and CVs of information-management personnel	5. Names and CVs of information-management personnel
6. Assessment of delivery team capability and capacity	6. Delivery-team capability and capacity
7. Proposed information delivery strategy	7. Information-delivery strategy
8. Confirmation of compliance with the EIR and proposed amendments	8. Confirmation of compliance with the EIR
9. Proposed project information standards	9. Lead appointed party's EIR (EIR tailored for subcontracting and task teams)
10. Proposed LOIN and responsibility matrix	10. Project information standards
11. Proposed model-integration strategy	11. LOIN and responsibility matrix
12. Proposed information-production methods and procedures	12. Model-integration strategy
13. Proposed collaborative-information-production objectives	13. Information-production methods and procedures
14. Proposed delivery team risk register	14. Collaborative information production objectives
15. Proposed mobilization plan	15. Delivery team risk register
16. Summary of software, hardware, CDE, and IT infrastructure	16. Mobilization plan
	17. Summary of software, hardware, CDE, and IT infrastructure
	18. Annex: MIDP and TIDP

The Pre-Appointment BEP (Pre-BEP) is prepared during the bidding stage and consists solely proposed approaches developed by the prospective lead appointed party based on its interpretation of the Employer's Information Requirements (EIR).

Its primary purpose is to demonstrate the bidder's capability, readiness, and strategic approach to

information management, including proposed roles, workflows, deliverables, and technical solutions.

In contrast, the BEP is prepared after the lead appointed party has been formally appointed. It contains confirmed and detailed information, including fully developed responsibility matrices, finalized information-management procedures, and authoritative project standards.

The BEP further incorporates the lead appointed party's EIR, which is then cascaded to all task teams to ensure consistent and contractually aligned information delivery across the project. As noted in item 9 of the BEP, the EIR is shared by the lead appointed party to the entire delivery team, and may include a project-specific EIR tailored for downstream parties.

Table 6-8 presents examples of typical Pre-BEP and BEP contents.

Table 6-8 Representative Examples of Pre-BEP/BEP

Issuing Organization	Document Name	Pre-BEP	BEP	Year
Guideline Examples				
Centre for Digital Built Britain (CDBB), UK	International BIM Toolkit	https://www.cdbb.cam.ac.uk/file/pre-appointmentbepemplatedocx	https://www.cdbb.cam.ac.uk/file/deliveryteamsbepemplatedocx	2022
National Specification System of Australia (NATSPEC)	NATSPEC BIM Execution Plan (BEP) templates	https://bim.natspec.org/images/NATSPEC_Documents/BEP_Templates_Pre-appointment.zip	https://bim.natspec.org/images/NATSPEC_Documents/BEP_Templates_Delivery_Team.zip	2024
Construction Industry Council (CIC), Hong Kong	CIC BIM Standards	CIC BIM Standards - General (2024), with templates in Appendix D Publications Resources BIM	-	2024
Examples from Actual Projects				
Swiss Federal Railways (SBB) ⁸	BIM Execution Plan Template	-	https://company.sbb.ch/content/dam/internet/corporate/downloads/de/sbb-als-geschaeftpartner/einkauf/bim/vorlage-bim-execution-plan.pdf.sbbdownload.pdf	2025
Transport for NSW ⁹	Digital Engineering Execution Plan (DEXP) Template	-	https://www.transport.nsw.gov.au/system/files/media/documents/2023/DMS-FT-532-Digital-Engineering-Execution-Plan-%28DEXP%29-Template.docx	2023
Department of Transport and Main Roads, Queensland Government ¹⁰	Building Information Modeling Execution Plan (BEP) Template	-	https://www.tmr.qld.gov.au/-/media/busind/techstdpubs/road-planning-and-design/building-information-modelling/tmr-bep-template.docx?rev=c46e18d93124495388871ff8bb93d5a6&sc_lang=en&extension=docx&size=617777&hash=9AF34F8061B63424F167D9346299242C	2024
Metrolinx ¹¹	BIM Execution Plan-Template	-	https://assets.metrolinx.com/image/upload/Documents/Engineering/BEP_Template_Rev_1.0.pdf	2025

Source: The JICA Study Team

⁸ A state-owned railway company in Switzerland that actively implements European BIM standards.

⁹ An organization responsible for managing transport infrastructure in New South Wales, Australia.

¹⁰ An organization overseeing roads, railways, bridges, and other infrastructure in Queensland, Australia.

¹¹ A government-affiliated agency in Ontario, Canada, operating rail, bus, and LRT services.

(2) Task Information Delivery Plan (TIDP)

The Task Information Delivery Plan (TIDP) is developed by each task team and defines the team-specific deliverables, submission methods, responsibility allocation, and deadlines. Each task team is required to establish and maintain its TIDP throughout the delivery period and update it as necessary in accordance with project progress.

When preparing the TIDP, the following aspects should be taken into consideration:

- Project information-delivery milestones
- Scope of responsibility as defined in the detailed responsibility matrix
- Requirements of the Lead Appointed Party's EIR
- Time required for information creation, coordination, review, and approval

TIDPs are typically created in spreadsheet format, and it is recommended to record the following items for each deliverable:

- Deliverable name/title
- Preceding or dependent deliverables
- Required Level of Information Need (LOIN)
- Production period
- Responsible person for production
- Delivery milestone

(3) Master Information Delivery Plan (MIDP)

The Master Information Delivery Plan (MIDP) consolidates all TIDPs prepared by individual task teams. It is compiled and maintained by the lead appointed party and serves as the overall information-delivery plan for the delivery team. Based on the MIDP, the lead appointed party submits information containers to the Common Data Environment (CDE).

The MIDP must be updated promptly whenever planning changes occur and must be maintained at all times, as the single source of truth for information-delivery planning during the project.

The content included in the MIDP corresponds to that of the TIDP and typically covers:

- List of deliverables
- Delivery schedule
- Responsibility allocation
- LOIN definitions
- Dependencies between deliverables

Table 6-9 Representative Examples of MIDP/TIDP

Issuing Organization	Document Name	MIDP	TIDP	Year
Guideline Examples				
National Specification System of Australia (NATSPEC)	NATSPEC BIM Execution Plan (BEP) Templates	https://bim.natspec.org/images/NATSPEC_Documents/BEP_Template_Delivery_Team.zip	https://bim.natspec.org/images/NATSPEC_Documents/BEP_Template_Pre-appointment.zip	2024
Centre for Digital Built Britain (CDBB), UK	International BIM Toolkit	https://www.cdbb.cam.ac.uk/file/midpmatrixtemplatexlsx	https://www.cdbb.cam.ac.uk/file/tidpmatrixtemplatexlsx	2022
Examples from Actual Projects				
Rail Baltica (Baltic States)	Rail Baltica	https://www.railbaltica.org/wp-content/uploads/2025/11/RBD-G-TPL-015-0103_MIDPTemplate.xlsx	https://www.railbaltica.org/wp-content/uploads/2025/11/RBD-G-TPL-014-0103_TIDPTemplate.xlsx	2025
Transport for NSW	Master Information Delivery Plan (MIDP) Template	https://www.transport.nsw.gov.au/system/files/media/documents/2023/Master-Information-Delivery-Plan-%28MIDP%29-Template-Version-4.4.xlsx	-	2022
Metrolinx	Master Information Delivery Plan (MIDP) Template	https://assets.metrolinx.com/raw/upload/Documents/Engineering/MX-ALM-TMP-002.xlsx	-	2025

Source: The JICA Study Team

6.8 Security Information Requirements (SIR)

ISO 19650-5 requires the appointing organization to implement a security triage process to determine whether a security-minded approach is necessary for a given project, asset, or service.

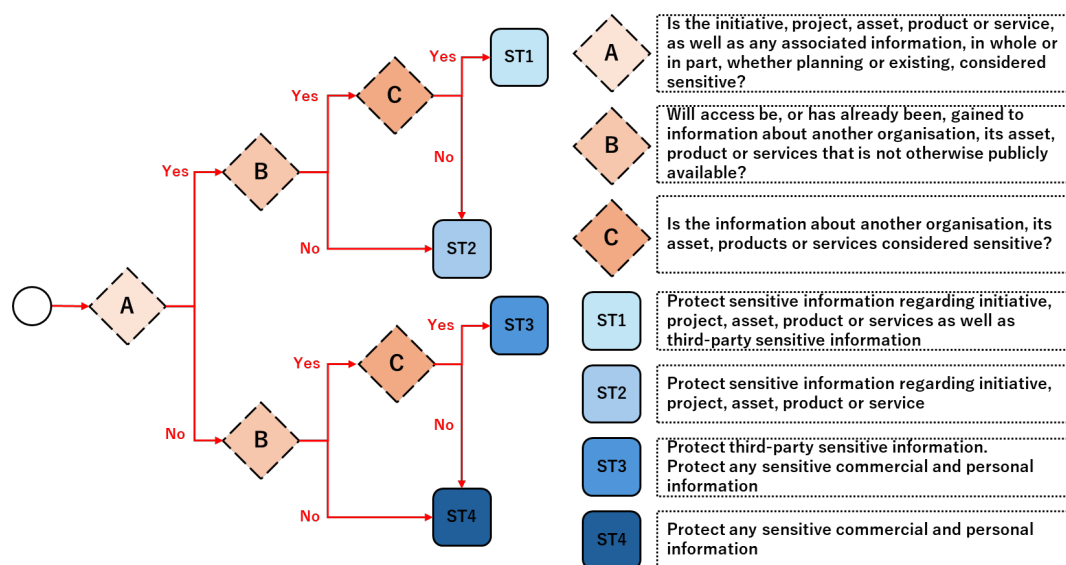
The outcome of the triage must be formally documented as part of the information requirements, and where applicable, shall result in the preparation of a Security Strategy, Security Management Plan, Incident Management Plan, and other associated management functions.

As illustrated in Figure 6-2, the triage process is applied to determine the appropriate security-focused measures, including:

- Whether a security-minded approach should be initiated;
- Whether the project requires the development of a Security Strategy, Security Management Plan, and Incident Management Plan;
- Whether collaboration with specific stakeholders is necessary.

If the triage concludes that a Security Management Plan is required, the plan must define the Security Information Requirements (SIR) for the exchange, sharing, and publication of new, updated, and existing information.

The requirements shall clearly specify whether they apply to individual documents or to the information model as a whole.



Source: The JICA Study Team based on ISO 19650-5

Figure 6-2 Outline of the Security Triage Process (ST: Security Triage)

The SIR, as defined within the ISO 19650 series, establish the conditions for the secure handling information related to sensitive assets and systems.

It forms part of the overall project information-management framework and addresses the following:

- The acquisition, processed, shared, stored, accessed, and use of information;
- The structure of the security-management regime; and
- The scope and content of security controls, determined based on identified security risks and corresponding mitigation measures.

Because asset operation typically extends well beyond the design and construction phases, security-related information management must be continuously maintained within the Asset Information Model (AIM) to ensure that security risks can be addressed effectively during the operational phase.

In line with ISO 19650-5, the security-information-management framework must also be incorporated into the EIR. This approach integrates security considerations into the project's overall information-management policy and establishes a shared understanding and coordinated response among stakeholders. This is particularly critical for public infrastructure and other high-value or sensitive facilities, where establishing and applying SIR helps prevent information leaks, unauthorized access, and other threats, ultimately contributing to a secure and trustworthy information environment.

6.8.1 Overview of Collected SIR Templates

This section reviews the Security Information Requirements (SIR) templates available for consideration when developing an SIR framework for ODA loan projects. Among the templates surveyed, the only practical example obtained was the CIC BIM SIR from Hong Kong, as shown in Table 6-10.

Table 6-10 List of Collected SIR Templates

Template Name	Issuing Organization	Year of Publication
CIC BIM SIR (Hong Kong)	CIC (Construction Industry Council)	2021

Source: The JICA Study Team

Below is an outline of the CIC BIM SIR template.

(1) CIC BIM SIR (Hong Kong)

Developed for the Hong Kong construction industry, the CIC BIM SIR designed to align with the ISO

19650 series and the Hong Kong CIC BIM Standards. It offers a structured framework for managing information security throughout the project and asset lifecycle. Its components are designed to ensure compliance with a security-minded approach, as mandated under ISO 19650-5.

Structure	
0.	Introduction - Purpose and positioning of the SIR - Overview of the security-triage process based on ISO 19650-5
1.	Security Information Requirements Overview
1.1	Information - Relationship with the EIR - Definition of personnel, technologies, and processes required for SIR implementation
1.2	Security Information Management Functions - Roles, responsibilities, and functional authority - Definition of security access controls - Description of the Security Information Management System (SIMS)
1.3	Security Policies and Procedures - Security policies applicable to the project - Related documentation
2.	Security Requirements
2.1	Sensitivity-Assessment Process - Procedures for identifying risks and determining the necessity of mitigation measures
2.2	Security Risks - Identification and characterization of project-specific security risks
2.3	Security Federation Requirements - Requirements for managing federated models and associated security controls
2.4	Nomenclature and Obfuscation - Information-naming rules - Generalization of drawings/models (e.g., abstraction of sensitive details) - Obfuscation techniques, such as maintaining data keys in separate secure locations
2.5	BIM Object Security Information - Identification of security-relevant attributes within BIM objects
3.	Security (COBie-Related Requirements) - The template includes COBie-based requirements for secure information delivery
3.1	Security Risks - Re-identification and documentation of project security risks
3.2	Security Mitigation Measures - Measures to reduce identified security risks
3.3	Tolerated Security Risks - Definition of acceptable risks, including justification and conditions
3.4	Policies and Procedures for Mitigation Measures - Procedures for applying and maintaining security controls
3.5	Security Information-Sharing Agreements - Requirements for establishing and recording agreements governing secure information exchange

6.8.2 Analysis of the SIR Template

(1) Overview and Scope of Application

The CIC BIM SIR is aligned with ISO 19650-5 and requires the establishment of Security Information Requirements (SIR) as the foundational input for developing a Security Strategy, Security Management Plan, and Incident Management Plan, based on the outcomes of the security-triage process.

As stated in 1.1, General Information, of the CIC BIM SIR, the SIR should be cross-referenced with the EIR.

While the EIR defines what information must be produced and how it should be delivered, the SIR defines the manner in which that information must be protected.

The SIR defines the information-protection requirements across both the project lifecycle and the asset lifecycle, covering information creation, sharing, storage, and disposal. Its scope therefore extends across the entire duration of information handling, from initial planning through long-term operations.

(2) Chapter Structure and Key Points

Following the structure of the CIC BIM SIR, the requirements are organized into three main chapters:

Chapter 1: Overview

This chapter describes:

- The purpose and scope of the SIR;
- The project's information-security management framework; and
- Applicable security policies and principles.

It establishes the foundation for how security risks will be identified and managed.

Chapter 2: Security Requirements

This chapter presents:

- The security risk assessment process, including procedures for identifying risks and determining necessary mitigation measures,
- Approaches for defining security requirements for BIM models, including:
 - The separation or federation of BIM models according to defined security zones;
 - The use of naming conventions that avoid revealing sensitive information;
 - Obfuscation strategies, such as generalizing drawings and models or the separate management data keys.

These requirements ensure that sensitive information is appropriately controlled based on the triage outcome.

Chapter 3: Security Measures and Risk Management

This chapter documents:

- A list of identified security risks;
- Risk-mitigation measures;
- Tolerated (acceptable) risks with justification and conditions;
- References to policies and procedures that govern the implementation of mitigation measures; and
- The requirement to establish and record security information-sharing agreements.

By codifying these items, the SIR ensures consistent control over risk-management practices and secure information exchange.

6.8.3 Structure of the SIR Template for ODA Loan Projects

(1) Design Principles

The SIR template for ODA loan projects shall be based on the components of ISO 19650-5, ensuring that a security-minded approach is applied in accordance to the results of the security-triage process.

The structure shall be capable of integrating the appointing organization's information-management policies, contractual requirements, and project-specific characteristics.

Based on these principles, the following section presents the proposed chapter structure and contents of an SIR template specifically tailored for ODA loan projects.

(2) Proposed SIR Template

The proposed SIR template for ODA loan projects is intended to support the integrated development and implementation of the Security Strategy and Security Management Plan of the appointing organization.

The structure and the content of each section are outlined below.

Structure	
1.	Introduction - The purpose and scope of the SIR - A description of the security-triage process - An overview of the security-management framework - References to related security strategy documents, policies, guidelines, and legal references
2.	Security Information Requirements (SIR) - Security assessment requirements based on triage outcomes - Naming conventions and information-obfuscation rules, including generalization of model and drawing details and the separation of sensitive keys - Requirements for the secure handling of BIM objects, documents, and datasets
3.	Security Risks and Mitigation Measures - The identification and classification of security risks - Security-risk mitigation measures - Accepted (tolerated) security risks and justification - Records of security information-sharing agreements governing the secure exchange of security-related information
4.	Feedback and Governance

6.9 Templates for Information Requirements in ODA Loan Projects

6.9.1 Overview of the Templates

Based on the template structures described throughout Chapter 6, this section presents the proposed templates for each category of information requirements applicable to ODA loan projects.

These draft templates are provided as appendices to this document.

Table 6-11 List of Templates Developed by the The JICA Study Team

Reference	Title
Handbook Draft – Appendix 1	OIR Template
Handbook Draft – Appendix 2	AIR Template
Handbook Draft – Appendix 3	PIR Template
Handbook Draft – Appendix 4	EIR Template
Handbook Draft – Appendix 5	SIR Template

Source: The JICA Study Team

6.9.2 Notes on Use

The draft templates are intended to support the systematic organization and examination of information requirements. They are intended to be adapted, modified, and supplemented to suit the specific needs of each project. Users shall verify applicability of the templates based on their professional judgement and technical responsibility, make appropriate adjustments in accordance with project-specific requirements, and refer to the relevant contractual documents, standards, and legal frameworks as necessary.

These templates serve as a foundation for establishing consistent information-management requirements in ODA loan projects, but shall be tailored appropriately to the context of each project.

7 TRENDS IN BIM COST-BENEFIT ANALYSIS

This chapter reviews international frameworks and tools for cost-benefit analysis (CBA) and return on investment (ROI) assessment, used to evaluate the benefits of BIM adoption, both quantitatively and qualitatively. Drawing on methods applied at the pre-investment stage and during project delivery, the chapter clarifies how BIM benefits are being measured to support decision-making and accountability, particularly within public infrastructure investment.

7.1 Background

As BIM adoption has progressed across public works and infrastructure programmes worldwide, stakeholders are increasingly required not only to demonstrate the technical value of BIM, but also to articulate and provide evidence of the benefits realized in a transparent and systematic manner. Such evaluation acts as a strategic framework that aligns project objectives with outcomes and enhances the credibility and accountability of investment decisions. In practice, BIM benefits are commonly addressed through a business-case approach, in which benefits, costs, and risks are structured and assessed to support informed decisions on BIM adoption.

7.2 International Benefit Evaluation Tool and Practice

A number of internationally recognized tools have been developed to support the assessment of BIM benefits from different perspectives, enabling both CBA- and ROI-based evaluation. Key examples are summarized below.

Table 7-1 Reference Tools for BIM Benefit Assessment

Tool	Publisher	Year	Key Characteristics
TFRS BIM ROI Tool	Transportation Research Board	2022	Excel-based tool developed for the US transport sector, enabling both simplified and detailed ROI analysis of BIM adoption
CBA Tool	EU BIM Task Group	2021	Excel-based tool for quantitative cost-benefit assessment of BIM, suitable for policy appraisal and investment decision-making
ROI Calculator	Scottish Future Trust	2019	Self-assessment tool to estimate BIM ROI at the early project stage, developed for public infrastructure projects
Benefit Measurement Methodology (BMM)	PwC, Innovate UK, CDBB	2018	Framework that structures BIM benefits using “impact pathways”, supporting systematic benefit identification and measurement

Source: Compiled by the JICA Study Team based on references 1, 2, 3, 4

These tools provide both theoretical and practical foundations for structured benefits management, applicable across project planning, delivery, and performance measurement. The sections below synthesize their approaches to clarify key evaluation perspectives at each stage.

7.3 Evaluation Perspectives at the Planning Stage

This section organizes evaluation perspectives that support BIM adoption decisions at the planning stage, drawing on the structure and functionality of the tools introduced above.

At the early stage of a project, BIM adoption requires both quantitative and strategic appraisal. Benefits should be considered not only in technical terms, but also in relation to process change, performance outcomes, and organizational impact. Key perspectives include the following sections.

1 [Front Matter | Lifecycle BIM for Infrastructure: A Business Case for Project Delivery and Asset Management | The National Academies Press](#)

2 [Front Matter | Lifecycle BIM for Infrastructure: A Business Case for Project Delivery and Asset Management | The National Academies Press](#)

3 [Home - Building Information Modelling: ROI Calculator](#)

4 [pwc_BIM Level2 Benefits Measurement Methodology_March 2018](#)

7.3.1 Scenario-Based Sensitivity Analysis

Given the inherent uncertainty in forecasting BIM costs and benefits, evaluating multiple scenarios enhances the robustness of decision-making. The TFRS BIM ROI Tool, for example, assesses high, medium, and low scenarios to calculate ranges for ROI, NPV, and benefit-cost ratio (BCR). The EU CBA Tool similarly enables comparisons between different levels of BIM implementation.

7.3.2 Comparison of Base Case and Investment Case

A clearly defined base case (no or minimal BIM) and investment case (BIM-enabled delivery) are essential for meaningful comparison. Analytical tools such as the TFRS BIM ROI and CBA tools facilitate evaluation of traditional 2D-based workflows versus BIM-based processes by quantifying impacts such as fewer design changes and shorter program duration.

The TFRS tool further distinguishes between pre- and post-adoption conditions using BIM maturity levels (Level 0 through Level 3), enabling a structured framework for comparison.

7.3.3 Benefit Matrices and Use-Case Definition

Structuring benefits according to defined BIM use cases supports evaluation tailored to project characteristics and objectives. Frameworks such as the BMM, CBA Tool, and ROI Calculator link specific BIM applications across design, construction, and operation to benefits such as time savings, cost reduction, and safety improvements.

This structured approach underpins project-specific CBA and ROI analysis and strengthens the rationale for BIM adoption.

7.3.4 Discount Rates and Timing of Benefit Realization

BIM benefits are often realized over time rather than immediately upon implementation. Consequently, analytical tools incorporate phased benefit realization and discounting to enable realistic investment appraisal. For example, the TFRS BIM ROI Tool models design and construction benefits as emerging after three years adoption, while operation and maintenance benefits appear after five years, and applies a 4% discount rate to determine NPV. Similar assumptions can be configured within the CBA Tool.

7.3.5 Use of Benchmark Benefit Factors

At the planning stage, detailed project data is often unavailable. Benchmark-based benefit factors derived from previous projects enable indicative ROI estimation. The TFRS BIM ROI Tool includes default assumptions (e.g., 10% design efficiency improvement, 12% reduction in tender prices, and 15% reduction in change orders), which may be adjusted to suit organizational context. This facilitates early quantitative appraisal and supports strategic decision-making.

7.4 Benefit Management during Project Delivery

The tools discussed above are also applied during project delivery to support ongoing benefits management. As BIM-enabled benefits emerge and evolve in real time, evaluation at the implementation-stage requires dynamic and continuous monitoring. Key approaches are outlined in the following subsections.

7.4.1 Real-Time Monitoring of Benefits

Continuous recording and visualization of benefit indicators are essential for understanding BIM performance during delivery. The TFRS BIM ROI Tool allows ongoing input of metrics such as design efficiency, tender prices, and change orders, enabling periodic recalculation of ROI and NPV. This supports evidence-based performance review and the implementation of corrective action.

7.4.2 Use-Case-Based Benefit Tracking

Tracking benefits by defined BIM use cases (e.g., design coordination, construction sequencing, asset management) clarifies the relationship between BIM application and outcomes. The EU CBA Tool, for example, associates “4D scheduling” with program reduction and “drone-based inspection” with improved

safety and reduced inspection costs.

7.4.3 Updating Benefit Factors Using Actual Data

Revising previously assumed benefit factors using actual project performance data enhances the accuracy of ROI assessments. The TFRS BIM ROI Tool facilitates adjustment of initial assumptions (e.g., design efficiency improvements) as evidence accumulates, enabling responsive and flexible benefit management.

7.4.4 Re-evaluation of ROI through Cumulative Cost and Benefit Recording

By cumulatively recording both realized benefits and additional costs during delivery, ROI and NPV can be periodically reassessed. The ROI Calculator supports dynamic updates of ROI as projects progress, providing decision-makers with timely insights for strategic steering.

7.4.5 Benchmarking Against Case Studies

Objective assessment of project performance is enhanced by benchmarking against comparable past projects. The BMM provides case-based impact pathways (from activity to BIM use, intermediate benefit, and final benefit), enabling validation of outcomes and the identification of improvement opportunities.

7.5 Examples of Quantitative Evaluation Indicators

Clear, measurable indicators are essential for demonstrating BIM benefits. Across the tools reviewed (TFRS BIM ROI Tool, EU CBA Tool, ROI Calculator, BMM), indicators are structured according to purpose and project phase and support investment appraisal, delivery monitoring, and post-project review.

Indicators may include cost, time, safety, environmental impact, quality, and collaboration, and can be tailored to project scale and type of project. Typical categories include:

- Cost indicators: reduction in design change costs; avoidance of construction errors; initial and operating costs for software, hardware, and training
- Time indicators: program reduction; decrease in design revisions; faster reviews and approvals
- Environmental and safety indicators: CO₂ reduction; incident reduction; waste minimization
- Efficiency and quality indicators: improved information sharing; accuracy of quantities; user satisfaction
- Investment performance indicators: discounted benefits and costs; NPV; BCR; payback period; IRR
- These indicators consistently enhance benefit visibility and support informed decision-making, despite variations in structure and granularity across tools.

Table 7-2 Example of Measuring Cost Items

TFRS BIM ROI Tool	CBA Tool	ROI Calculator	BMM
(1) Initial cost ① System implementation ② Hardware upgrades ③ Staff training ④ Staff time required for training (2) Operational costs ① Software subscription fees ② Additional costs on IT resources ③ Hardware replacement costs ④ Training costs ⑤ Staff time required for training ⑥ Time spent preparing documentation ⑦ Increasing in specialist service fees ⑧ Recruitment of additional staff ⑨ Production of digital as-built information ⑩ Database operation and maintenance	⑪ Increasing labor costs (pre-tender, tender, post-contract stages) ⑫ Consultancy costs related to public procurement processes ⑬ BIM modeling costs ⑭ Hardware upgrade investment ⑮ Annual software license fees ⑯ Staff training costs ⑰ BIM coordination costs	(1) Strategic definition and design stage ① Investment in a CDE ② Information manager role ③ BIM training ④ Preparation of the EIR ⑤ Preparation of the OIR/AIR (2) Procurement and construction stage ① Investment in FM systems (3) Operational stage ① Maintenance of the AIM	① Software and system-related costs ② Training and capability development costs ③ Model preparation and update costs ④ Organizational change and contractual compliant costs

Source: The JICA Study Team

Table 7-3 Example of Measuring Benefit Items

TFRS BIM ROI Tool	CBA Tool	ROI Calculator	BMM
(1) Internal organizational cost savings ① Reduction in paper consumption ② Reduction in storage requirements ③ Improvement of health and safety ④ Reduction in inspection costs (2) Project cost saving ① Avoidance of change orders ② Improvement in schedule management ③ Reduction in tender prices ④ Reduced costs associated with visualization ⑤ Optimization of materials and design options (3) Staff-related benefits ① Reuse of previous contents	① Reduction in changes through clash detection ② Improved accuracy of quantity takeoffs ③ Reduction in claims and litigation ④ Program duration reduction ⑤ Labor cost savings through faster analysis of FM and maintenance documentation ⑥ Improved efficiency of annual maintenance ⑦ Reduction in social costs through improved health and safety ⑧ Reduction in CO ₂ emissions through waste minimization	(1) Strategic definition and design stage ① Reduction in internal management costs, enabling reallocation to other projects ② Reduction in printing costs (2) Procurement and construction stage ① Reduction in temporary works costs on site ② Reduction in time-related and inflation-related costs ③ Improved tender outcomes ④ Reduction in construction risk ⑤ Reduction in client-side risk exposure ⑥ Reduction in building services and installation costs ⑦ Reduction in change management costs (3) Operation stage	(1) Time savings (2) Material reduction (3) Cost reduction ① Cost savings achieved through clash detection ② Reduction in design change costs ③ Reduction in operational costs ④ Reduction in maintenance costs ⑤ Reduction in disposal and asset sale costs ⑥ Reduction in litigation costs (4) Safety improvement ① Improved safety during the construction stage ② Improved safety during maintenance and decommissioning (5) Risk reduction ① Reduced effort required for risk mitigation measures ② Improved reliability of cost estimates

② Avoidance of searching for information ③ Avoidance of design rework ④ Faster review and approval processes ⑤ Reduction in RFIs ⑥ Automation of schedule management ⑦ Time savings during construction inspections ⑧ Automation of quantity takeoffs (4) User benefits (Including reduced road closures resulting from the effects of item (3)⑥) ① Reduced travel time ② Fuel savings ③ Reduction in emissions ④ Accident avoidance		① Improved reliability of data transfer at project completion ② Improved efficiency of data management ③ Improved energy performance ④ Improved efficiency of maintenance activities	(6) Improved asset utilization ① Reduction in asset downtime ② Improved efficiency of space utilization ③ Faster incident response (7) Improved asset quality ① Improved design quality ② Increased user satisfaction ③ Improved quality of service delivery (8) Reputational benefits ① Reduced impact on surrounding communities and stakeholders during construction ② Improved service reliability ③ Improved customer satisfaction

Source: The JICA Study Team

Table 7-4 Example of Measuring Asset Effectiveness Items

TFRS BIM ROI Tool	CBA Tool	ROI Calculator	BMM
① Total discounted benefits ② Total discounted costs ③ Net Present Value (NPV) ④ Benefit-Cost Ratio (BCR) ⑤ Payback period ⑥ Internal Rate of Return (IRR)	① NPV ② Economic Net Present Value (ENPV) ③ BCR ④ Economic Benefit Cost Ratio (E-BCR)	Not verifiable (Investment performance is calculated by combining quantitative benefits (monetized) with qualitative benefits such as improved collaboration, transparency, and quality of decision making.)	Final benefits within the impact pathway model*
*This framework provides a structured and causal approach to identifying and quantifying the benefits associated with the adoption of BIM Level 2. It consists of four elements — (1) Activity, (2) BIM Enabler, (3) Intermediate Benefit, and (4) End Benefit — and clarifies both the source and the scope of each benefit, while preventing double-counting.			

Source: The JICA Study Team

7.5.1 Current Challenges

The evaluation tools and indicators introduced above offer comprehensive frameworks for analyzing the quantitative and qualitative impacts of BIM adoption. However, several common challenges have been identified in practical application. Addressing these challenges is essential for embedding effective benefits realization within BIM-enabled project delivery.

(1) Insufficient Actual Performance Data and Limited Feedback Mechanisms

Many BIM benefit evaluation tools are designed to estimate potential benefits using predefined coefficients and assumptions. Mechanisms for updating these assessments with actual project data are often inadequate.

Although analytical tools such as the TFRS BIM ROI Tool allow users to adjust benefit factors, most organizations lack structured processes for collecting and recording real project data. As a result, it remains challenging to accurately capture realized benefits or leverage these insights to support continuous improvement.

(2) Lack of Standardization in Quantitative Evaluation

Quantifying BIM benefits is essential for supporting transparent and accountable decision-making. However, current evaluation practices exhibit significantly variation across tools and user organizations.

While financial indicators such as ROI, NPV, and BCR are widely employed, the selection of input values and benefit categories often depends heavily on user judgement, resulting in inconsistent outcomes.

Frameworks such as the Benefit Measurement Methodology (BMM) and the CBA Tool provide structured benefit categories by BIM use case; however, determining which benefits to prioritize and how to monetize them remains subjective. This highlights the need for greater standardization to improve objectivity and reproducibility.

(3) Difficulty in Measuring Non-Financial Benefits

Non-financial benefits—including improved quality, enhanced safety, environmental gains, and better collaboration—are widely recognized as core outcomes of BIM adoption. However, methodologies for quantifying these benefits remain limited.

Although the CBA Tool Handbook emphasizes the importance of non-financial benefits, the tool itself treats them primarily as supplementary information. This restricts their contribution on strategic or policy-level decision-making.

(4) Excessive Information Requirements at the Early Project Stage

Evaluating BIM costs and benefits in advance requires detailed input data. However, at the planning stage, many conditions remain uncertain, making high-accuracy evaluation challenging.

Analytical tools like the BMM and CBA Tool provide detailed benefit items grouped by use case; however, in practice, evaluations often remain at a simplified, preliminary level, which may limit their utility as a basis for strategic decision-making.

(5) Limited Stakeholder Awareness and Insufficient Collaboration Frameworks

Effective benefits realization management depends on collaboration among multiple stakeholders. However, engagement with the tools and willingness to share data are often limited.

The ROI Calculator assumes regular data entry and periodic evaluation by project stakeholders. In practice, such structures are intermittently established, creating challenges for sustaining continuous benefits management.

8 APPLICATION OF ISO 19650 AND EXAMPLES OF INFORMATION MANAGEMENT IN LARGE-SCALE PROJECTS

The objective of this chapter is to systematically organize and analyze practical examples of ISO 19650 series implementation in large-scale projects, along with related BIM-based information management practices. The ISO 19650 series has been widely adopted as a framework to ensure consistency and transparency of information across the design, construction, and operation & maintenance (O&M) phases, thereby promoting standardized information management.

This chapter examines multiple international large-scale projects through case studies systematically structured around the following common elements:

- Project Overview: Project context, scale, construction period, and implementation structure.
- Description of Information Sources: Design documents, models, contractual documents, and other sources of information.
- Applicable BIM Standards: PAS 1192, ISO 19650 series, national guidelines, and other information management standards and policies.
- ISO 19650-Related Initiatives: Establishment of project-specific information requirements (OIR, AIR, PIR, EIR, etc.) and mechanisms for their integration into contractual arrangements.
- Common Data Environment (CDE): Platforms used, access control, and workflow configurations.
- Classification Systems: Adoption and operational practices of classification systems such as Uniclass.
- Data Exchange Formats (IFC, COBie, etc.): Data exchange and delivery formats, implementation status, and actual utilization.
- Asset Management Policies and Practices: Transfer and utilization of information generated during design and construction in operation and maintenance phases, including integration with FM, maintenance planning, and digital twin initiatives.
- Contractual Arrangements: Contract clauses, terminology, and scope of application.
- Education and Training: BIM education and training programs for stakeholders, including the supply chain.

8.1 Criteria and Overview for Case Study Selection

This section presents the selection criteria and a list of case studies for large-scale projects covered in this chapter.

8.1.1 Case Study Selection Criteria

The projects and guidelines selected as case studies were chosen based on the criteria shown in Table 8-1.

Table 8-1 Case Study Selection Criteria

Selection Criteria	Description
Region	BIM-advanced countries such as the UK, USA, EU member states, Australia, Hong Kong
Project Scale and Type	Railway, road, and airport projects with a value of several tens of billions of yen or more (including new construction and extensions/expansions)
BIM Maturity	Proven application of the ISO 19650 series or an equivalent level of BIM maturity
Complexity of Information Management	Involvement of multiple stakeholders requiring integrated information management
Connection to Asset Management	BIM is utilized, or planned to be utilized, during the operation and maintenance phase after completion

Source: The JICA Study Team

8.1.2 List of Target Projects / Guidelines

Table 8-2 provides an overview of the projects and guidelines featured in this chapter.

Table 8-2 Case Study List

Country	Project / Guideline	Sector	Start of Operation
UK	Crossrail	Railway	2023
	High Speed 2		2026 (Planned)
Baltic States	Rail Baltica		2030 (Planned)
New Zealand	Kiwi Rail		2008 (Nationalization)
UK	Heathrow Airport	Airport	1946
USA	Denver International Airport		1995
	Massachusetts Port Authority		
	BIM Beyond Design Guidebook (2020)		
	I-80/I-380 Systems Interchange Project	Road	2024
Norway	Randselva Bridge		2022
Sweden	E4 The Stockholm Bypass Project		2030 (Planned)

Source: The JICA Study Team

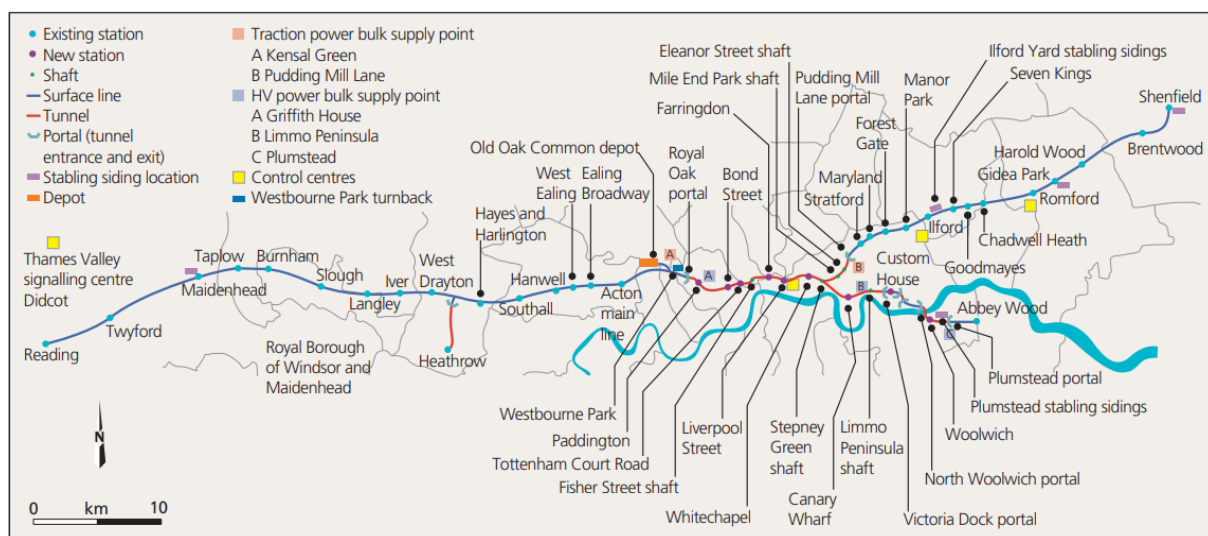
8.2 Case Studies

8.2.1 Crossrail (UK)

This section provides an overview of the Crossrail project and introduces the “Crossrail Learning Legacy”, which served as a primary information source for this study. It then analyzes and describes, in sequence, the applicable BIM standards, the evolution of the CDE, the status of classification systems and data exchange formats, asset management policies and initiatives, and education and training for stakeholders.

8.2.1.1 Project Overview

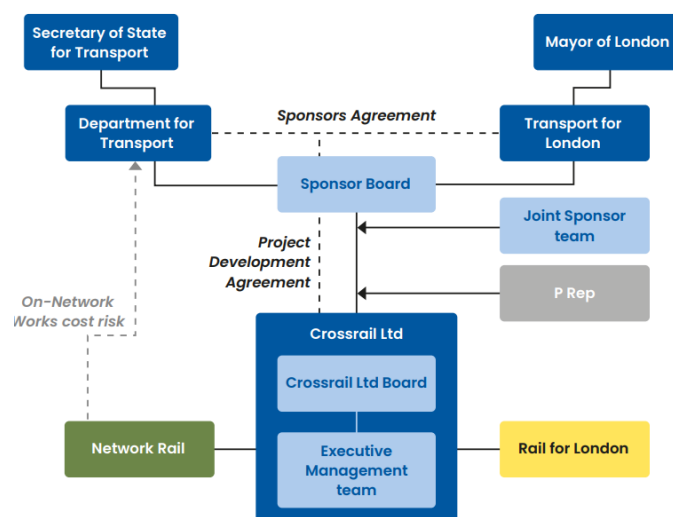
The Crossrail project is a major construction initiative to build the Elizabeth line, a high-speed railway running east to west across London. The concept dates back to the 1940s with the project receiving formal approval in 2007. After approximately 15 years of construction, full through-service operations commenced in May 2023. The line extends from Shenfield and Abbey Wood in the east to Reading and Heathrow in the west, covering a total length of over 100 km. It includes 41 stations, 10 of which are newly constructed. The Elizabeth line functions as a critical transport link connecting central London with surrounding regions.



Source: [The Execution Strategy for Delivering London's Elizabeth line - Crossrail Learning Legacy](#)

Figure 8-1 The Elizabeth Line

The project governance structure involved joint sponsorship by Transport for London (TfL) and the UK Department for Transport (DfT), which established Crossrail Ltd. (CRL) as the delivery organization. This joint sponsorship arrangement was formally defined in the Sponsors Agreement signed in 2008. Under this agreement, both sponsors shared responsibilities for funding, decision-making, and oversight of deliverables. During the delivery phase, TfL and DfT established the Sponsor Board as the decision-making body. The Sponsor Board served as the strategic core for sponsor-level decisions, including approval of requirement changes, contract amendments, senior appointments within CRL, final approval of key documents, and issuance of review notifications. Additionally, an independent assurance body—the Project Representative (P Rep)—was appointed to audit cost, progress, quality, and environmental compliance from a third-party perspective. The P Rep provided recommendations to the Sponsor Board as necessary, ensuring the overall integrity and health of the project.

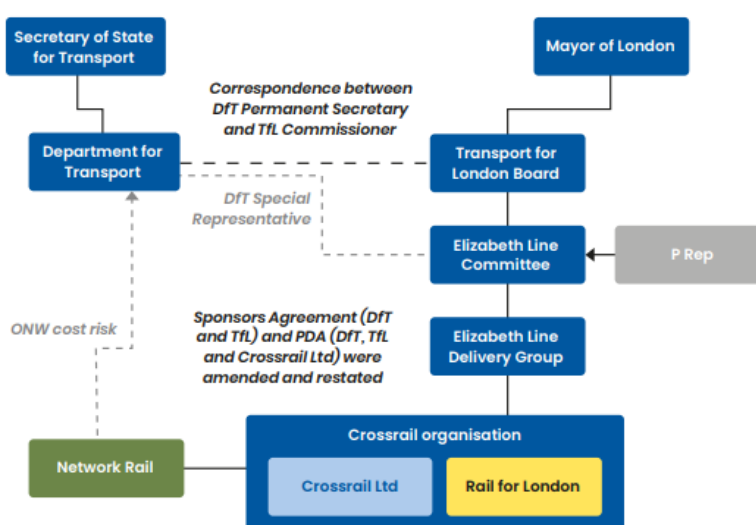


Source: [Governance-arrangements-to-complete-the-Crossrail-project.pdf](#)

Figure 8-2 Organizational Structure of the Crossrail Project in its Early Stage

Due to the impact of COVID-19 and delays in opening, governance was strengthened and restructured in 2020. Specifically, the Crossrail Ltd. Board was reorganized into the Elizabeth Line Committee, while the Sponsor Board and the Elizabeth Line Readiness Group were consolidated into the Elizabeth Line Delivery Group and incorporated within TfL. Furthermore, certain functions were transferred to the existing TfL committees, resulting in the dissolution of Crossrail Ltd.'s role.

As a result, the organizational structure after 2020 is as shown in Figure 8-3.



Source: [Governance-arrangements-to-complete-the-Crossrail-project.pdf](#)

Figure 8-3 Final Organizational Structure of the Crossrail Project

8.2.1.2 Description of Information Sources

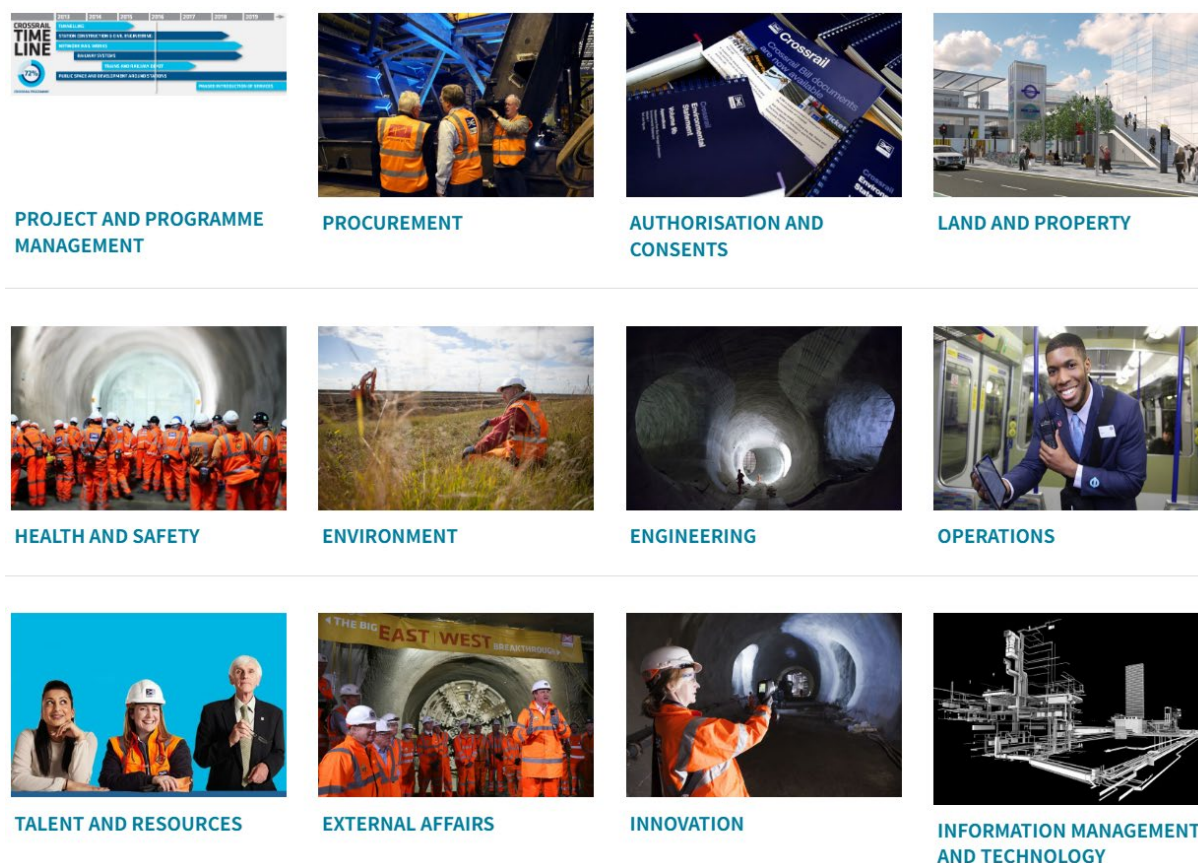
This section explains the origin and structure of the Crossrail Learning Legacy¹ (hereafter referred to as “Crossrail Legacy”), which served as the primary information source for this study.

Crossrail Legacy is a website that systematically compiles insights, lessons learned, best practices, and examples of innovative initiatives obtained during the implementation of the Crossrail project. The platform was launched following a recommendation from the UK National Audit Office, which recognized the

¹ [Homepage - Crossrail Learning Legacy](#)

importance of knowledge sharing in public infrastructure projects, and was developed with the support of Crossrail's executive management.

Modeled on the Learning Legacy from the London 2012 Olympics, the platform is organized into 12 thematic areas, as shown in Figure 8-4.



Source: [Learning Legacy Themes - Crossrail Learning Legacy](#)

Figure 8-4 Thematic Areas of the Crossrail Learning Legacy

Each theme is further divided into subtopics, and the overall website structure is designed around these 12 themes and their topic classifications. The content published on the site includes technical papers, case studies, micro-reports, research papers, best practice documents, as well as video and audio materials. In total, more than 840 resources have been made publicly available.

This comprehensive knowledge base enabled detailed analysis of the Crossrail project for this study.

8.2.1.3 ISO 19650-Related Initiatives

At the time that the Crossrail project commenced, BIM had not yet been mandated in the UK. Nevertheless, from the earliest stages of the project, significant emphasis was placed on ensuring the handover of information to future infrastructure operators. As a result, a BIM strategy and a comprehensive framework for data and information management—aligned with BS/PAS 1192, the predecessor of ISO 19650—were introduced.

Notably, Crossrail made substantial contributions to the development and standardization of the PAS 1192 series by providing practical insights, as outlined below:

- **PAS 1192-2:**
Crossrail actively adopted the principles of PAS 1192-2 while promoting BIM implementation. In constructing and operating the CDE, the project achieved centralized management and sharing of

information, enabling efficient collaboration among multiple stakeholders.^{2, 3}

- PAS 1192-3:
The CDE for Crossrail was designed so that future operators and maintainers could use it seamlessly, serving as a practical model for building an Asset Information Model (AIM) as intended by PAS 1192-3. In particular, the structure was developed to maintain and transfer asset information required during the operational Phase.^{2, 3}
- PAS 1192-5:
PAS 1192-5 defines security considerations for BIM and digital environments. As a pioneering infrastructure project, Crossrail implemented measures that anticipated the security principles later formalized in PAS 1192-5, thereby contributing to the standardization of BIM security practices.⁴

8.2.1.4 Common Data Environment

The CDE for the Crossrail project was progressively developed and enhanced throughout the project lifecycle, with continuous efforts to optimize information management. Its evolution can be categorized into three stages:

(1) Initial Stage: Decentralized Management Using Non-Integrated Systems

At the outset, Crossrail established its CDE in alignment with BS/PAS 1192 standards. Although the project team sought to manage and integrate information in accordance with contractual and configuration standards, multiple systems were, in practice, operated in parallel without integration. This resulted in insufficient centralized management and limited real-time collaboration. Design and construction teams managed 3D models, documents, and drawings independently, leading to fragmented information silos. This siloed approach created issues including inconsistencies in data, complexity in update and version control, and reduced transparency and visibility of information across the project. For example, subcontractors developed BIM models independently for design purposes, while asset information was maintained in separate systems, with no direct linkage between the models and asset data. As a result, integration work had to be performed at later stages. In response to these inefficiencies, Crossrail initiated fundamental improvements to system architecture and information management practices.

(2) Intermediate Stage: System Integration and Operational Reinforcement

To address the challenges identified in the initial stage, Crossrail established an integrated information management framework. A dedicated information management department was created, and dashboards and data warehouses were introduced to enhance information visualization and analysis. Operational rules were enforced to ensure that all stakeholders accessed the latest information through the CDE. These measures ensured consistency, integrity, and accessibility of data used across the entire project lifecycle (design, construction, and operation/maintenance). At this stage, the CDE evolved into a structure where systems interacted seamlessly, each fulfilling a clearly defined role, as shown in Table 8-3, thereby eliminating the silos observed in the initial stage.

Table 8-3 Systems Comprising Crossrail's CDE

System	Software	Primary Role
EIMS	Bentley eB	Management of contractual, design, and construction documents
AIMS	Bentley eB	Asset information management
CDE/BIM/CAD	ProjectWise/MicroStation	Management of 3D design and construction models
GIS	Oracle Spatial/ArcSDE	Geographic information management; spatial visualization and analysis

Source: Prepared by the JICA Study Team based on reference 5

² [Information Handover Principles - Crossrail Learning Legacy](#)

³ [Better Information Management to Optimise Whole Life Business Decisions - Crossrail Learning Legacy](#)

⁴ [BIM Introduction to PAS 1192-5](#)

⁵ Boyes, G. A., Ellul, C., and Irwin, D.: Exploring BIM for Operational Integrated Asset Management – A Preliminary Study Utilizing Real-World Infrastructure Data, ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci., IV-4/W5, 49–56, <https://doi.org/10.5194/isprs-annals-IV-4-W5-49-2017>, 2017.

Through this integrated system architecture, the efficiency and quality of information management improved significantly, facilitating smoother collaboration among stakeholders.

(3) Maturity Stage: Handover and Integration of Information Assets

In preparation for handovers to future operators, the vast amount of information accumulated in the CDE was organized and consolidated. At this stage, emphasis was placed on linking physical assets with information assets—such as design data and construction records—to create a structure that could be directly utilized for future operations and maintenance.

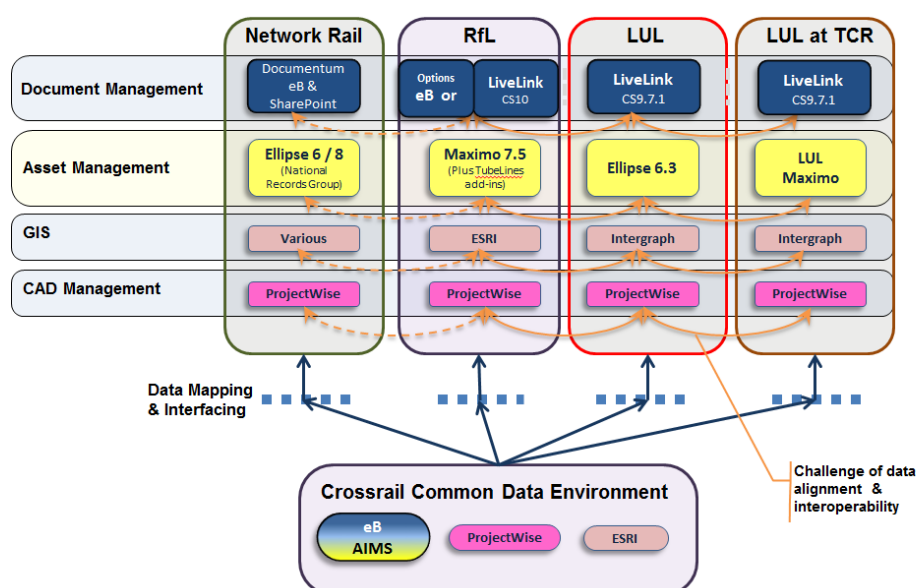
Rather than mere data aggregation, a mechanism was established to enable continuous value creation during the operational phase, ensuring that knowledge and experience were transferred as a foundation for asset management.

However, due to difficulties in system integration among multiple operating entities (see Table 8-4 and Figure 8-5), achieving a fully realized “Single Source of Truth” at the time of handover was not possible.

Table 8-4 Operations and Maintenance Organizations for Crossrail (Elizabeth Line)

Name	Overview and Responsible Sections/Areas
Network Rail	A public body managing the UK’s national railway infrastructure. Responsible for sections connecting Crossrail to existing lines.
Rail for London (RfL)	A division of TfL responsible for maintaining the central section of Crossrail (CCOS: Crossrail Central Operating Section). Unlike TfL’s operations division, RfL specializes in infrastructure management.
London Underground Limited (LUL)	TfL’s underground railway division. Responsible for maintaining stations and facilities connected to Crossrail.
LUL at TCR	A specialized unit within LUL focused on Tottenham Court Road Station, addressing complex station interfaces.

Source: The JICA Study Team



Source: [Information Handover Principles - Crossrail Learning Legacy](#)

Figure 8-5 Overview of System Operations and Information Management Organizations, as of 2016

As a result of the phased development and optimization of the CDE, Crossrail generated direct financial benefits of approximately £10 million per year for over seven years, in addition to achieving sustained reductions in management and IT-related personnel costs for more than five years.⁶

⁶ [London Crossrail: BIM and CDE in the Design and Construction](#)

8.2.1.5 Information Classification Systems (e.g., Uniclass)

As information serves as the foundation for decision-making in project management, the availability of accurate and reliable data was a critical requirement for the Crossrail project. However, at the start of the project, Uniclass2015 had not yet been established, and the existing Uniclass versions—such as Uniclass97 and 2.0—did not sufficiently cover railway and civil engineering facilities and assets required for BIM. To deal with this, Crossrail independently designed and developed an Asset Classification System based on Uniclass, known as the Asset Data Dictionary (ADD). The ADD clearly defined the functions and attributes of each asset class, providing a framework for consistent classification and description of assets (see details in Section 8.2.1.7). This hierarchical structure—with consistent classification codes and identifiers assigned to all assets—was organized as follows:

- Operating Section
- Facility
- Primary Functional Unit
- Functional Unit
- Asset

This hierarchy clarified the affiliation and function of each asset, making asset information easier to search, track, and manage.

Furthermore, Crossrail managed attribute data and design models (2D/3D drawings and BIM models) separately, with clearly defined and distinct roles. Specifically:

- Design Models (Geometrical Data): Used for shape representation during design and construction, updated or exchanged as necessary.
- Asset Attributes: Stored in information management systems like AIMS/EIMS, following attribute items defined in the ADD, and managed using naming conventions and identifiers assigned to each asset.

A key feature of Crossrail's information management approach was the clear separation and management of geometrical data (e.g., 3D models) and asset attribute data. Geometrical information was used for spatial verification and clash detection during design and construction, while asset attributes were stored in a separate database as attribute sets defined by the ADD. Consistency between the two was ensured by using the common classification system and naming conventions, enabling cross-referencing within information systems when required.

This separation of data management achieved several benefits: it ensured lightweight models and compatibility between file formats, while also providing flexibility for easy updates to attribute information during the operation and maintenance phase. Since attribute data could be modified without requiring updates to the shape model, information maintenance efficiency improved significantly, creating a structure well-suited for long-term asset management.

8.2.1.6 Data Exchange Formats (e.g., IFC, COBie)

The Crossrail project utilized Bentley eB and its associated systems to collect and manage information, implementing data migration to the Infrastructure Manager (IM). To meet the required level of detail for railway station asset and linear infrastructure asset management, a policy was established to provide information compliant with COBie. The COBie-compliant information management system enabled the standardized organization of asset information accumulated throughout the project. This achieved greater efficiency in maintenance and management operations during the operational phase.

8.2.1.7 Asset Management Policies and Specific Initiatives

Asset Management Policy

The Crossrail project established a fundamental policy to provide complete and detailed asset information

to support the operation and maintenance of the Elizabeth line. In alignment with international standards—such as the ISO 55000 series and BS/PAS 1192—the project implemented a phased and systematic approach to collecting and managing asset information throughout the entire lifecycle.

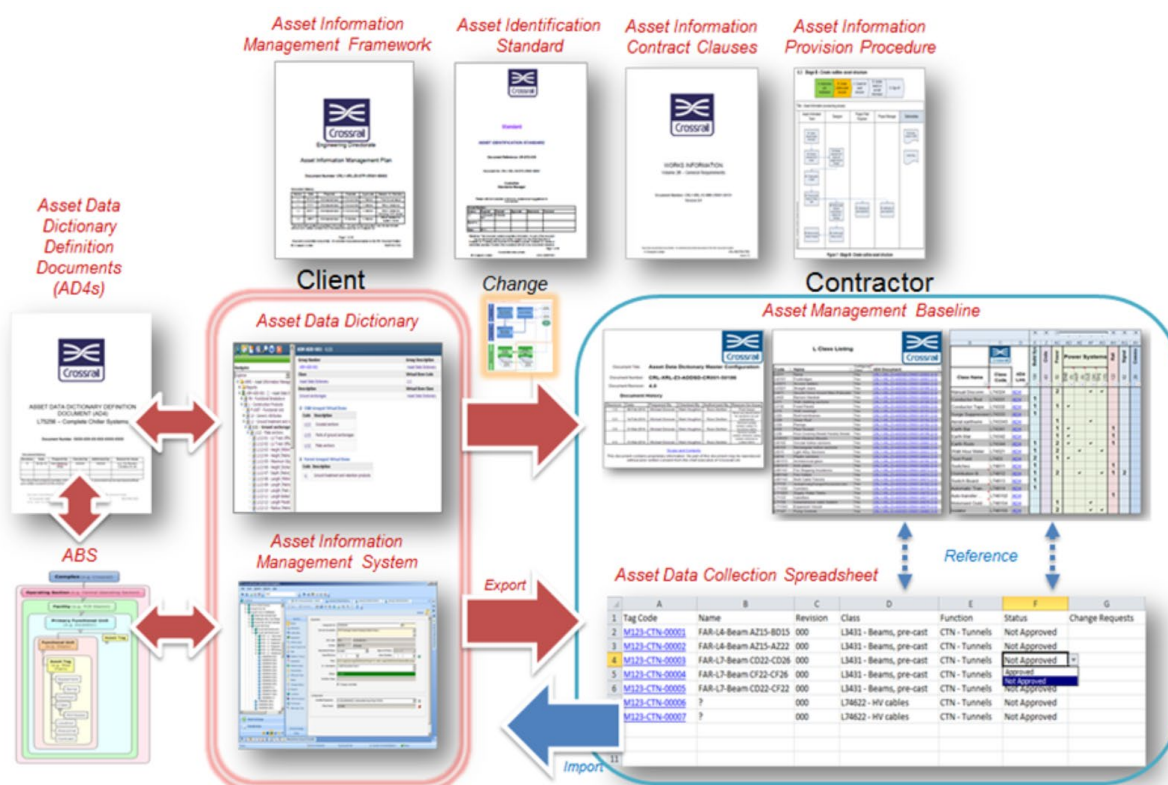
Key Mechanisms and Practices

According to Mr. Ross⁷, the following mechanisms, processes, and structures were key factors in Crossrail's success in securing high-quality asset information:

- **Asset Information Management Framework:**
A framework defining the acquisition, management, and governance of asset information.
- **Asset Identification Standard:**
Specifies naming conventions, label formats, installation requirements, and machine-readable compatibility for assets.
- **Central and Asset Information Management Systems (CIMS/AIMS):**
Core hub systems for information management. While CIMS handles overall information management, AIMS is a specialized asset management tool complementing CIMS. Built on Bentley eB, AIMS manages approximately 500,000 physical assets and related information.
- **Asset Data Dictionary:**
Defines Asset Breakdown Structure (ABS) functions, ABS classifications, and related attributes pertaining to assets.
- **Asset Data Dictionary Definition Documents (AD4s):**
Describe detailed specifications related to over 600 ABS classifications and functions within the ADD.
- **Asset Data Collection Spreadsheet (ADCS):**
A spreadsheet developed to standardize and efficiently collect asset information. It contains separate tabs for each asset classification defined in the ADD, with each tab containing the attribute fields required for that classification. Contractors input this attribute information based on the AD4s.
- **Master Configuration Baseline:**
Defines the standards for all asset-related documentation and classifications.
- **Asset Information Provision Procedure:**
Defines the standard procedure for asset information provision by Crossrail staff, contractors, and third parties for asset registration in AIMS.
- **Asset Information and Configuration Management Team:**
The team responsible for managing various data, preparing it for handover to the IM, and implementing the design and operation of AIMS.
- **Asset Information Delivery Team:**
Oversees all asset information provision, coordination with contractors, and governance from packaging information after registration in AIMS until handover completion to the IM.
- **Contract Clause:**
Contract terms ensuring contractors comply with the above mechanisms, processes, and structures.

The relationships between each system and document are as shown in Figure 8-6.

⁷ Mr. Ross Dentten has served as a key expert in asset information management and traceability for the Crossrail project for over a decade. He has particularly focused on the development and standardization of virtual asset information. During an interview conducted with Bentley Systems for this study, Ross provided valuable advice.



Source: [Better Information Management to Optimise Whole Life Business Decisions - Crossrail Learning Legacy](#)

Figure 8-6 The Relationships Between Each System and Document

8.2.1.8 Contractual Framework

The NEC3 contract form, widely used in UK public works, was adopted by Crossrail in late 2008. The reasons for its selection were as follows:

- Alignment with CRL's culture and objectives;
- Fair risk allocation;
- Robust contract management process;
- Capable of accommodating diverse contract forms and meeting all Crossrail project requirements; and
- Proven track record in other major projects.

CRL obtained a copyright license for NEC3 and modified the standard contract to ensure uniform application across the entire project. The development and adjustment of contractual conditions involved a working group composed of the legal department, procurement team, and site teams. As part of the contract management framework, the Procurement Steering Group/ Procurement Sub-Committee (PSG/ PSC) was established. Significant contractual changes were escalated from the working group to the PSG/PSC. As the bidding process progressed, the Commercial Steering Group (CSG) was formed and delegated decision-making authority from the PSG/PSC. Additionally, the "Contract Administration Manual" was developed to ensure consistency in contract administration and implementation.

8.2.1.9 Education and Training for Project Stakeholders, Including the Supply Chain

In the Crossrail project, it was necessary to systematically manage and utilize a vast and diverse range of information, including drawings, 3D models, contractual documents, and progress data. To address this requirement, a comprehensive BIM strategy was developed at the project level. To ensure that all project stakeholders shared a common understanding of this strategy and were able to operate under a unified

information environment and consistent operational rules, the Crossrail-Bentley Information Academy⁸ (hereafter referred to as “the Academy”) was established in 2012 to promote education, training, and the enhancement of information management skills.

The Academy adopted an educational approach centered on “People”, “Process”, and “Technology”, delivering training programs for Crossrail staff, design and construction partners, and supply chain stakeholders. The facility was located within Bentley’s⁹ offices and equipped with a conference room accommodating 30 participants and 10 technology pods, providing a virtual environment that replicated the actual system setup. Within this virtual environment, participants could experiment with new ideas and assess the impact on existing systems, processes, users, and operational contexts.

In addition, thematic sessions titled “Crossrail BIM Overview Session” were held monthly, covering the following topics:

- An overview of Crossrail’s BIM strategy;
- Understanding of the Information Management approach;
- Understanding and clear guidance on Asset Information management;
- Understanding the use and benefits of Crossrail’s Geographical Information System;
- Understanding and clear guidance on CAD data and model management; and
- An overview of Crossrail’s data migration (handover) strategy.

Participants in these sessions received CPD accreditation, reinforcing the professionalism and credibility of the training. Feedback on the Academy sessions was consistently positive, with attendees reporting an improved understanding of Crossrail’s information strategy and a greater appreciation of data as an asset in its own right following their participation.

⁸ [Information Academy - Crossrail Learning Legacy](#)

⁹ Vendors for BIM/CAD and CDE. In the Crossrail project, the vendors provided the CDE and software listed in Table 8-3.

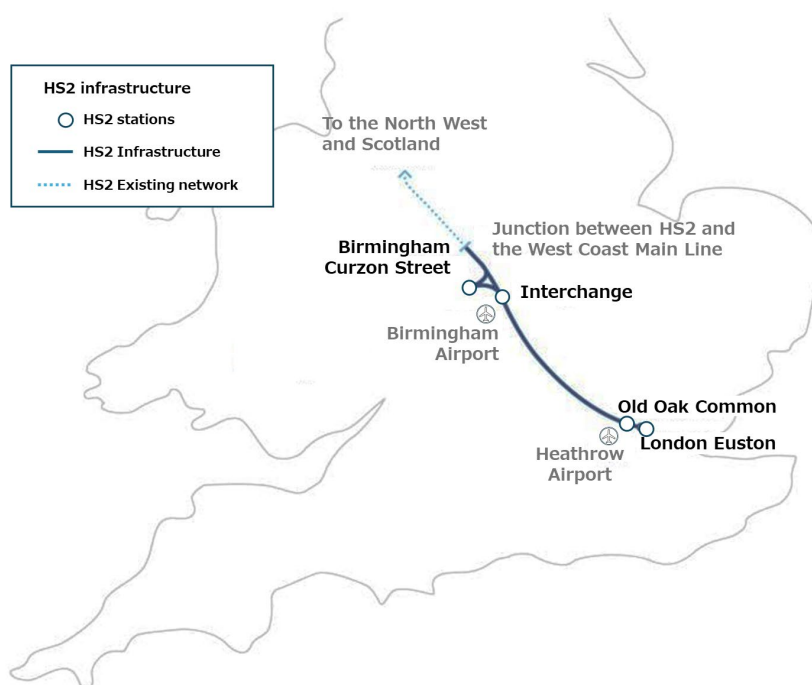
8.2.2 High Speed 2 (UK)

This section provides an overview of High Speed 2 (hereafter referred to as “HS2”) and introduces the HS2 Learning Legacy, which served as a primary information source for this study. It then analyzes and describes, in sequence, the applicable BIM standards, information management systems (e.g., CDE), the status of classification systems and data exchange formats, asset management policies and initiatives, and education and training for stakeholders.

8.2.2.1 Project Overview

The HS2 project is a high-speed rail development designed to connect London with the northern regions of England. Initially, the plan aimed to link London to Manchester and Leeds via Birmingham; however, due to rising costs and other factors, extensions beyond Birmingham were reconsidered. Currently, the focus is on constructing the section between London and Birmingham.

HS2 Ltd. was established in 2009, and the project was officially announced by the UK government in 2012. As of 2025, construction is underway for Phase 1, which spans approximately 225 km between London and the West Midlands. The plan includes the construction of four new stations: Euston, Old Oak Common, Birmingham Interchange, and Curzon Street.



Source: Prepared by the JICA Study Team based on [What is HS2 - HS2](#)

Figure 8-7 HS2 (Phase 1)

In terms of governance, the DfT functions as the sole sponsor of the HS2 project, assuming responsibility for funding, strategic decision-making, and oversight. The delivery organization is High Speed 2 Ltd. (HS2 Ltd.)—established in 2009—which holds the overall responsibility for design, construction, and operational readiness.

HS2 Ltd.’s organizational structure consists of a Board of Directors, under which the executive team led by the Chief Executive Officer (CEO) operates. Below the executive level, departments are organized for engineering, project management, procurement, environment, digital/BIM, and communications.

In 2025, following significant delays and cost overruns, the UK government implemented a Programme Reset¹⁰. As part of this initiative, Mark Wild, who previously led the Crossrail recovery, was appointed

¹⁰ [The HS2 Experience: major transport projects governance and assurance review](#)

CEO of HS2 Ltd., and Mike Brown became Chair of the Board. These changes strengthened project governance and restructuring. In particular, stricter progress monitoring and financial controls were introduced between DfT and HS2 Ltd.

8.2.2.2 Description of Information Sources

The primary information source for this study is the official HS2 website¹¹, particularly the “Learning Legacy” section¹² (hereafter referred to as “HS2 Legacy”). The following explains the origin and structure of the HS2 Legacy.

The HS2 Legacy is an initiative aimed at systematically publishing technical documents, research findings, best practices, and design/construction case studies related to the HS2 project, thereby promoting knowledge sharing. As of September 2025, 225 resources were publicly available—including extensive information on BIM such as “Building Information Management” and “Project Information Management”—making it highly valuable for understanding BIM implementation and information management practices.

The platform was developed with reference to Learning Legacy initiatives from major UK projects, such as the London 2012 Olympics and Crossrail. Content is provided in diverse formats, including case studies, technical papers, micro-reports, best practice documents, and videos, and continues to be expanded. The structure is organized into 15 thematic areas, as shown in Figure 8-8, covering technical, operational, and social domains. Each theme is further subdivided into subtopics, enabling cross-referencing of various aspects of the project.

¹¹ [Homepage - HS2](#)

¹² [Homepage - HS2 Learning Legacy](#)



Communications and Engagement



Consents and Powers



Design, Engineering and Architecture



Digital, Data and Information Management



Environment



Equality, Diversity and Inclusion



Health, Safety and Wellbeing



Heritage and Archaeology



Innovation



Land and Property



Operations



Procurement, Commercial, Legal and Supply Chain Management



Project and Programme Management



Project Startup and Sponsorship



Talent & Resources

Source: [Themes - HS2 Learning Legacy](#)

Figure 8-8 Thematic Areas of HS2 Learning Legacy

Thus, HS2 Legacy serves not only to systematize the knowledge and experience gained from the HS2 project but also to share insights applicable to other infrastructure projects. It has been a critical source supporting the reliability and depth of analysis in this study.

8.2.2.3 Applicable BIM Standards

BIM implementation in the HS2 project has been aligned with the UK government's mandatory BIM Level 2 requirements introduced in 2016. Initially, compliance was based on the earlier BIM Level 2 standards developed in 2011), specifically BS/PAS 1192 series, including BS 1192-4:2014, PAS 1192-2:2013, and PAS 1192-3:2014. Subsequently, the international ISO 19650 series was progressively adopted, including ISO 19650-1:2018, ISO 19650-2:2018, ISO 19650-3:2020, and ISO 19650-5:2020. As of 2025, these standards form the foundation of HS2's information management workflows.

Across all phases—planning, design, construction, and operation—the project requires compliance with BIM Level 2 objectives, which include:¹³

- A consistent approach to data management;
- Clear contractual requirements for data procurement;
- Information models providing reliable data for decision-making;
- Exchange and management of multiple data sources within the CDE;
- Connected data that can be accessed and interpreted efficiently; and
- A fundamental principle: procurement of data itself, rather than drawings.



Source: [Towards a Digital Blueprint: Data, Technology and Collaboration at the Core of HS2 - HS2 Learning Legacy](#)

Figure 8-9 Illustration of the HS2 Vision, Harnessing the Power of BIM to Increase Productivity, Reduce Waste, and More Importantly, Leave a Legacy

8.2.2.4 ISO 19650-Related Initiatives

The HS2 project has implemented an information management framework centered on the ISO 19650 series. The project involves multiple organizations responsible for planning, design, and construction, requiring a system that enables diverse stakeholders to exchange and utilize information on a common platform.

The CDE plays a central role in this framework, supporting the accumulation and sharing of information across the entire lifecycle—from design models and contractual documents to construction progress data and asset information for post-handover operations (see details in Section 8.2.2.5).

¹³ [BIM Upskilling](#)

8.2.2.5 Common Data Environment

Although HS2 has not published EIRs or detailed BIM operation manuals, insights from the official website and Learning Legacy reveal how the CDE is internally managed. Based on these examples, the following summarizes CDE operational methods and their benefits:

(1) Document and Qualitative Data Management¹⁴

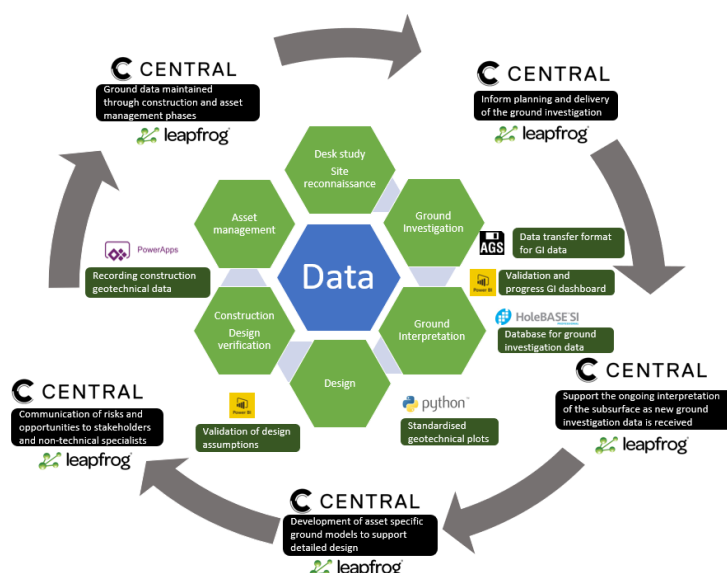
This initiative focused on improving the efficiency of creating, managing, and delivering information for Phase 1 Northern Sections (N1–N2: Long Itchington Wood Green Tunnel to Delta Junction, Birmingham Spur, and Delta Junction to West Coast Main Line connection).

Under the traditional document-based approach, frequent template changes and updates required extensive manual work, creating challenges in efficiency and consistency. To address this, Bentley ProjectWise was introduced as the official CDE, enabling centralized management of documents and qualitative data. Additionally, Microsoft Access was used to complete document creation and updates within a database, ensuring that a single update automatically propagated across all deliverables, achieving a “Single Source of Truth”. Later, limitations in Microsoft Access—such as size constraints, access control, and long-term maintainability—prompted migration to a cloud-based system. The new user interface (UI) allowed web-based viewing and editing, while API integration enabled seamless data exchange between the database and the UI. Data was stored in JSON format, supporting integration with GIS and BIM models for unified handling of spatial, attribute, and document information.

These improvements reduced report preparation time by up to 80%, significantly cut quality-check workloads, and delivered measurable benefits—over 18 months, 1,350 document updates, 176 new documents, and 688 asset updates were completed—generating an estimated £30,000 in savings.

(2) Geotechnical Data Management and 4D Ground Modeling¹⁵

This initiative targeted geotechnical investigation and design activities in Phase 1 Northern Sections (N1–N2). Since investigations and design progressed concurrently, HS2 implemented a system using multiple software tools and Python scripts to automate updates and share geotechnical data and models. This enabled stakeholders to access real-time, auditable information, improving design accuracy and accelerating decision-making.



Source: Reference 15

Figure 8-10 Software Tools Used for Geotechnical Data and Model Management

¹⁴ [Organizing qualitative data into asset databases to standardize reports and improve BIM practices - HS2 Learning Legacy](#)

¹⁵ [Innovative ground data management - HS2 Learning Legacy](#)

The following tools were integrated within the CDE framework:

- Bentley ProjectWise: Official CDE used by the design JV for document and model status management.
- Seequent Central: Cloud-based platform for geotechnical model management, offering version control, annotation, change tracking, and notifications.
- Leapfrog: 3D geotechnical modeling tool integrated with Seequent Central for model creation and updates.
- HoleBASE SI: Database tool for geotechnical data, supporting AGS data import and visualization.
- Power BI Dashboard: Automated monthly AGS data comparison via Python scripts for progress and change visualization.
- GiGi: Tool for processing and analyzing geotechnical data.

Rather than multiple disconnected CDEs, ProjectWise served as the official common platform, complemented by specialized tools integrated into the workflow.

(3) Chiltern Tunnel¹⁶

The Chiltern Tunnel, part of HS2 Phase 1, spans approximately 16 km, comprising twin TBM tunnels, two portals, two bored tunnels, and 40 cross-passages. BIM was extensively applied in design and construction, with design data centrally managed in the CDE using Bentley ProjectWise. Workflows adhered to BS 1192:2007+A2:2007, ensuring standardized quality control and delivery processes.

8.2.2.6 Information Classification Systems (e.g., Uniclass)

The HS2 project adopts Uniclass2015 as the primary classification system for information management centered on BIM. In addition, to enable 4D modeling (adding a time dimension to 3D models) and 5D BIM (integrating cost management), HS2 incorporates Civil Engineering Standard Method of Measurement (CESMM) as a quantity measurement framework. CESMM is specifically designed for civil engineering works, defining standardized methods for calculating quantities for activities such as excavation, foundations, and structures, and serves as the basis for contracts and payments. HS2 applies CESMM as needed for quantity estimation and contractual processes.

For example, in the case of slab elements, the system automatically recognizes the Uniclass code assigned as an attribute and executes quantity calculations. Geometric attributes are used to calculate formwork and volume, design attributes provide material specifications, reinforcement ratios, and strength, while common attributes reference asset classifications and codes. At this stage, Uniclass2015 and CESMM are mapped within the system, and CESMM codes are applied internally. Consequently, it is not necessary to store all information within the model; instead, efficient and consistent quantity estimation and cost management are achieved by relying on key attributes only.

By combining Uniclass and CESMM in a complementary manner, HS2 has established an information framework that, at least partially, supports continuity across design, construction, and operation and maintenance phases.

8.2.2.7 Data Exchange Formats (e.g., IFC, COBie)

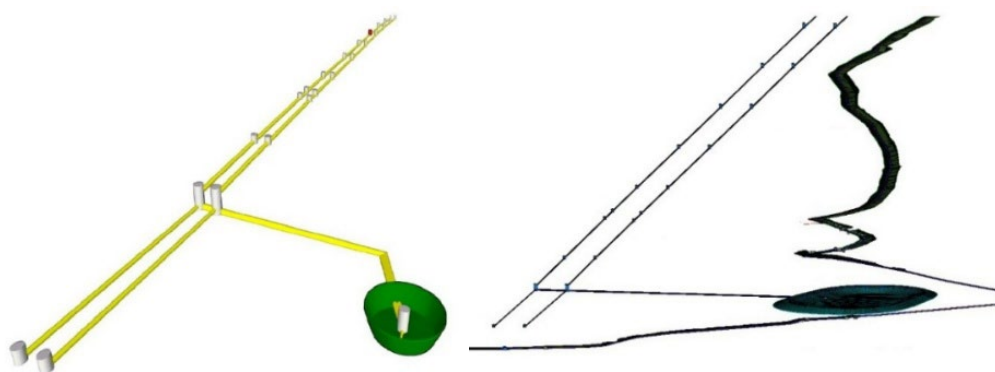
Although HS2 has not published EIRs or detailed BIM operation manuals, insights from the official website and Learning Legacy reveal how data exchange formats are utilized. The following summarizes practices based on a drainage design example from the Phase 1 Northern Sections (Long Itchington–Delta Junction and Birmingham Spur–West Coast Main Line).¹⁷

This case involves the integration of BIM information formats and information management processes into drainage design. During the design phase, MicroDrainage (MD) was used for the hydraulic design and simulation of the drainage system (see Figure 8-11), and the drainage network was modeled based on the

¹⁶ [Using 3D models and BIM for the Chiltern Tunnel Design - HS2 Learning Legacy](#)

¹⁷ [Bridging the gap between drainage design and BIM modelling - HS2 Learning Legacy](#)

results obtained. Bentley OpenRoads Designer (ORD) was primarily used to create the BIM model (see Figure 8-11), with Autodesk Civil 3D (C3D) also used in some areas. Elements such as drainage pipes, manholes, and gradients were represented as 3D models, integrating geometric information. Because native data formats had limited interoperability, geometric data was converted to the IFC format before being stored in the CDE. This enabled clash detection with other discipline models and construction simulations, ensuring design information was shared across the project. Meanwhile, the hydraulic calculation results, design parameters, and maintenance-related attributes generated by MD were exported in CSV format and stored in the CDE. The CSV format provided a tabular structure suitable for numerical comparison, quality checks, and traceability of design changes. By cross-referencing IFC geometric data with CSV numerical data, missing performance-related quantitative information was supplemented, ensuring consistency from design through construction and operation. Thus, HS2 established a clear division of roles: geometry in IFC, and attributes in CSV, integrated within the CDE for unified reference.



Source: [Bridging the Gap Between Drainage Design and BIM Modelling - HS2 Learning Legacy](#)

Figure 8-11 Examples of HS2 Drainage Design Model (Left) and BIM Model (Right)

8.2.2.8 Asset Management Policies and Specific Initiatives

Although HS2 has not published documents such as OIR, AIR, or PIR, insights from the official website and Learning Legacy confirm that these requirements are applied internally. Based on available examples^{18, 19, 20}, the following summarizes HS2's asset management policies and practices:

Asset Management Policy

HS2 aims to transition from PIM created during design and construction to AIM for use in operation and maintenance. All information is managed within the CDE, enabling lifecycle-wide utilization from design and construction through operation and maintenance.

Specific Initiatives

- **Utility Asset Management (Phase 1):**
Approximately 5,000 utility assets (electricity, water, telecommunications, etc.) are managed by categorizing activities as contestable (outsourced) or non-contestable (managed directly by asset owners). A dedicated utility team was established, and for non-contestable assets, HS2 adopted a policy of direct coordination with UAOs (Utility Asset Owners) to enable early design and construction readiness.
- **Environmental and Landscape Asset Management:**
Environmental and landscape assets such as terrain, ecosystems, and trees are managed through integration with CAD/GIS/AIMS, ensuring data remains useful not only during construction but also in future maintenance phases. Soil and tree survey data are incorporated into BIM models, informing

¹⁸ [Asset Management Archives - HS2 Learning Legacy](#)

¹⁹ [Soils, Landscape and Woodland: How HS2 is using integrated asset information management in a BIM environment. - HS2 Learning Legacy](#)

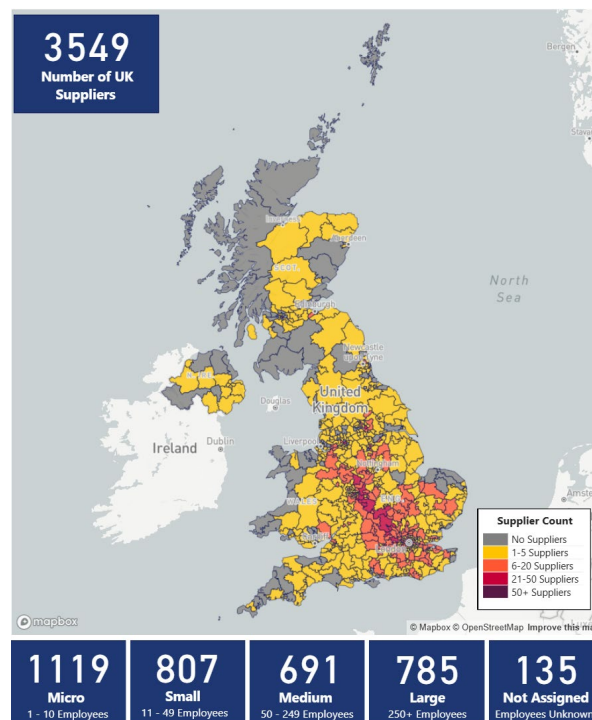
²⁰ [Planning and Managing Utilities on HS2 \(High Speed 2\) - HS2 Learning Legacy](#)

design decisions and construction planning to minimize environmental impact.

8.2.2.9 Contractual Framework

HS2 is one of the UK's largest infrastructure projects, involving thousands of companies across a hierarchical supply chain. The main structure is as follows:

- **Main Works Contractors (Tier 1):**
Responsible for major civil works (tunnels, trackbeds, bridges), often operating as temporary joint ventures (JVs).
Examples: Balfour Beatty Vinci, Skanska Costain STRABAG JV, Align JV
- **Design Consultants and Engineering Firms:**
Provide design support, systems engineering, and environmental impact assessments.
Examples: Arup, Mott MacDonald, WSP, Jacobs
- **Suppliers (Tier 2, Tier 3):**
Supply materials, equipment, IT systems, and BIM/CDE solutions. Participation by SMEs is actively encouraged, contributing to regional economic development.



Source: [HS2 - Number of UK Suppliers](#)

Figure 8-12 Supply Chain Map

HS2 adopts the NEC3 contract form, widely recognized for its collaborative approach and strong industry acceptance. Reasons for selection include:

- Alignment with HS2's culture and objectives
- Fair risk allocation
- Robust contract management processes
- Flexibility to accommodate diverse contract types
- Proven track record in major projects

Specifically, the following contract types are used depending on the contract category:

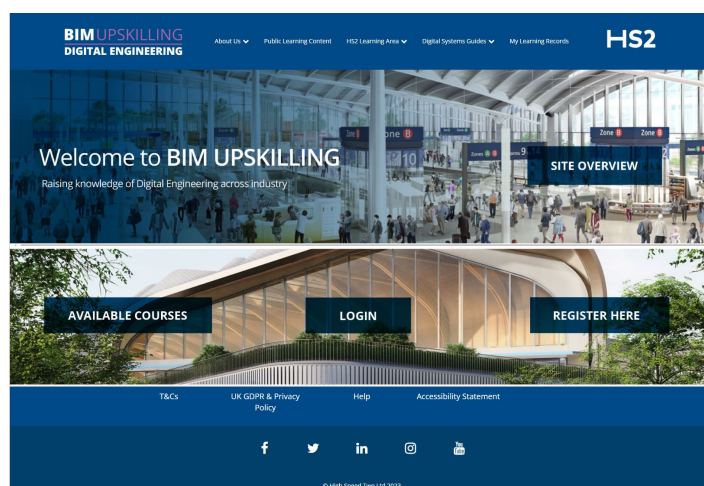
- The Professional Service Contract (PSC): For consulting services
- The Engineering and Construction Contract (ECC): For construction works
- NEC Option C (Target Cost Contract): For major civil works

In cases where NEC3 is unsuitable (e.g., certain corporate or rolling stock contracts), alternative contract forms are applied.

HS2 promotes consistent application of these contractual conditions across primary and secondary subcontractors, ensuring uniformity throughout the supply chain.²¹

8.2.2.10 Education and Training for Project Stakeholders, Including the Supply Chain

HS2 operates an online learning platform for its supply chain, including designers and contractors, offering free access to e-learning materials under the “BIM Upskilling” program.²² The content covers HS2’s strategy, vision, and objectives for BIM and digital engineering, as well as detailed descriptions of roles and responsibilities and key reference documents. It also provides an overview of HS2’s processes, policies, and standards, along with insights into the benefits realized through the implementation of digital engineering.



Source: Reference 22

Figure 8-13 BIM Upskilling

²¹ [Supply Chain FAQs](#)

²² [BIM Upskilling](#)

8.2.3 Rail Baltica (Baltic States)

This section provides an overview of the Rail Baltica project and sequentially analyzes the applicable BIM standards, the configuration and data migration of information management systems (CDE), the status of classification systems and data exchange formats, asset management policies, and contractual arrangements.

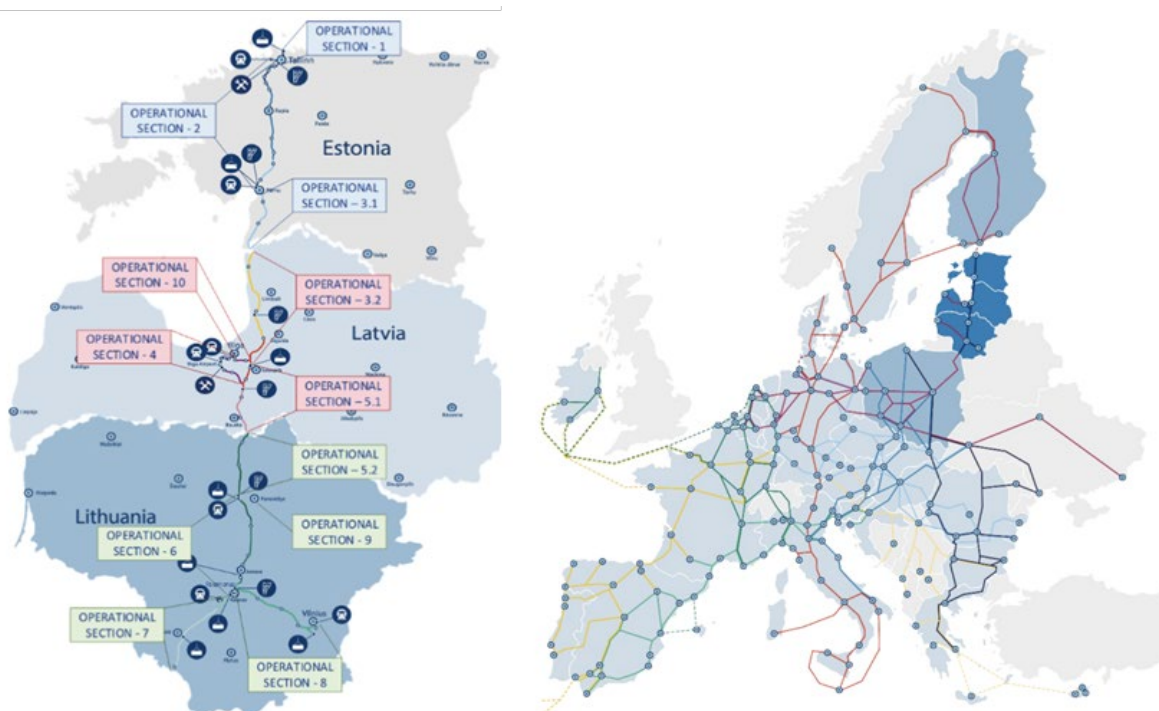
8.2.3.1 Project Overview

The Rail Baltica project is a new railway infrastructure development aimed at connecting the Baltic States (Estonia, Latvia, and Lithuania) to the European rail network. Historically, the Baltic States—formerly part of the Soviet Union—have used the Russian broad-gauge system (1,520 mm). To achieve independence from the Russian rail network, the project adopts the European standard gauge (1,435 mm).

The planned railway will extend approximately 900 km, running from Tallinn in northern Estonia to the Polish border in the south. Rail Baltica is positioned as a strategic project within the EU’s North Sea-Baltic TEN-T Corridor and the Baltic-Black Sea-Aegean TEN-T Corridor.

The project commenced in 2014 and is progressing through phased design, procurement, and construction, with the goal of starting operations by 2030. Funding is primarily provided by the EU Connecting Europe Facility (CEF), covering 85% of costs, with the remainder financed by the national budgets of the Baltic States.

Expected benefits include reduced travel and freight times, lower CO₂ emissions, job creation, and long-term economic and environmental gains not only for the Baltic region but for Europe as a whole.



Source: [RB Rail AS Company strategy 2024-2030, Rail Baltica](#)

Figure 8-14 Rail Baltica Route Overview and Position within TEN-T

8.2.3.2 Description of Information Sources

The primary source of information for this study is the “Rail Baltica Official Website”²³, which provides comprehensive details about the entire project. The site includes essential information such as project background, objectives, technical specifications, history, key milestones, and financial status. In addition, it is regularly updated with the latest news, construction progress, and event information. The website

²³ [Rail Baltica Official Website](#)

features rich visual content, including high-resolution photos and videos, interactive route maps, and thematic explanatory videos, enabling an intuitive understanding of the project's current status. Furthermore, it offers extensive resources for stakeholders, such as procurement and tender information, contract status, and compliance guidelines. Specialist materials are also available, including cost-benefit analyses, BIM and GIS related documentation, and studies on material supply surveys.

8.2.3.3 Applicable BIM Standards

As a large-scale railway infrastructure project spanning the Baltic States, Rail Baltica promotes BIM implementation to enhance information management and efficiency through digital technologies. As of 2024, BIM operations are based on processes compliant with the ISO 19650 series (ISO 19650-1:2018, ISO 19650-2:2018, ISO 19650-3:2020, ISO 19650-5:2020), which form the foundation of its information management workflows. Some related documents were developed with reference to BS/PAS 1192, the predecessor of ISO 19650. In addition to international standards, Rail Baltica incorporates national standards such as LVS 1052:2018 (Latvia) and EVS 928:2016 (Estonia) to address country-specific requirements. This approach ensures both international interoperability and compliance with local regulations, creating a robust BIM framework tailored to the project's multinational context.

8.2.3.4 ISO 19650-Related Initiatives

The Rail Baltica BIM Manual, published in 2022, designates ISO 19650-1:2018 and ISO 19650-2:2018 as mandatory reference standards, defining the overarching BIM strategy and implementation principles for the entire project. Additionally, the predecessor standards PAS 1192 (PAS 1192-2:2013, PAS 1192-3:2014, PAS 1192-4:2014, PAS 1192-5:2015) were adopted to ensure consistent information management across the full lifecycle—from design and construction to operation and maintenance.

In 2024, Rail Baltica introduced Digital Information Requirements, incorporating ISO 19650-3:2020 and ISO 19650-5:2020 alongside ISO 19650-1 and -2, and adopted BS 1192-4:2014 to clarify information handover requirements.

(1) ISO 19650-1

Rail Baltica emphasizes information reuse throughout the entire lifecycle (design, construction, operation, and maintenance) and has established a structured framework for information management. A BIM strategy ensures consistency and efficiency in managing information across all project phases.

(2) ISO 19650-2, 3

Rail Baltica specifies information management processes for each phase (planning, design, construction, operation) based on ISO 19650-2 and 3. For example, it promotes coordination among project stakeholders by establishing Information Exchange Requirements (EIR) and BIM Execution Plans (BEP), clarifying roles and responsibilities.

The CDE serves as the foundation for information sharing, enabling smooth and efficient data exchange (see 8.2.3.5). Information exchange follows openBIM principles, avoiding dependency on proprietary software. The primary format is IFC, supplemented by LandXML, BCF, CSV, XML, and PDF as needed (see 8.2.3.7).

To ensure quality, authoring rules are established for georeferencing, naming conventions, attribute sets, and Level of Definition (LOD). Verification through mockup reviews and checklists is mandatory before delivery. This establishes a system guaranteeing the consistency and completeness of information.

(3) ISO 19650-5

Rail Baltica has implemented ProjectWise as its CDE, enabling secure and efficient information exchange while ensuring advanced IT security. This framework maintains reliability and transparency in information management from design through construction.

8.2.3.5 Common Data Environment

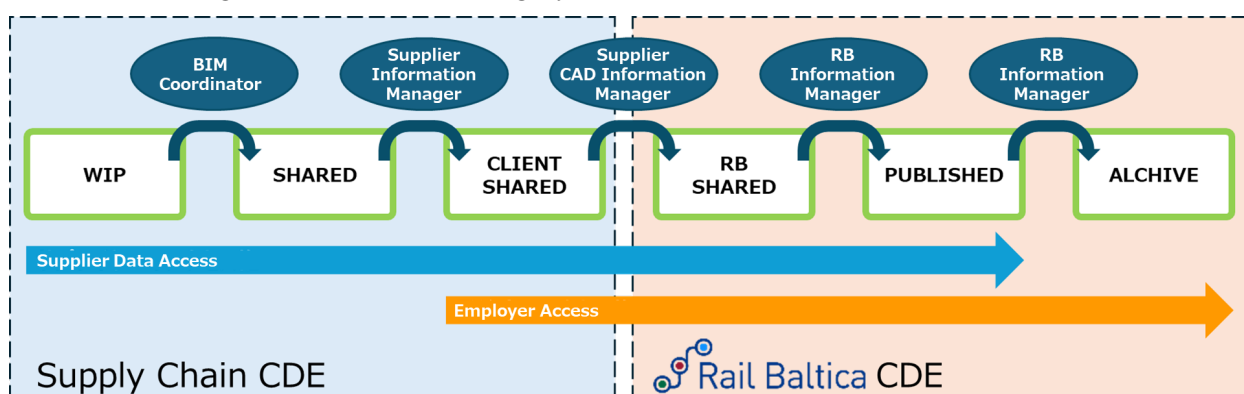
(1) Basic Structure of the CDE

In the Rail Baltica project, the CDE serves as the core platform for BIM-based information management. Its operation follows the principles of ISO 19650 and the PAS 1192 series, functioning as the foundation for transitioning from Project Information Models (PIM) during design and construction to Asset Information Models (AIM) for the operational phase.

The CDE workflow is managed through a series of information status stages: WIP (Work in Progress) → Shared → RB Shared → Published → Archive (see Figure 8-15). Suppliers create data within their own organizational CDEs, perform quality checks, and then submit it to the Shared area. Upon submission, metadata such as applicability codes and status codes are added, along with quality control checklists and clash detection reports.

These data sets are tracked and managed centrally within the CDE. Submitted data is transferred to the RB Shared area and then reviewed and approved by the Rail Baltica BIM team before being registered in the Published area, making it accessible to the entire project team. At major project milestones, progress records are stored in the Archive area for future reference and validation.

Access control is strictly enforced. Rail Baltica's BIM Information Managers and access administrators oversee permissions and quality assurance, while suppliers assign discipline-specific coordinators and information managers to maintain data integrity.



Source: Prepared by the JICA Study Team based on Rail Baltica documentation

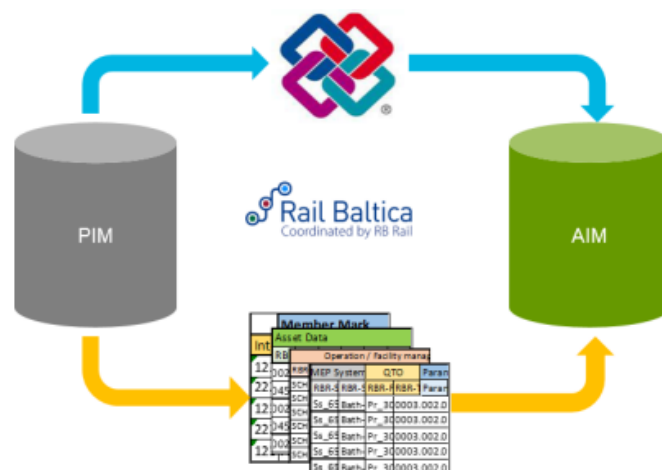
Figure 8-15 CDE Workflow

(2) Transition from PIM to AIM

At project handover, a structured process is implemented to transition from PIM to AIM. The AIM CDE operates under the same rules as the PIM CDE but manages only as-built documentation (final versions of models, drawings, documents, and reports).

The main migration processes are as follows (see Figure 8-16):

- **Data Mitigation (Attribute Data Migration):**
Attribute information extracted from BIM models (Excel/CSV format) is mapped and transferred to the AIM asset register database.
- **3D Geometry Mitigation (Geometric Data Migration):**
Geometric data extracted from BIM models (IFC format) is transferred to the AIM asset register database. Post-migration link management follows the asset register's BIM model governance policy, referencing Object ID, Member Mark, and AssetMark.



Source: [RBDG-MAN-035-0103_CodificationDataManagement.pdf](#)

Figure 8-16 Transition from PIM to AIM

8.2.3.6 Information Classification Systems (e.g., Uniclass)

Rail Baltica adopts an asset classification system based on Uniclass 2015, in compliance with ISO 12006-2:2015. Uniclass2015 ensures consistent attribute assignment across technical specifications, BIM models, and quantity take-off documents, creating an integrated system for asset information management throughout the entire lifecycle.

Figure 8-17 illustrates an example where quantity items specified in a technical specification are linked to a System Code (Ss), which is also assigned as an attribute within the BIM model, ensuring consistency across all deliverables.

Table 187. Units of measurement - Wooden fence

Uniclass code	Type number	Work item	Unit	Work item includes
Ss_25_14_63_95	000301	WOODEN FENCE OVER CUTTING OR EMBANKMENT CROSS SECTIONS	m	Wooden fence over cutting or embankment cross sections consists of all works and expenses necessary to achieve the specified end result, e.g. workforce, materials, equipment and transportation (incl. fuel, insurance, etc.). This item is meant for supply and placement of wooden fence composed of structural steel posts and wooden boards, including the foundation of the posts with reinforced concrete, the subsequent filling of soil and the protection of the slope with a stone pitching finishing with a kerbstone.

RBR-Pr_Code	RBR-Type_number	RBR-VolSysZone	RBR-Functional_cla...	RBR-Volume
✓ Ss_25_14_63_95 (20)	Varies	Varies	CV-BR-OPSS-WL	
> Ss_25_14_63_95	000301	BR1640ZZ	CV-BR-OPSS-WL	--
> Ss_25_14_63_95	000301	BR1645ZZ	CV-BR-OPSS-WL	--

Source: Reference 24

Figure 8-17 Example of Consistent Attribute Assignment Using Uniclass2015 Across BIM Models, Specifications, and Quantity Take-Offs

24 Miina Karafin, Digital Data Flow: A General Contractor's Perspective on Rail Baltica BIM and Handover Requirements, infraBIMopen, 2025

8.2.3.7 Data Exchange Formats (e.g., IFC, COBie)

Rail Baltica's BIM implementation follows a fundamental principle: to ensure future data availability and interoperability, the use of open, non-proprietary formats (such as IFC and CSV) is strongly recommended. IFC serves as the core format for information exchange across design, construction, and operation phases.

IFC usage complies with ISO 16739, with IFC4 recommended, although IFC2x3 remains acceptable. Where open formats cannot retain certain data or editing is required, submission in native software formats is permitted. These requirements are defined in the BIM Execution Plan (BEP) and are agreed upon by the client and Rail Baltica's BIM Information Manager.

The main file types and their purposes are shown in Table 8-5.

Table 8-5 File Types/Formats and Their BIM Uses

File Type / Format	Extension	BIM Uses
Native BIM File Formats	.rvt, .dgn, .ndw, .dwg, .pln, .pla, 等	Design authoring
Open BIM Format	.ifc	Information and model exchange
Alignment Open BIM Format	LandXML	Existing conditions, alignments and civil engineering Information
Point Clouds Open BIM Format	.txt, .las, .laz, .e57, .ptx, .pts, .asc, .ply 等	Existing conditions information
Federated BIM Models	.nwc, .nwd, imodel-i.dgn, .smc 等	Design review, coordination, CDE visualization
2D Drawing (CAD) Formats	.rvt, .dgn, .ndw, .dwg, .pln, .pla, 等	Drawing deliverable
BIM Coordination Format	.bcf	Design review, coordination
I-Model Overlay	imodel.overlay	Design review, coordination
Open BIM Data Base Readable File Format	.xlsx, .csv, .gml	Data capture, classification and information
Excel Spreadsheet	.xlsx	Data capture, classification and information
Document Export	.xlsx, .docx, .pdf	BIM-related documents (reports, specifications, etc.)
Video	.avi, .mpeg, .mov	Sequencing visualization
Image	.jpeg, .png	Image capture, rendering

Source: Prepared by the JICA Study Team based on Rail Baltica documentation

The BEP specifies version control and export settings, requiring the use of buildingSMART-certified software to maintain the prescribed attribute structures. To ensure accessibility, recipients must be able to view open formats using free viewers.

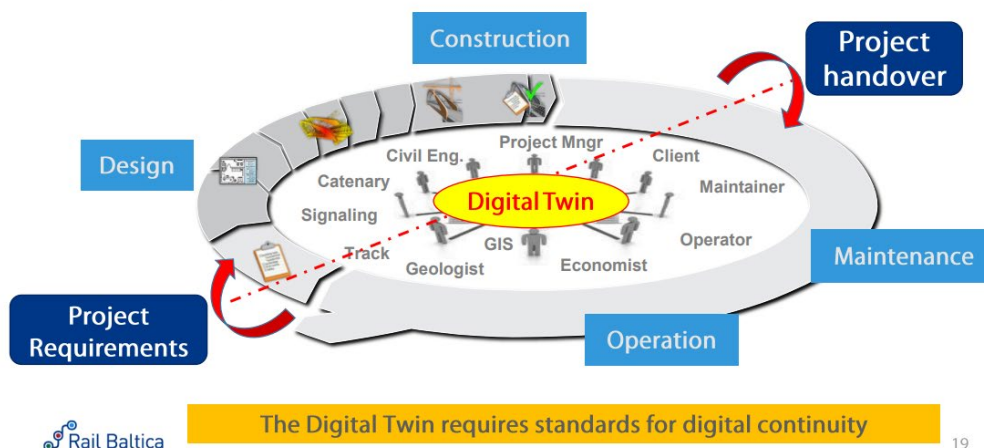
For asset registration and handover during the operation and maintenance phase, Data Drops (Excel/CSV format) are required for the submission of asset attribute data (e.g., product name, specifications, manufacturer, model number, installation date, and maintenance manual references). These data are ultimately entered into the Asset Register (AR) system and managed in accordance with Rail Baltica's defined asset attribute coding structure. As an alternative, COBie spreadsheets are also proposed for information exchange.

8.2.3.8 Asset Management Policies and Specific Initiatives

The Rail Baltica project positions asset management as an integral component of its broader digital transformation enabled through BIM information processes (see Figure 8-18).

VISION: Design and Maintain a Digital Twin

A major improvement to efficiency, in both projects and maintenance activities, will come from our capacity to organize collaboration between contributors, and their solutions.



9th RailTopoModel conference – 22nd May 2018 by Alain Jeanmaire from SNCF Réseau email: alain.jeanmaire@outlook.com

Source: [Sustainability: Next Steps](#)

Figure 8-18 Asset Management Vision for the Rail Baltica Project

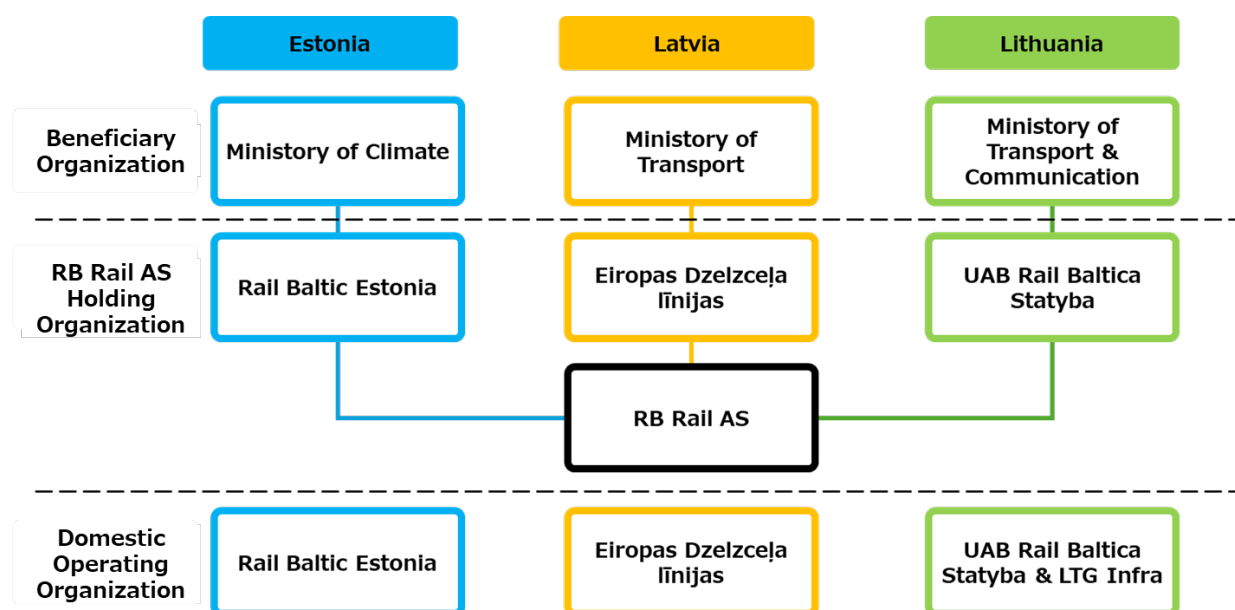
When the BIM strategy was formulated in 2018, the future infrastructure operator had not yet been determined. Therefore, the requirements defined in the documentation were intentionally designed as a standardized yet flexible framework. This strategy aligns with ISO 55001:2014, with the primary aim of facilitating handover, supporting the development of operational and maintenance plans, and ensuring a smooth transition to the operational phase.

The approach provides a concise definition of the general asset management processes at the end of the construction phase and throughout the operation and maintenance phase, specifying procedures for planning, analysis, and documentation. It also incorporates flexibility to accommodate any equivalent documentation or processes that may be adopted by the future infrastructure operator, ensuring alignment and interoperability.

8.2.3.9 Contractual Framework

The Rail Baltica project is a new railway infrastructure development jointly implemented by the three Baltic States—Estonia, Latvia, and Lithuania—with each country's transport ministry designated as a beneficiary. The joint venture RB Rail AS, established in 2014 through equal contribution from the three countries, serves as the central project entity responsible for overall coordination, unified procurement, and the standardization of technical requirements.

Actual design and construction activities are carried out by national implementing bodies established in each country: Rail Baltic Estonia in Estonia, *Eiropas Dzelzceļa līnijas* in Latvia, and UAB Rail Baltica Statyba and LTG Infra in Lithuania. These organizations execute project components under the unified contracting and procurement framework coordinated by RB Rail AS (see Figure 8-19).



Source: Prepared by the JICA Study Team based on [Project governance - RB](#)

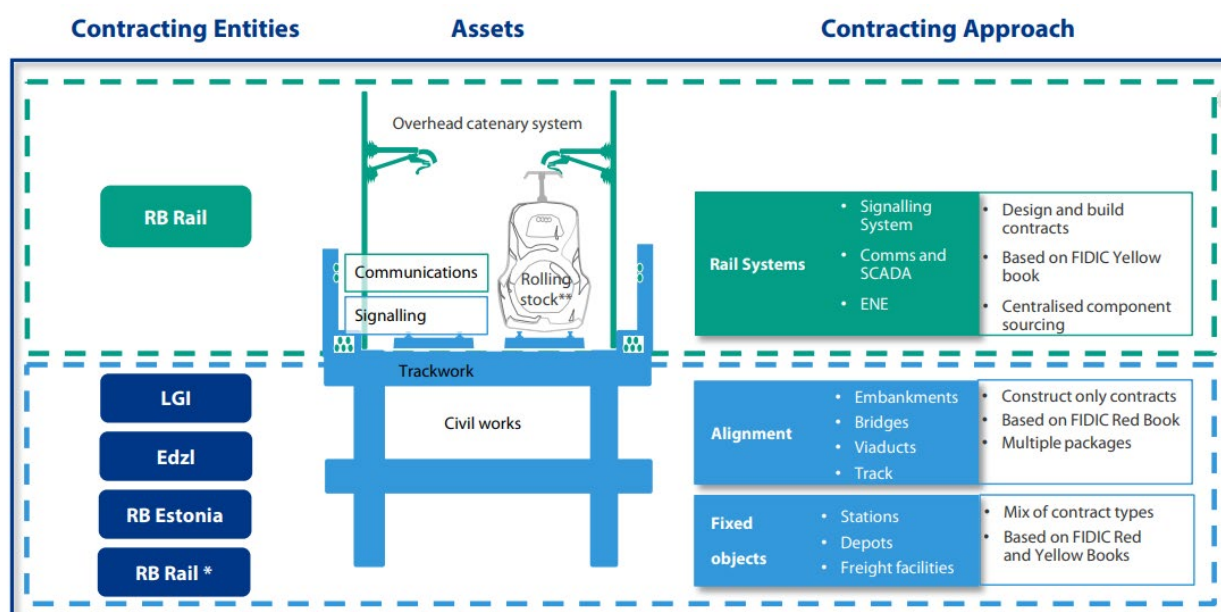
Figure 8-19 Rail Baltica Project Structure

Under this organizational structure, while each country may apply its own contracting methods for domestic sections, the project as a whole adopts the FIDIC contract conditions, ensuring alignment with international standards.

As of May 2025, the project remains in the delivery phase, with design and construction progressing. The following summarizes the confirmed contractual arrangements.

(1) Common Contracting Framework Across the Three Countries

The basic contracting structure, as of 2020, is shown in Figure 8-20.



* RB Rail is responsible for cross border elements of alignment ** Rolling stock procurement is not part of the project scope

Source: [M. Loader: Project Delivery - Overview | RBOnlineForum 2020](#)

Figure 8-20 Contracting Overview

For railway systems such as Control-Command and Signaling (CCS) and Energy Supply (ENE), a Design-Build approach based on the FIDIC Yellow Book is adopted. For infrastructure works—embankments, bridges, viaducts, and other civil structures—the project uses a Design-Bid-Build approach based on the FIDIC Red Book, divided into multiple construction packages. Station facilities and depots apply either the FIDIC Yellow or Red Book depending on project characteristics.

(2) Contracting Characteristics by Country

Estonia

Building on the 2020 baseline framework, Estonia revised its contracting strategy toward meeting the 2030 opening target. In 2024, an alliance procurement strategy was introduced, and by May 2025, major construction contracts for Estonia's sections had been tendered using the alliance model. This approach promotes collaborative contract execution, risk and reward sharing, enhanced cost efficiency, and shortened construction schedules.

Latvia

For major construction sections, Latvia adopts the FIDIC Red Book with a unit-price (measure-and-value) contract structure. For construction supervision, the role of FIDIC Engineer is defined, based on a consultant contract structure equivalent to the FIDIC White Book.

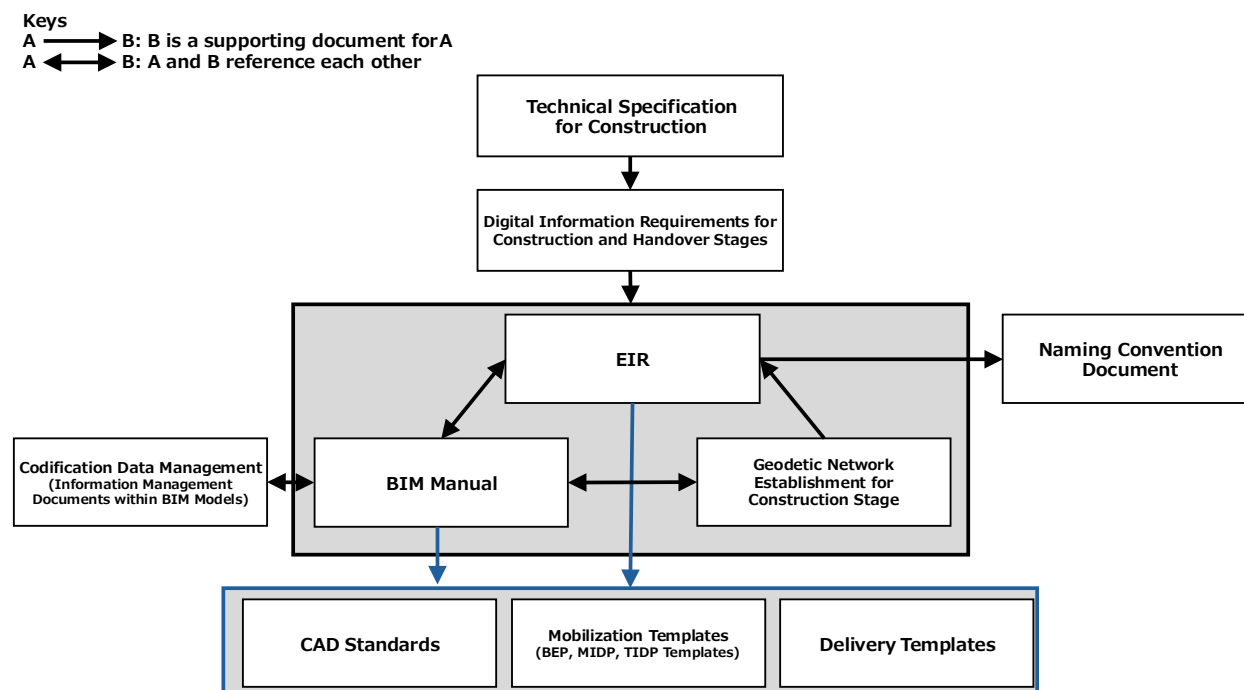
Lithuania

In Lithuania, the FIDIC Red Book is most widely used across both public and private sectors. It has also been applied in procurement for major works such as the railway bridge over the Neris River.

(3) Contractual Treatment of BIM Requirements

As noted above, construction contracts in the Rail Baltica project are based on the FIDIC Red and Yellow Books. Because FIDIC (Red/Yellow Book) does not include explicit BIM clauses, BIM requirements are typically addressed through supplemental guidance documents.

Technical specifications prepared by the client include descriptions of the CDE, and BIM requirements are operationalized through a set of documents—EIR, BIM Manual, Geodetic specifications, and others—that carry de facto contractual authority (see Figure 8-21).



Source: Prepared by the JICA Study Team based on Rail Baltica documentation

Figure 8-21 Relationship Between Technical Specifications and Key BIM-Related Documents

As of June 2025, the BIM Manual specifies the following deliverable templates:

- BIM Delivery Report Template
- QA/QC CAD/BIM Checklist Report Template
- Clash Check Report Template
- Quantity Extraction (QEX)
- Quantity Take-Off (QTQ)
- Data Drop Template
- CAD Template

8.2.3.10 Education and Training for Project Stakeholders, Including the Supply Chain

At present, no formal policy documents have been published regarding BIM training or standardization programs for project stakeholders, including those in the supply chain. However, initiatives aimed at knowledge sharing and technology dissemination have been identified.

A representative example is the Rail Baltica Academy, held annually for students and industry professionals. The program is organized in cooperation with universities and educational institutions and features lectures and sessions on themes such as digitalization and sustainability. Within the organization, internal forums dedicated to BIM and GIS are held regularly. These forums facilitate the sharing of progress updates, challenges, and strategic perspectives among project members.

8.2.4 Kiwi Rail Digital Engineering (New Zealand)

KiwiRail is a state-owned enterprise responsible for freight rail transport, metropolitan and intercity passenger rail services, and inter-island ferry operations in New Zealand. The organization undertakes the full range of rail activities—from train operations to maintenance—and owns extensive infrastructure including approximately 3,700 km of track, 3,096 signaling installations, 1,444 level crossings, and around 4,500 freight wagons, among other rail assets.²⁵

8.2.4.1 Project Overview

The New Zealand government has outlined a long-term vision and investment policy to enhance the safety and reliability of the national rail network, published since 2021 as the New Zealand Rail Plan²⁶. In alignment with this plan, KiwiRail prepares the Rail Network Investment Programme (RNIP)²⁷ every three years, specifying investment priorities, budget estimates, and project allocations. Upon approval by the Minister of Transport and Minister of Finance, funding is provided through the National Land Transport Fund (NLTF), enabling the implementation of the RNIP.

Under this framework, KiwiRail promotes “Digital Engineering (DE)” approach to improve capital project efficiency, strengthen asset lifecycle management, reduce construction risks, and ensure seamless data integration into operational phases.

Table 8-6 Expected Outcomes from Digital Engineering (Strategic Objectives)

Commercial Delivery	People & Safety	Capital Projects Delivery	Sustainability, Innovation & Collaboration
- Enable data driven commercial decision making - Improved productivity in the construction of new assets - DE tools & processes enable risk to be managed at the right time in the asset life cycle	- Keeping our people safe through the scaled implementation of Machine Avoidance and other DE technologies - Develop our “digital way of working” on projects that aligns with the wider high-performance high engagement culture	- Structured and reliable asset information - Coordinated designs produced in a single source of truth location - Connected technologies that drive delivery efficiencies	- Carbon reduction through the improved quality of digitised assets - An environment for innovation to thrive within the business - Industry leading, chairing the Digital Asset Owner and Committee for Digital Engineering in NZ forums

Source: Digital Engineering Framework v5

As noted above, KiwiRail’s strategic objectives encompass the entire asset lifecycle. Accordingly, the goal is not merely the introduction of “design BIM,” but the establishment of a comprehensive information platform that support the full lifecycle of railway assets.

The DE framework was developed through pilot projects conducted as part of the Wellington Metro Upgrade Programme (WMUP)²⁸, which began in 2018. One such pilot was the double-tracking project between Trentham and Upper Hutt (2.7 km) undertaken from 2019 to 2020.²⁹ With a commitment to paperless delivery, all designs were produced digitally—a pioneering achievement that earned KiwiRail, Downer, and Aurecon New Zealand the Engineering Innovation Award (2021). Other pilot initiatives included CDE implementation, clash detection, machine avoidance protocols, and monthly as-built submissions. The lessons learned from these activities laid the foundation for KiwiRail’s organization-wide

²⁵ [Kiwi Rail Integrated Report 2024](#)

²⁶ [the New Zealand Rail Plan](#)

²⁷ [Rail Network Investment Programme \(2021\)](#)

²⁸ [Wellington Metro & Lower North Island | KiwiRail](#)

²⁹ [Trentham-to-Upper-Hutt-Residents-info-Pack](#)

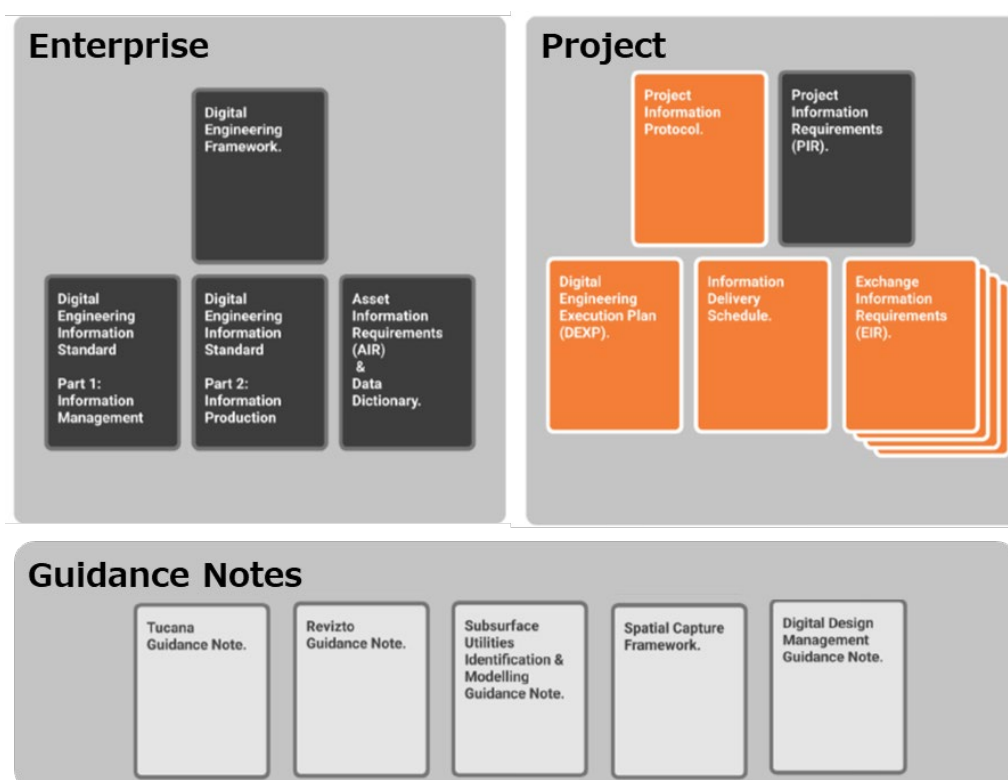
deployment of Digital Engineering.

Through DE adoption, KiwiRail expects benefits such as:

- Reduction of design-stage clashes and associated construction changes and cost increases (pilot results showed cost reductions of approximately 10% of contract value)
- Improved construction productivity
- Enhanced accuracy of asset data
- Direct integration of asset information into the Computerized Maintenance Management System (CMMS)

8.2.4.2 Description of Information Sources

KiwiRail's Digital Engineering (DE) initiatives are documented across multiple layers of guidance materials. At the enterprise-level, there are overarching documents such as the Digital Engineering Framework v530, which outlines the overall vision, objectives, and strategy, as well as the information management approach (including alignment with ISO 19650), the structure of CDE, workflows, and training guidelines. At the project level, documentation includes the Asset Information Requirements (AIR), Project Information Requirements (PIR), Exchange Information Requirements (EIR), and the Digital Engineering Execution Plan (DEEP). Guidance materials also comprise various tool-specific manuals and generic templates used for PIR and related documentation.



Source: Prepared by the JICA Study Team based on Digital Engineering Framework v5

Figure 8-22 Digital Engineering Document Structure

As outlined in the Framework, KiwiRail intends to deploy DE in four phases—Test → Scale → Advise → Transform—in accordance with its internally developed Programme Plan. The Framework also emphasizes the importance of managing not only design models but also asset information, including attributes, in a structured and systematic manner.

30 [Digital Engineering Framework v5](#)



Source: Digital Engineering Framework v5

Figure 8-23 Digital Engineering Programme Plan

8.2.4.3 Applicable BIM Standards

The KiwiRail DE Framework states that DE practices are to follow the ISO 19650 series in principle. Under this approach, DE goal-setting and the methods for creating, sharing, and managing information (including AIR/PIR/EIR), information frameworks, and CDE development processes are implemented in accordance with the principles of ISO 19650.³⁰

With respect to the application of specific parts of ISO 19650, the EIR template defines requirements—such as roles, responsibilities, and information delivery timelines—in alignment with ISO 19650-2.³¹ The Framework also indicates that practical aspects of delivery management and workflows are operated in compliance with ISO 19650-2.

Furthermore, for the creation and exchange of Asset Information, the Framework explicitly adopts ISO 19650-3 (operations phase) as well as ISO 19650-5, which governs the secure management of information.³²

8.2.4.4 ISO 19650-Related Initiatives

As noted earlier, the KiwiRail DE Framework explicitly adopts the ISO 19650 series, establishing OIR, AIR, PIR, and related structures in alignment with ISO 19650 principles. The templates for PIR, AIR, and EIR incorporate all elements required under ISO 19650, including client information requirements, delivery schedules, and clearly defined roles and responsibilities.

Organizational Information Requirement (OIR)

Within KiwiRail's DE Framework implementation, the OIR defines the strategic objectives for project information deliverables and information requirements. These objectives are aligned with KiwiRail's overall business goals and are designed to address challenges identified in previous projects involving Digital Engineering.

³¹ [Exchange Information Requirements \(EIR\)](#)

³² [Asset Information Requirements \(AIR\)](#)

- To have access to all project data federated in one common data environment.
- To provide freely accessible as-built asset information in an environment and format that does not require specialist software.
- To ensure information is re-usable without reworking or rebuilding datasets throughout the asset lifecycle (or put plainly stop focusing on the production of 'dead end' data such as drawings when we will be better served by the exchange of geometric and asset data that drawings can be derived from).
- To improve underground service information that will support KiwiRail's Permit to Dig process through known location and accuracy of data.
- To provide rich asset data that can be analysed for performance trends (e.g. identifying premature decaying sleepers specific location & quantity).
- To maintain and retain asset information for future procurement events (reducing inefficiency associated with loss of data through asset life cycle).
- To improve accuracy in cost estimating and assist in determining whole life cycle cost of assets
- To hold safety in design information against specific assets and ensure future work is cognisant of the risks and hazards.
- To reduce the occurrence (and therefore cost) of re-work or clashes during construction/maintenance/renewal activities.
- To improve internal and external stakeholder engagement through 3D visualisation.

Source: Digital Engineering Framework v5

Figure 8-24 OIR for KiwiRail DE Framework

Asset Information Requirement (AIR)

KiwiRail has developed a detailed AIR document that defines the asset information required at project completion and outlines improved methods for acquiring and managing as-built information.³² As previously described, the creation and exchange of asset information must comply with ISO 19650-3:2020, ISO 19650-5:2020, and ISO 16739.

Project Information Requirement (PIR)

The PIR consolidates information requirements across the entire project lifecycle—covering both the PIM created during design and the AIM delivered at the end of construction.³³ The PIR is designed to answer the following high-level questions comprehensively:

- What is the scope of the project?
- What are the expected project delivery milestones?
- What information needs to be created?
- Who is responsible for creating this information?

Exchange Information Requirement (EIR)

The EIR is developed for each project using KiwiRail's standardized template. It determines what information (models, documents, data) is required at each stage of the project and informs suppliers of expectations regarding the development of:³¹

- Digital Engineering Execution Plan (DEXP) prior to contract award, and
- Project BIM Execution Plan (BEP) after contract award.

The EIR is structured to respond to the following high-level questions:

³³ [Project Information Requirements \(PIR\)](#)

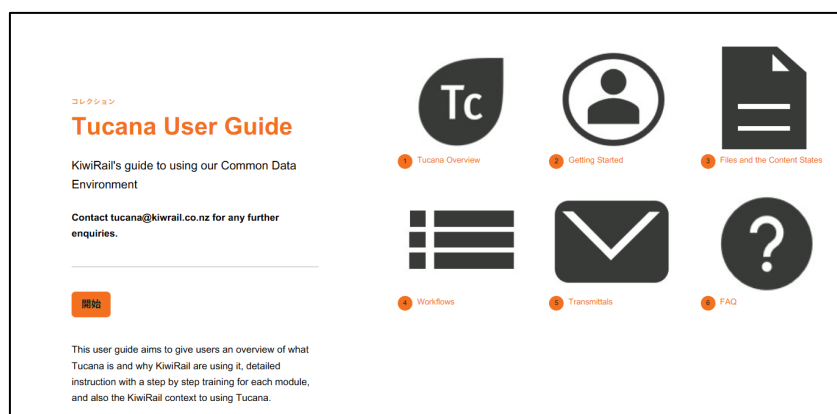
- Where will information be shared? (i.e., the CDE)
- Who will share the information?
- What information is required?
- When is the information needed?
- How will the information be used?
- Why is the information required?

8.2.4.5 Common Data Environment

To support the implementation of Digital Engineering (DE), KiwiRail has established a CDE as a digital platform that facilitates the provision and integration of design models, survey data, and other DE-related information between design and construction teams. This platform enables users to access, manage, and view project information that was previously inaccessible due to the absence of necessary software or licenses for handling multiple proprietary file formats such as point clouds, survey data, design models, and project documentation.

The CDE is used to control the creation and distribution of project information throughout the entire project lifecycle, encompassing design, construction, operation and maintenance, and renewal. It also provides input data to the organization's asset management systems and engineering document management systems.

KiwiRail's CDE system is built around Tucana, a proprietary platform developed in-house, which is deployed across all capital projects undertaken by KiwiRail. The platform intended purpose, functionalities, and usage requirements are documented in the Tucana Guidance Note, which is made available to suppliers.³⁴



Source: [Home | KiwiRail](#)

Figure 8-25 Tucana User-Guide

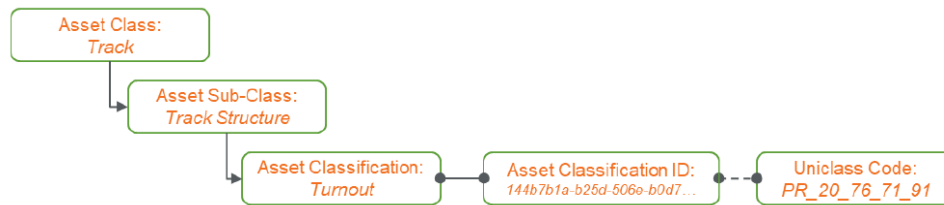
8.2.4.6 Information Classification Systems (e.g., Uniclass)

For asset classification, KiwiRail uses both its traditional internal classification system and Uniclass 2015, published by the National Building Specification (NBS). As shown in Figure 8-26, Uniclass2015 codes are linked to the existing KiwiRail classification framework wherever applicable, enabling a structured and interoperable approach to asset information management.

In addition, the actual asset information used by KiwiRail is publicly available via the company's website³⁵, as illustrated in Figure 8-27.

³⁴ [Tucana User Guide](#)

³⁵ [Asset Information Requirements Viewer](#)



Source: Digital Engineering Asset Information Requirement ver.1

Figure 8-26 Asset Information Classification Using Uniclass 2015

Open	Group by Class	Asset Class	Asset Sub-...	Name	Maturity Status	Maximo Cla...	RIR Discipline	Geospatial...	Uniclass ID	Description
☒	▼	Civil Infrastructure (29)								
☐	▼	Coastal Protection (3)								
☐	☒	Civil Infrast...	Coastal Pr...	Revetment	Defined	PROTNW...	CIVILS	2D LINE	En_32_85...	Revetments are onshore structures with the principal function ...
☐	☒	Civil Infrast...	Coastal Pr...	Seawall	Defined	PROTNW...	CIVILS	2D LINE	En_32_85...	Sea walls are onshore structures with the principal function of ...
☐	☒	Civil Infrast...	Coastal Pr...	Unprotected Coastal Hazard	Defined	PROTNW...	CIVILS	2D LINE		A coastal stretch of the railway corridor that has no formal prot...
☐	▼	Culverts (4)								
☐	▼	Drains and Drainage (8)								
☐	☒	Civil Infrast...	Drains and...	Drainage Network (current)	Defined	DRAIN I D...	CIVILS		EN_55_30	Collection of interconnected drains and drainage structures th...
☐	☒	Civil Infrast...	Drains and...	Track Drain	Defined	DRAIN I T...	CIVILS	2D LINE	PL_58_52_24	Surface or sub-surface drains within or adjacent the railway to ...
☐	☒	Civil Infrast...	Drains and...	Drainage Chamber	Defined	DRAIN I C...	CIVILS	2D POINT		Structure in a drainage system to collect or dissipate water (e...
☐	☒	Civil Infrast...	Drains and...	Rolling Eye	Defined	DRAIN I R...	CIVILS	2D POINT	PL_58_52...	Structure in a drainage system to access buried pipes for rodd...
☐	▼	Formation (3)								
☐	▼	Slopes and Geotech (2)								
☐	▼	River Protection (3)								

Source: [Home | KiwiRail](#)

Figure 8-27 Asset Information Displayed in the KiwiRail AIR Viewer

8.2.4.7 Data Exchange Formats (e.g., IFC, COBie)

For the creation and exchange of asset data throughout the entire project lifecycle, KiwiRail requires compliance with ISO 16739 (Industry Foundation Classes, IFC).³⁶ Suppliers are encouraged to use COBie, a subset of IFC, particularly for the exchange of asset-related data.

KiwiRail also permits the use of flat tabular formats (Excel or CSV) for data creation where appropriate.

8.2.4.8 Asset Management Policies and Specific Initiatives

At KiwiRail, data generated during the development and construction phases of each project are stored within the organization's CDE. These data are intended for use by various internal asset management teams across the organization (see Figure 8-28).

³⁶ Digital Engineering Asset Information Requirements Version 1



Source: Digital Engineering Asset Information Requirement ver.1

Figure 8-28 Internal Use of Asset Information Accumulated in the CDE

KiwiRail emphasizes the critical importance of these data in supporting investment prioritization and decision-making within the Rail Network Investment Programme (RNIP) ³⁷, which is updated every three years. KiwiRail aims not only to improve data quality but also to increase the number of asset inspectors and asset management teams capable of effectively utilizing the data.

For the 2021–2023 period, KiwiRail reports that these initiatives have been successful, contributing significantly to improvements in investment prioritization models and cost estimation methodologies.

8.2.4.9 Contractual Framework

The KiwiRail Digital Engineering Framework³⁸ references the existence of a Project Information Protocol, which is intended to define the scope of Digital Engineering within contractual arrangements. However, this document is not publicly available.

No published sources provide detailed information regarding specific contractual arrangements for KiwiRail's Digital Engineering programme. Therefore, the contractual mechanisms governing stakeholder engagement remain unclear. Nevertheless, the following contract forms are considered likely:

(1) KiwiRail Standard Contract Conditions

Publicly available information indicates the use of the following KiwiRail-specific terms:

- Procurement: KiwiRail's standard terms and conditions³⁹
- General Commercial Transactions: KiwiRail's general terms and conditions⁴⁰

(2) Contract Forms Used by New Zealand Government Agencies

Given that KiwiRail is a state-owned enterprise operating within New Zealand's government sector, it is likely that contract forms commonly adopted across government agencies are also utilized.

According to the New Zealand Government Procurement Rules⁴¹, the following forms may be used for construction-related contracts:

- New Zealand Standards (NZS): NZS 3910 (Construction), NZS 3916 (Design and Construct), NZS 3917 (Fixed Term)

³⁷ [Rail Network Investment Programme \(RNIP\)](#)

³⁸ [Digital Engineering Framework v5](#)

³⁹ [Procurement Manual 2020 ver 25 June 2020.docx](#)

⁴⁰ [General terms and conditions](#)

⁴¹ [Standard types of construction contract - Information sheet](#)

- New Engineering Contract (NEC): NEC3, NEC4
- FIDIC Contract Forms: FIDIC Red Book, FIDIC Yellow Book, FIDIC Silver Book

In practice, NZS 3916:2013 has been used in at least one railway bridge construction project involving KiwiRail.⁴²

8.2.4.10 Education and Training for Project Stakeholders, Including the Supply Chain

KiwiRail provides a range of training programs to support the adoption and effective use of new tools and processes associated with Digital Engineering (DE).⁴³ As of 2025, four primary training areas have been established:

- **ISO 19650 Training:**
The KiwiRail DE Team delivers ISO 19650 training to internal delivery team members to deepen understanding of the standard's principles and promote consistent implementation across projects. The team also engages in outreach activities aimed at enhancing knowledge and understanding of the ISO 19650 series across the wider industry and supply chain.
- **Technical Training for TUCANA:**
The DE Team provides training on Tucana, KiwiRail's CDE, to all internal and external stakeholders required to use the platform. In addition to covering basic platform functionality, training includes guidance on how Tucana aligns with information management workflows in accordance with ISO 19650.
- **Technical Training for REVIZTO⁴⁴:**
To support visual collaboration during design and construction processes, KiwiRail has adopted Revizto, a tool used for issue management, clash detection, viewpoint creation, and cross-disciplinary coordination. Training is provided to stakeholders to ensure the effective use of Revizto's functions within project workflows.
- **Asset Information Handover Training:**
The DE Team offers guidance to internal and external stakeholders involved in the creation and exchange of asset information, ensuring that asset handover processes are conducted in compliance with KiwiRail's DE and asset information requirements.

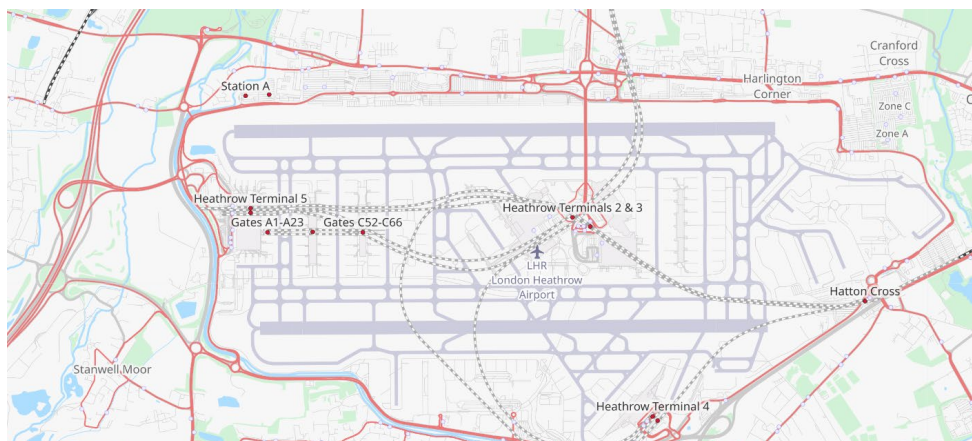
⁴² [GETS | Kaikoura District Council - Kaikoura Green Lane Upgrade and Rail Overpass Bridge Project](#)

⁴³ [Training and Resources | KiwiRail](#)

⁴⁴ A cloud-based BIM collaboration and issue management platform developed by Switzerland's Vizerra. Specializes in issue management and model integration.

8.2.5 Heathrow Airport (UK)

Heathrow Airport (hereafter “Heathrow”) is the largest international hub airport in the United Kingdom, located in West London. Opened in 1946, it is currently operated by Heathrow Airport Holdings (HAL). Key airport data are presented in Table 8-7.



Source: OpenStreetMap (Screenshot date: 6 October 2025)

Figure 8-29 Aerial View of Heathrow Airport

Table 8-7 Key Data for Heathrow Airport

Item	Details
Terminal Areas	4 passenger terminals (T2, T3, T4, T5; T1 closed in 2015)
Runways	2 runways (North: 3,902m; South: 3,658m)
Annual Passengers (July 2024- August 2025)	Approx. 99.95 million
Destinations	Approx. 230 cities in more than 90 countries
Airlines	Approx. 80-90 airlines

Source: The JICA Study Team

Heathrow is the busiest airport in the UK and one of the largest international airports in Europe. While domestic flights operate, the majority of traffic is international, connecting the UK with Europe, the Asia-Pacific region, North America, the Middle East, and other global destinations. Heathrow also serves a major role as a gateway for air cargo, functioning as essential national infrastructure supporting both passenger mobility and logistics.

8.2.5.1 Project Overview

Handling nearly 90 million passengers annually, Heathrow is the UK’s largest international airport and one of the world’s leading aviation hubs. Its infrastructure spans passenger terminals, runways, cargo facilities, and extensive transport networks, requiring continuous expansion and renewal.

Accordingly, an efficient and secure information management system covering the full lifecycle—from planning, design, and construction to operation and maintenance—is essential. BIM and digital technologies have been implemented as fundamental tools to address these requirements.

The evolution of BIM and digital technology adoption at Heathrow is as follows:^{45, 46, 47}

1980s: Terminal 3 Refurbishment (proto-BIM era)

During the 1986 refurbishment of Terminal 3, Heathrow introduced Really Universal Computer-Aided Production System (RUCAPS), an advanced CAD tool at the time. It was used for phased construction

⁴⁵ [20 Years of Information Management at Heathrow Airport | Autodesk University](#)

⁴⁶ [Asset Digitalization Takes Off at Heathrow | Autodesk University](#)

⁴⁷ [Heathrow Airport, digital controls, UK | Turner & Townsend](#)

planning and prefabrication workflows. This approach is sometimes described as “proto-BIM”, although modern concepts such as a CDE or collaborative digital workflows did not yet exist.

2000s-2010s: Terminal 5 Construction - Early Large-Scale BIM Implementation

In the construction of Terminal 5 (opened in 2008), large-scale BIM modelling and construction simulations were extensively adopted. Unified asset classification and naming conventions were developed as a common language, and early concepts of a CDE began to emerge.

2018 Onwards: Establishing an Information Management Foundation

Expansion projects, including the proposed third runway, brought together large numbers of diverse stakeholders. In response, Heathrow strengthened its CDE infrastructure and information management protocols. Although the third runway project faced legal challenges regarding environmental impact assessments, the UK Supreme Court ruled the plan lawful in 2020, leaving future progress fluid.

2019-2024: Integrated Digital Management of Capital Programmes

From around 2019, major capital programmes began adopting integrated digital solutions under the Digital Transformation Program, aimed at improving efficiency, reducing rework, and enhancing design and construction safety. This enabled centralized management of capital project delivery across the entire airport.

2020s (Present): Digital Expansion into the Asset Lifecycle

In recent years, Heathrow has advanced Asset Digitization, focusing on operations, maintenance, and renewal phases. Digital twin technologies are being deployed to visualize and analyze operational data in real time—such as aircraft movements, fuel systems, baggage handling, and passenger flows. These initiatives support operational optimization and environmental targets, including a goal to reduce CO₂ emissions by 30,000 tonnes per year.

Overall, Heathrow’s use of BIM and digital technologies began with proto-BIM experimentation in the 1980s, progressed to large-scale BIM adoption with Terminal 5 in the 2000s, helped inform standardization efforts such as BS 1192 and ISO 19650, and has evolved into a comprehensive, CDE-based information management ecosystem supporting the entire asset lifecycle.

These developments contribute not only to construction efficiency but also to the airport’s long-term operational reliability and the competitiveness of the UK as a global aviation hub.

8.2.5.2 Description of Information Sources

The primary information sources for this study are the official Heathrow Airport website⁴⁸ and publicly available materials from presentations delivered by Heathrow representatives. In particular, significant reference was made to documents⁴⁹ published in 2024 on “Connected Airports”, an industry-focused community platform operated by Autodesk for airport capital programmes and BIM implementation. This platform provides case studies and best practices to support the adoption of digital solutions across the aviation sector.

8.2.5.3 Applicable BIM Standards / ISO 19650-Related Initiatives

Heathrow Airport opened in 1946, long before the development of the BS/PAS 1192 series or the ISO 19650 suite. As a large, continuously operating infrastructure asset requiring ongoing construction, refurbishment, and operational upgrades, Heathrow has long recognized the importance of advanced information management in construction projects.

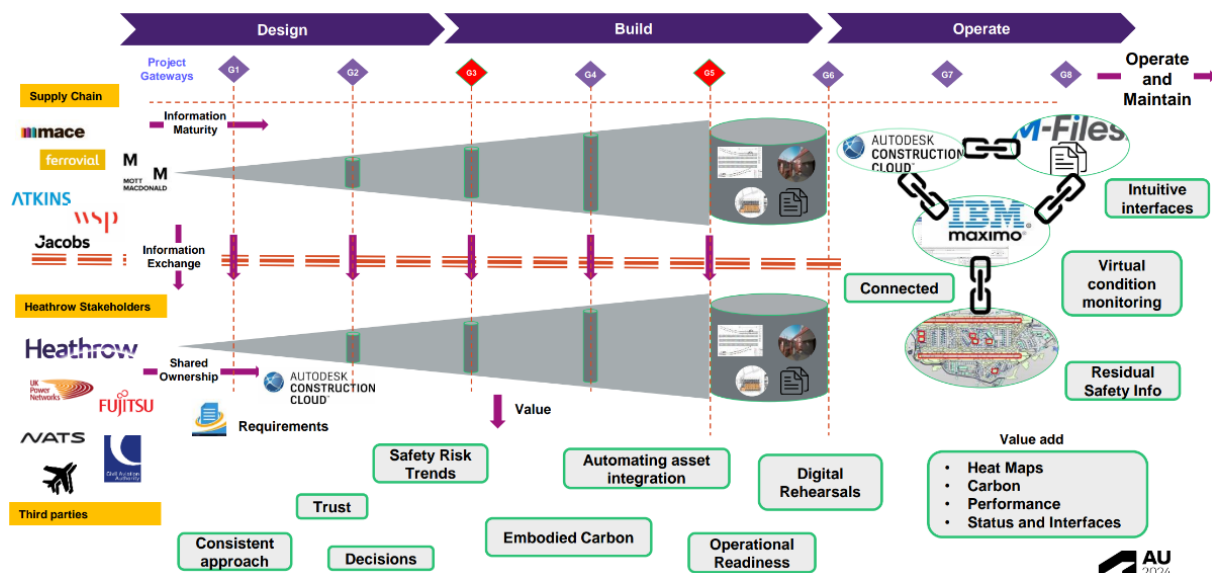
The Terminal 5 project, constructed from 2001 and opened in 2008, is widely regarded as a pioneering example of digital collaborative design and construction for its time. Multiple design and construction teams operated within a Single Model Environment, enabling integrated use of digital models for design

⁴⁸ [Heathrow: Welcome to Heathrow Airport | Heathrow](#)

⁴⁹ [Connected Airports | Autodesk](#)

coordination, clash detection, construction logistics, and services routing. This approach represented a fundamental shift away from fragmented information-sharing practices and became one of the formative case studies that later informed the development of BS 1192 and PAS 1192.

Although no publicly available documentation specifies Heathrow's current BIM standards, evidence from the Terminal 5 programme and the later Digital Transformation Program suggests that Heathrow now employs information management practices aligned with the ISO 19650 series. The establishment of EIR concepts, development of structured CDE workflows, lifecycle asset information management, and deployment of digital twin technologies all reflect principles consistent with ISO 19650 framework.



Source: [Asset Digitalization Takes Off at Heathrow | Autodesk University](#)

Figure 8-30 Heathrow's Collaborative Delivery Approach

8.2.5.4 Common Data Environment

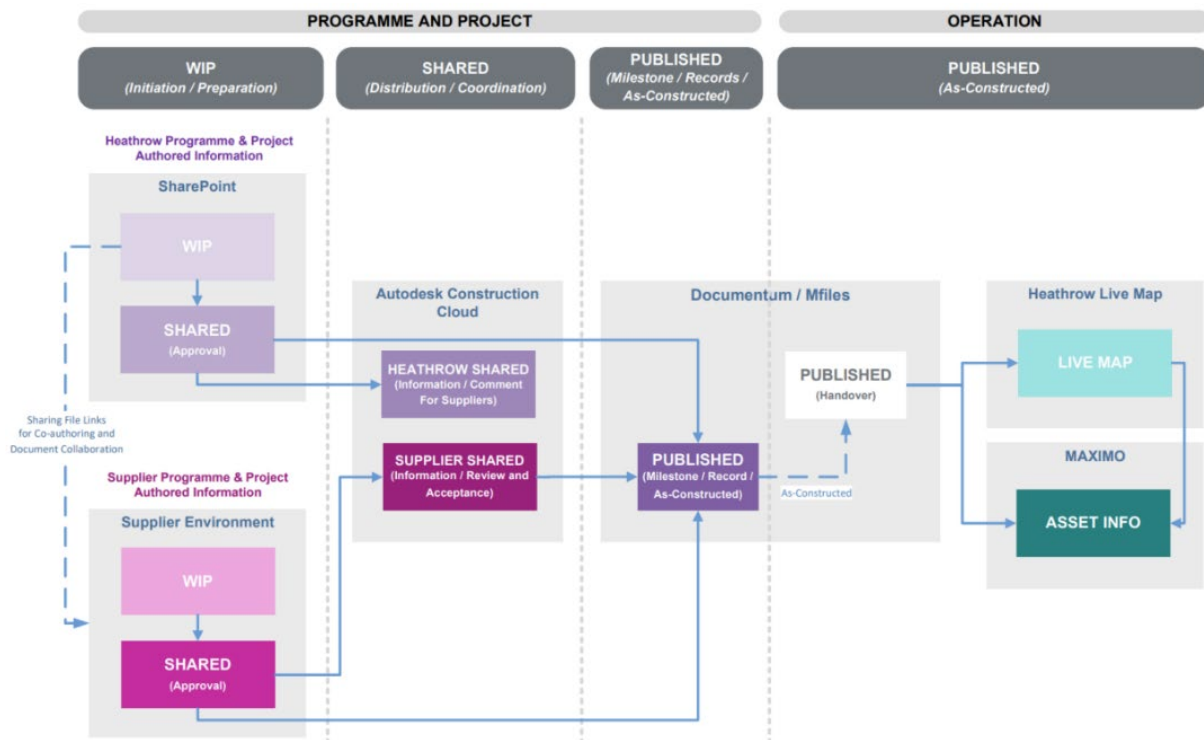
With support from Excitech, Heathrow implemented a CDE solution combining GroupBC's Enterprise CDE (later integrated into BCDE/Bentley) and Autodesk BIM 360, placing this system at the core of its information management strategy. Information processes and workflows are standardized across all project lifecycle stages, enabling centralized data management, enhanced visibility, and robust traceability.

Heathrow's CDE workflow manages information through the following status stages (See Figure 8-31):

- WIP (Initiation / Preparation)
- Shared (Distribution / Coordination)
- Published (Milestone / Records / As-Constructed)
- Published (As-Constructed)

While supply chain partners may use their own CDE systems during project execution, they must transfer (or synchronize) required information—complete with revision control—into Heathrow's CDE system at handover.⁵⁰

⁵⁰ [Asset Digitalization Takes Off at Heathrow | Autodesk University](#)



Source: Reference 50

Figure 8-31 Heathrow's CDE and Data Flow Diagram

8.2.5.5 Information Classification Systems (e.g., Uniclass)

At Heathrow, a bespoke information classification system has been developed to accommodate the distinctive attributes of airport infrastructure and its complex operational requirements. Although Uniclass is extensively employed within the building and civil engineering sectors, airport facilities encompass highly specialized infrastructure—such as runways and taxiways, aviation fuel distribution networks, advanced baggage handling systems, and security perimeters—each managed by multiple system owners. As a result, standard classification systems like Uniclass, in isolation, are frequently inadequate for the systematic structuring and integration of airport asset information in a manner suitable for operations, maintenance, and renewal.

Heathrow implemented a proprietary data model prior to the widespread adoption of Uniclass. Under this model, all airport assets are governed through a hierarchical structure consisting of Location, Level, Space, System, and Asset. This approach enables Heathrow to maintain a classification framework optimized for operational and maintenance management, while preserving the capability to map seamlessly to standard external classification systems when required.

Figure 8-32 shows the “Common Language” established during the Terminal 5 project.



Source: [Heathrow's BIM Journey](#)

Figure 8-32 Heathrow's Common Language Developed in 2007

8.2.5.6 Data Exchange Formats (e.g., IFC, COBie)

Although Heathrow is likely to specify data exchange formats within its own Exchange Information Requirements (EIR) and BIM Execution Plans (BEP), no explicit specifications were identified in publicly available materials.

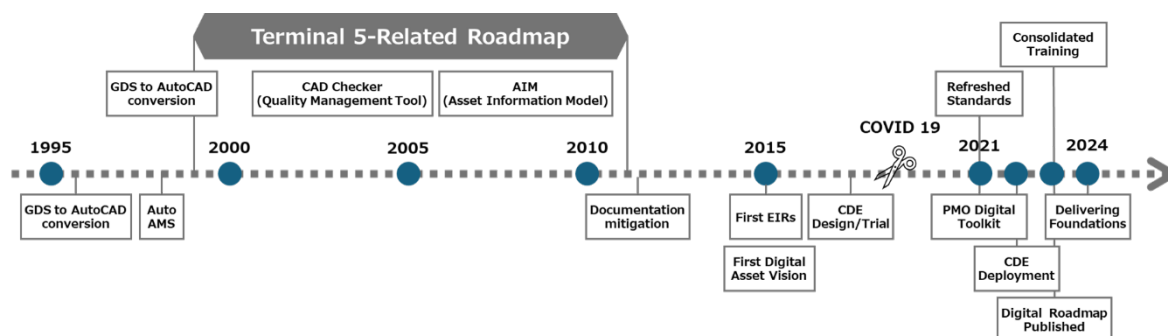
8.2.5.7 Asset Management Policies and Specific Initiatives

Heathrow's asset management programme aims to realize asset value across the entire lifecycle by reducing risk and optimizing performance. Key historical milestones in Heathrow's BIM and information management initiatives are illustrated in Figure 8-33. These include:

- Development of the first EIR and Digital Asset Vision (2015)
- Design of the CDE (2017)
- Pilot implementation of the CDE (2018)

- Updating of standards and PMO digital toolkits (2021)
- Integration of training and a comprehensive Digital Roadmap (2023)

These demonstrate Heathrow's phased and ongoing advancement toward digital maturity. Heathrow continues to introduce new programmes and systems, reflecting an adaptable approach that aligns with emerging technologies, future workforce needs, and evolving market conditions.



Source: Prepared by the JICA Study Team based on Heathrow documentation

Figure 8-33 Evolution of Asset Management at Heathrow

In 2024, Heathrow published three guiding principles for asset management on the Connected Airports platform:⁵¹

- Continuous Innovation: Respect existing systems without allowing them to impede necessary change.
- Process Redesign: Go beyond digitization to fundamentally rethink the pathways to outcomes.
- Reconstruction of Work Practices: Challenge existing methods and recognize that robust information management is central to enabling transformation.

The following initiatives illustrate how these principles are being implemented:

- Introduction of a CDE:
Excitech, as consortium lead, secured a seven-year framework contract to deploy GroupBC's Enterprise CDE together with Autodesk technologies (e.g., BIM 360). Deployment was announced in 2019 with full rollout targeted for 2020.
- Asset Management Compliance (AMC) Programme
As part of Heathrow's H7 period (2022–2027)⁵², Mott MacDonald is supporting strategy development and practical implementation of asset management compliance. Objectives include:
 - Improved understanding of asset health and risk
 - Enhancements to long-term investment planning
 - Development of documentation aligned with ISO 55001
 - Advancement of digital maturity
- Digitalization of Assets:
In line with the Digital Roadmap, Heathrow is progressing the digitalization of physical assets and associated information (models, attribute data, etc.). Benefits include:
 - Reduction of design changes and rework in maintenance
 - Improved design and delivery safety

⁵¹ [Connected Airports | Autodesk](#)

⁵² The designation for Heathrow Airport's five-year regulatory period ("Heathrow's Regulatory Period") established in agreement with the regulatory authority (the UK Civil Aviation Authority: CAA). Each period is designated as a regulatory cycle using the format "H + number," during which investment levels, asset maintenance, and fee structures are adjusted.

- Operational optimization and improved lifecycle decision-making

8.2.5.8 Contractual Framework

In UK construction projects, NEC (New Engineering Contract) and JCT (Joint Contracts Tribunal) forms are widely used. Major projects at Heathrow Airport are no exception; however, the construction of Terminal 5 represented a significant departure from conventional contracting practices.

For Terminal 5, the airport operator at the time, BAA, chose not to use standard NEC or FIDIC conditions. Instead, it developed a bespoke contract known as the “T5 Agreement.” The defining characteristic of this agreement was that almost all project risks were borne by the client (BAA), thereby eliminating the need for contractors to include “risk premiums” in their bids.

In place of traditional risk allocation, the T5 Agreement contractually required full collaboration between BAA and the supply chain, ensuring transparency of information, joint decision-making, and dispute avoidance. This approach has been described as an early form of alliance contracting, and significantly influenced subsequent UK construction practices—for example, the strengthened collaboration clauses in NEC3 and NEC4.⁵³

For post-Terminal 5 projects (e.g., the Terminal 2 redevelopment and runway and taxiway renewal/expansion works), Heathrow has generally adopted NEC contract forms, consistent with UK public-sector procurement practice.⁵⁴

8.2.5.9 Education and Training for Project Stakeholders, Including those in the Supply Chain⁵⁵

Heathrow has developed a structured training framework to enhance information management capabilities and support the integration of asset information across the organization. This framework is designed for both Heathrow staff and partner organizations and is delivered primarily through online, on-demand modules.

Training is organized according to user personas, with each persona assigned a tailored set of modules. All users are required to complete three foundational modules covering:

- Introduction
- Standards
- CDE concepts

Additional role-specific modules follow based on the persona.

Table 8-8 User Types and Roles

Type	Persona	Roles	Description
A	Lite User	• HAL Programme Lead • HAL Heads	This user will have an awareness of Information Management and would need to be up-to-date.
B	General User	• HAL Programme Manager • HAL Senior Project Manager • HAL Project Managers	This user will primarily consume information on the solution and occasionally add documents. They may be required to raise a query against a document.
C	Full User	• Supplier delivery roles (example, Design Manager, IM or BIM Manager)	This user will regularly view, integrate or submit documents. In addition, they will transition documents between status codes and environments. Finally, they may be required to review, validate and approve documents.
D	Hand-over User	• Supplier Hand over Managers	This user will regularly view, integrate and add documents. In addition, they will support the transition of documents between status codes and environments to transfer to AIM.

Source: Reference 55

⁵³ [The T5 Project Agreement \(A\): Case Study Reference No 308-308-1 | PDF | Liability Insurance | Airport](#)

⁵⁴ [Projects | NEC Contracts](#)

⁵⁵ [Heathrow-DigitalAssetRoadmap-CA24.pdf | Autodesk](#)

8.2.6 Denver International Airport (USA)

8.2.6.1 Project Overview

Denver International Airport is situated in Denver, the capital of the U.S. state of Colorado. Key airport data are presented in Table 8-9, and an aerial view of the airport layout is shown in Figure 8-34.

Denver International Airport has established design standards to ensure a consistent approach to technical design across all projects. All consultants engaged by the airport or its tenants, as well as any organizations responsible for design activities at the airport, are required to adhere to these standards.

Table 8-9 Key Data for Denver International Airport

Item	Details
Terminal Complex	1 passenger terminal and 3 gate concourses
Runways	6 runways
Annual Passengers (2024)	82.4 million (highest since opening; 3 rd in U.S., 6 th globally)
(International Passengers)	4.6 million
Key Issue	Preparing airport services to accommodate future demand, as annual passenger numbers are expected to reach 100 million within the next few years (Management Strategy “Vision 100”).

Source: Prepared by the JICA Study Team based on Denver International Airport official website (<https://www.flydenver.com/about-den/>, <https://www.flydenver.com/about-den/vision-100-operation-2045/>, accessed 4 September 2025)



Source: Google Earth Pro (Image date: 5 September 2023; Screenshot: 22 August 2025)

Figure 8-34 Aerial Image of Denver International Airport

8.2.6.2 Description of Information Sources

Among the design standards, this study referenced the publicly available “Design Standards Manual—Digital Facilities & Infrastructure—Design, Engineering and Construction (Revised: Q4 2023)” 56 (hereafter “DFI”). The DFI outlines requirements related to BIM tools and processes used during design

56 [Denver International Airport Design Standards Manual Digital Facilities & Infrastructure Revised: Q4 2023](#)

and construction, as well as procedures for integrating BIM with the airport's asset management systems. Target users include design and construction providers responsible for submitting BIM data to the airport, as well as airport executives and project managers. All civil and architectural projects at the airport are required to comply with the design standards described in the DFI.

8.2.6.3 Applicable BIM Standards

The information management process at Denver International Airport references ISO 19650-1:2018 and ISO 19650-2:2018.

For the Level of Development (LOD) framework, the airport adopts the "BIM Forum Level of Development Specification 2021."

8.2.6.4 ISO 19650-Related Initiatives

As noted previously, the DFI references ISO 19650-1:2018 and ISO 19650-2:2018, and includes sections on OIR, AIR, PIR, EIR, PIM, and AIM. Certain portions of the AIR, as well as the PIR, EIR, PIM, and AIM sections, are designated as "Sections in Development," indicating that the manual is currently being updated to achieve full alignment with the ISO 19650 framework.

The BIM Execution Plan (BEP) is referred to in the DFI as the "BIM Project Execution Plan (BIMPxP)."

Regarding the Level of Development (LOD), the DFI references the "BIM Forum Level of Development Specification 2021."

A summary of the ISO 19650-related content detailed in the DFI is provided below.

(1) OIR

The DFI defines the OIR as the specification of information required to support Denver International Airport's asset management programme, as well as the operational, maintenance, financial, and development needs of the airport.

The DFI states that the development of the OIR must incorporate input and feedback from key stakeholders, as shown in Table 8-10.

Table 8-10 Stakeholders Considered Relevant to OIR Development in the DFI

Project Sponsors	Facility Managers
Project Managers	Users and Employees
Asset Managers	Authorities Having Jurisdiction
Maintenance Planners	Consultants
Maintenance Personnel	

Source: Prepared by the JICA Study Team based on Denver Airport DFI (Revised: Q4 2023)

The DFI further identifies activities that support strategic objectives and specifies how collected and processed information is to be utilized, as summarized in Table 8-11. These activities were developed in alignment with ISO 19650-1:2018 and Denver International Airport's asset management processes. The information required to perform these activities constitutes the OIR.

Table 8-11 Information Uses Identified in the OIR and Airport-Specific Considerations

No.	Items	Key Considerations Beyond Airport Characteristics
1	To optimize the asset management strategy and optimize / prioritize the asset management plan	
2	To promote the use and development of consistent industry, national, and international standards	Given the participation of diverse fields and national organizations in airport operations, the implementation of consistent and easily understandable specifications is crucial.
3	To form part of the organizational information resource – an institutional asset	
4	To develop a digital asset model to support operational decision making	
5	To support informed and justified decision making for operational, developmental, and maintenance activities	
6	To develop a common data environment in which asset information can be accessed by all departments/stakeholders	Given that airport operations involve numerous personnel and stakeholders, it is essential to develop a CDE that enables authorized personnel with timely access to required information.
7	To validate legacy data and identify knowledge gaps	
8	Produce data where gaps exist, such as survey data	
9	Assess the value of defect liabilities for funding and budgeting purposes	
10	Assess priorities for the forward planning of operational, developmental, and maintenance activities	
11	To undertake on-going identification, assessment, and mitigation of risks to operations	
12	To reduce the duplication of work and produced information, make information available to a wider audience, promote collaboration and improve efficiencies	
13	To provide a visual / graphical summary of asset related data	
14	To facilitate the production of data driven reports for a range of uses / stakeholders	To ensure smooth progression of project, the preparation of accountable documentation for various stakeholders is essential.
15	To facilitate detailed, component level data management	
16	To meet statutory and regulatory obligations	Operations must comply with regulations such as the Aviation Act.
17	To support quality assurance and performance management activities	
18	Identifying expiration of warranty periods	
19	Determining the end of an asset's economic life, e.g., When the asset related expenditure exceeds the associated income	
20	Determining the cost of specific activities (activity based costing), e.g., The total cost of maintaining a specific asset(s)/asset system	
21	Obtaining/calculating asset replacement values	
22	Innovation and change management	
23	Data, information, and knowledge management	
24	Maintenance, inspection, condition, and performance monitoring	
25	Contingency planning and emergencies	At airports, planning and operational responses that consider the needs of international travelers are essential.
26	Energy efficiency and environmental aspects, e.g., Renewable resources, recycling, waste management, air purity, hygiene	The aviation industry is a major contributor to carbon dioxide emissions, and measures to reduce emission are currently being strongly promoted.
27	Risk assessment and management	
28	Safety, health, and environmental management	

Note: "Asset modeling to support operational decision-making" was originally placed between items 17 and 18, but it was deleted as it was deemed redundant with item 4.

Source: Prepared by the JICA Study Team based on Denver International Airport DFI (Revised: Q4 2023)

(2) AIR

Information identified as necessary to satisfy the OIR constitutes the AIR. The AIR consists of detailed asset data required to address the information needs defined in the OIR.

The DFI identifies typical events during which detailed asset data may be required, as shown in Table 8-12. During these events, the information exchanged is expected to constitute AIR.

Table 8-12 Events Identified in the DFI Requiring Detailed Asset Data

No.	Events
1	Receiving information during a capital improvement project
2	Managing asset information
3	Evaluating performance of an asset
4	Planned or reactive maintenance work
5	Minor works (repairs, component replacements)
6	End-of-life works (decommissioning, mothballing)
7	Change in regulations relating to the asset
8	Change in organizational requirements for the asset
9	Change in owner, operator, or maintainer

Source: Prepared by the JICA Study Team based on Denver Airport DFI (Revised: Q4 2023)

(3) BEP (BIMPxP)

Denver International Airport recommends the preparation of a full BIMPxP for all projects, and mandates its use for projects with an expected value exceeding USD 10 million.

The airport provides a standard template based on the buildingSMART “BIM Project Execution Planning” framework, as published by the Computer Integrated Construction Research Group at Pennsylvania State University.

The template contains the chapter structure shown in Table 8-13.

Table 8-13 Chapter Structure of the Penn State BIM PxP Template (Version 3.0)

Section No.	Title
A	BIM Project Execution Plan Overview
B	Project Information
C	Key Project Contacts
D	Project Goals / BIM Uses
E	Organizational Roles / Staffing
F	BIM Process Design
G	BIM Information Exchanges
H	BIM and Facility Data Requirements
I	Collaboration Procedures
J	Quality Control
K	Technological Infrastructure Needs
L	Model Structure
M	Project Deliverables
N	Delivery Strategy / Contract
O	Attachments

Source: Prepared by the JICA Study Team based on Penn State “BIM Project Execution Planning Guide, Version 3.0,” Appendix G

The DFI specifies the following aspects to be defined in the BIMPxP:

- LOD requirements
- Scope of modelling, including existing conditions
- Data required for design, bidding, and construction phases
- Time allowed for model review by Denver International Airport
- Frequency of model and drawing uploads to the CDE

(4) LOD (Level of Development)

LOD classifications for all model elements are structured within the DFI matrix in accordance with Unifomat 2010, and must adhere to the 2021 BIM Forum Level of Development Specification.

Table 8-14 presents both the BIM Forum definitions and Denver International Airport's corresponding interpretations for each LOD level.

Table 8-14 Interpretation of LOD in the Denver International Airport DFI

LOD	LOD Definitions in the 2021 BIM Forum Level of Development Specification	DEN Interpretations
100	The Model Element may be graphically represented in the Model with a symbol or other generic representation, but does not satisfy the requirements for LOD 200. Information related to the Model Element (i.e. cost per square foot, tonnage of HVAC, etc.) can be derived from other Model Elements.	LOD 100 elements are not geometric representations. Examples are information attached to other model elements or symbols showing the existence of a component but not its shape, size, or precise location. Any information derived from LOD 100 elements must be considered approximate. (No Change from BIMForum Interpretation).
200	The Model Element is graphically represented within the Model as a generic system, object, or assembly with approximate quantities, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element.	At this LOD elements are generic placeholders. They may be recognizable as the components they represent, or they may be volumes for space reservation. Any information derived from LOD 200 elements must be considered approximate. (No Change from BIMForum Interpretation).
300	The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of quantity, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element.	The quantity, size, shape, location, clearances, and orientation of the element as designed can be measured directly from the model without referring to non-modeled information such as notes or dimension callouts. The project origin is defined, and the element is located accurately with respect to the project origin.
350	The Model Element is graphically represented within the Model as a specific system, object, or assembly in terms of quantity, size, shape, location, orientation, and interfaces with other building systems. Non-graphic information may also be attached to the Model Element.	Parts necessary for coordination of the element with nearby or attached elements are modeled. These parts will include such items as penetrations, supports, clearances and connections. The quantity, size, shape, location, and orientation of the element as designed can be measured directly from the model without referring to non-modeled information such as notes or dimension callouts.
400	The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of size, shape, location, quantity, and orientation with detailing, fabrication, assembly, and installation information. Non-graphic information may also be attached to the Model Element.	An LOD 400 element is modeled at sufficient detail and accuracy for fabrication of the represented component. The quantity, size, shape, location, and orientation of the element as designed can be measured directly from the model without referring to non-modeled information such as notes or dimension callouts. (No Change from BIMForum Interpretation).
500	The Model Element is a field verified representation in terms of size, shape, location, quantity, and orientation. Non-graphic information may also be attached to the Model Elements.	LOD 500 represents a progression from whatever modeling level was specified in the preceding deliverable in regard to field verification of size and location. Additional modeled details are not required.

Source: Prepared by the JICA Study Team based on Denver Airport DFI (Revised: Q4 2023)

Appendix C of DFI – Object Types lists standard model objects, asset types, and the required LOD levels by phase and deliverable category, in alignment with Uniformalt 2010. Information for Passenger Loading Bridges and Baggage Handling Systems from Appendix C is extracted and presented in Table 8-15. The list defines LOD not only for general building structures, interior and exterior finishes, equipment, and communication devices, but also for airport-specific elements including security screening equipment, passenger boarding bridges, airport pavement, airfield lighting, and aviation fuel piping. Generally, LOD 100 applies to less than 60% of the design phase, LOD 200 to less than 90%, LOD 300 to less than 100%, and LOD 300 or LOD 350 to 100% and the record model. The construction and as-built models developed during the construction phase correspond to LOD 350.

Table 8-15 Example LOD Listings from DFI Appendix C

UNIFORMAT 2010 LEVEL								DESIGN MODEL LOD AT PACKAGE DELIVERABLE					CONSTRUCTION MODEL	
1	2	3	4	ELEMENTS	OBJECT TYPE	LAYER NAME	Asset Types	30-59% LOD	60-89% LOD	90-99% LOD	100%- IFC LOD	Record Model	Fabrication Model	As-Built Model
D				SERVICES										
D	10			Conveying										
D	10	30		Horizontal Conveying										
D	10	30	.50	Passenger Loading Bridges	SPEQ		Passenger Loading Bridge;	100	200	300	300	350	350	500
D	10	50		Material Handling										
D	10	50	.70	Baggage Handling Equipment	GENM, SPEQ		Valet Baggage Lift:	100	200	300	300	350	350	500

Source: Prepared by the JICA Study Team based on Denver International Airport DFI (Revised: Q4 2023), Appendix C Table 7-3

8.2.6.5 Common Data Environment

The DFI specifies the use of the Autodesk Construction Cloud as the CDE. This CDE does not contain any Security Sensitive Information (SSI). Instead, SSI must be stored in a separate model and managed in accordance with the requirements established by Denver International Airport's security division. This approach reflects practices unique to airports—particularly international airports—where stringent security protocols are essential.

The CDE is configured to support Project Information Models (PIM), and the DFI specifies that PIMs adhere to the ISO 19650 information status sequence within the CDE: Work in Progress (WIP) → Shared → Published. Archiving of PIM records, as well as final model deliveries, is also performed within the CDE.

Regarding authoring tools, the DFI specifies that:

- Autodesk Revit must be used for all building elements located within 5 feet of the building exterior, and
- Autodesk AutoCAD Civil 3D must be used for all elements located outside the 5-foot perimeter of the building envelope.

8.2.6.6 Information Classification Systems (e.g., Uniclass)

The DFI references Uniformalt 2010. Uniformalt serves as a foundational classification system for OmniClass, alongside MasterFormat and EPIC, and is used to organize model object types and asset categories throughout the project.

8.2.6.7 Data Exchange Formats (e.g., IFC, COBie)

The DFI instructs that Civil 3D deliverables should be submitted in IFC format when possible. No references to COBie were identified in the publicly available portions of the DFI.

8.2.6.8 Asset Management Policies and Specific Initiatives

(1) Overview

The primary current management strategy at Denver International Airport is “Vision 100”⁵⁷, which seeks to expand the airport’s capacity to accommodate 100 million passengers per year. Strategic asset management planning is positioned as a core mechanism to support this strategy.

Key asset management initiatives include:

- Implementation of digital data management workflows
- Development of structured datasets
- Promotion of innovations in asset management through the application of BIM standards
- Adoption of data-driven processes to enable rational and accountable decision-making

The airport articulates its vision through four pillars under Vision 100:

- Empowering Our People: The airport’s success depends on its staff and partners.
- Growing Our Infrastructure: Continuous investment to expand facilities.
- Maintaining What We Have: Maintaining and sustaining existing assets.
- Expanding Our Global Connections: Growing the aviation network to provide more options for passengers.

The relationship between these pillars and the airport’s asset management activities is illustrated in Figure 8-35.



Source: The JICA Study Team

Figure 8-35 Positioning of Asset Management within Denver International Airport

(2) Asset Categories

Assets are defined by Denver International Airport as the contracting authority. Asset types and abbreviations used for Revit family naming are documented in Appendix A – Asset Types of the DFI.

Examples extracted from Appendix A for Airfield Lighting Control & Monitoring and Passenger Loading Bridges are shown in Table 8-16.

⁵⁷ [Vision 100 and Operation 2045 | Denver International Airport](#)

Table 8-16 Examples of Asset Types from DFI Appendix A

Asset Type Revit Parameter ASSET_ASSET TYPE	Abbreviation For Revit Family Naming & LOD Matrix	Naming Reference
Actuator	ACT	DEN Mechanical DSM Ch 1.2-1.3
Air Compressor	AIRCOM	DEN Mechanical DSM Ch 1.2-1.3

Source: Denver Airport DFI (Revised: Q4 2023), Appendix A Table 5-1

8.2.6.9 Contractual Framework

Requirements documented in the Design Foundation (DFI) may be superseded by the project contract. Furthermore, the BIM Execution Plan (BIMPxP) and Level of Detail (LOD) are positioned as attachments to the contract.

The “BIM Beyond Design Guidebook (2020)”, referenced in Section 8.2.8, includes the contract language for Denver International Airport as Appendix A. This section provides an overview of that document.

Appendix A contains two types of contracts: contracts between Denver International Airport and contractors, and contracts between Denver International Airport and consultants. The overview of these two contract types is as follows:

Contracts with Contractors

The contractual language is presented as a BIM requirements agreement, written as a one-page English document requiring contractors to agree to seven specific provisions:

- The Contractor acknowledges and agrees to use the Autodesk BIM 360 Field (Field) and Autodesk BIM 360 Glue (Glue) platforms for this Project, and to make exclusive use of the <AGENCY> enterprise deployment of Field and Glue as provided by the <AGENCY>;
- The Contractor acknowledges and agrees to execute a BIM Project Execution Plan in cooperation with t <AGENCY> representatives, in compliance with the BIM Design Standards Manual, and to adhere to the terms of that plan;
- Contractor shall produce a construction model and perform clash detection using Glue in accordance with the standards outlined in the BIM Design Standards Manual and shall deliver the coordinated models to <AGENCY> representatives;
- Contractor shall utilize Field to record required asset data for all <AGENCY> assets, in compliance with the BIM Design Standards Manual, within five working days of installation of each identified asset;
- The Contractor acknowledges and agrees to conform to all requirements of the BIM Design Standards Manual;
- The Contractor acknowledges and agrees to use the Autodesk BIM 360 Field (Field) platform for tracking issues discovered during construction.
- The Contractor acknowledges and agrees to use the Autodesk BIM 360 Field (Field) platform for tracking warranty issues, as defined by General Contract Conditions Title 18-Warranties, Guarantees, and Corrective Work.

Penalties for non-compliance are also described, including:

- Withholding of payments,
- Contract termination, and
- Suspension.

Contracts with Contractors (As of July 2028)

The consultant contract language is provided as a contractual appendix comprising six chapters. The contents and notes for each chapter are summarized in Table 8-17.

Table 8-17 Overview of Consultant Contract Language (Denver International Airport)

Chapter	Section	Special Notes
General	Purpose of Exhibit	
	Application of Exhibit	This Exhibit constitutes a Contract Document and is intended to supplement the Professional Services Agreement ("Design Agreement") between the <AGENCY> ("Owner") and the Owner's Prime Design Consultant ("Consultant"), which this Exhibit is attached.
	Necessity of the Model	Failure to meet the specified LODs and/or to deliver the model in accordance with the BIMPxP may result in a for-cause termination of the Design Agreement.
Responsibility for Model Development	General	
	Subsidiary Models	
	Responsibility for Model Content and Coordination Among the Project Team	
	Responsibility for Detecting and Correcting Errors and Revising the Model	
	Deadlines for Model Delivery	The extent the BIMPxP modifies the original Model Delivery Schedule and such modifications affect the Consultant's initial pricing assumptions, the Consultant may be entitled to additional compensation.
	Owner's Review and Input	
	Standard of Care	
BIM Project Execution Plan ("BIMPxP")	BIMPxP Contract Status	The BIMPxP will be modified as the Project develops.
	Process for Development	
	Elements of the BIMPxP	
Responsibility for Model Ownership	Model Ownership	The Owner retains all legal rights of ownership and title to the Model and/or Model Elements, as well as to all other ancillary Project materials (electronic or otherwise) developed or prepared specifically for the Project by the Consultant, their subconsultants and all other project participants.
	Owner's License to Project Team	The owner grants a limited license to consultants and contractors.
	Authorized Use	
	Unauthorized Use	Unauthorized use shall be at that Party's sole risk and without liability to any other Project Participant or Third Party
Responsibility for Maintenance of Digital Data	Warranty of Authority to Transmit Digital Data	
	Confidential Digital Data	
Responsibility for Model Management	Archiving	The Consultant's obligations herein likewise include the duty to maintain the Project's Digital Data in an updated, accessible, and readable format for a period of five (5) years from Final Completion. This obligation also includes the duty to convert the Project's Digital Data into a format compatible with any subsequently developed technology that might render the Project's existing Digital Data obsolete
	Record Model	
	Software Upgrades	
	Governmental Approval of Model Drawings	
	Signing and Sealing Model	
	Standard of Care	

Source: Prepared by the JICA Study Team based on The "BIM Beyond Design Guidebook (2020)"

8.2.6.10 Education and Training for Project Stakeholders, Including the Supply Chain

No descriptions related to education or training for project stakeholders were identified in the DFI.

8.2.6.11 Other Considerations

The DFI also includes provisions related to tenant construction projects. In principle, tenant-delivered projects are required to comply with the standards and requirements established in the DFI. The DFI distinguishes between categories of tenant work using the terms “Tenant Civil” and “Tenant Facilities”, which also serve to define exceptions to the applicability of the standards.

The term “Tenant Civil” is considered equivalent to what is referred to in Japan as “Type B construction.” Under Type B construction, the building owner is responsible for contractor selection, and ownership of the constructed elements remains with the building owner. However, the tenant assumes responsibility for contractor procurement and all associated costs. The DFI states that no exceptions to its requirements apply to Tenant Civil work.

In contrast, the term “Tenant Facilities” corresponds to “Type C construction” in the Japanese context. In Type C construction, the tenant is responsible for contractor selection, procurement, and payment, and ownership of the constructed elements is retained by the tenant. For Tenant Facilities, the DFI lists specific exceptions to the standards, which include the following sections:

- Section 3.1.13 – Project Closeout and Completion
- Section 3.2.7.2 – External Content Sources
- Section 3.2.7.4 – Submission of Proposed Content
- Section 3.2.13 – Overview of BIM Spatial Coordination Procedures – Design Models

8.2.7 Massachusetts Port Authority Managed Airports (USA)

8.2.7.1 Project Overview

The Massachusetts Port Authority (Massport) is the governing entity responsible for owning and operating a range of facilities within the Commonwealth of Massachusetts, including Boston Logan International Airport, additional airfields, container ports, and cruise terminals.

Massport enables more informed and higher-quality decision-making through the strategic application of BIM. For tenant change-of-use applications, as well as for both its Horizontal⁵⁸ and Vertical Projects⁵⁹, Massport has implemented the BIM Decision Matrix, as shown in Table 8-18.

Table 8-18 Massport BIM Decision Matrix

PROJECT TYPES	TAAs More detailed TAA BIM Guides are available in the Guide to Tenant Construction		HORIZONTAL PROJECTS	VERTICAL PROJECTS			
ADDITIONAL DESCRIPTION	Large Developments	Tenant Spaces and Buildings	Utilities and Runways	Including Garages and Bridges			
ESTIMATED CONSTRUCTION COST	ECC > \$10M	\$1M < ECC < \$10M ECC < \$1M	After Jan 2016 Before Jan 2016	ECC > \$10M	\$1M < ECC < \$10M		
					Major Equipment	Building Renovations	New Construction
REQUIREMENTS	DTG to evaluate project type and requirements to determine BIM requirements		AutoCAD (no BIM)	Civil 3D with attributes at closeout AutoCAD/Civil 3D	BIM managed by Design and Construction Teams Lean and Co-location BIM managed by DTG, clash detections managed by GC/CM No BIM Clash detections managed by GC/CM	BIM managed by DTG, clash detections managed by GC/CM	BIM managed by DTG, clash detections managed by GC/CM
BIM AND NON-BIM DELIVERABLES (REVIT, AutoCAD, OR CIVIL 3D)	BIM As-Built delivered at project end	BIM As-Built delivered at project end	As-Built	Civil 3D: • 30-40-100% and • As-Built with attributes	Lean / BIM deliverables: • 30-40-100% and As-Built • Clash detection reports • As per BIM	BIM deliverables: • 30-40-100% and As-Built • Clash detection reports	BIM Deliverables: • 30-40-100% and As-Built • Clash detection reports
DISCIPLINES (IF BIM)	All disciplines for project	ARCH, MEP and STR	Any major disciplines	Civil disciplines, Site, Utilities	Major disciplines for project: ARCH, MEP and STR, and 3D Site, Utilities	BIM modelled ARCH, MEP and STR, Civil model only if needed or required by MPA	Major disciplines for project: ARCH, MEP and STR, Civil model only if needed or required by MPA

Source: BIM Guidelines for Vertical and Horizontal Construction Figure 1

8.2.7.2 Description of Information Source

The primary source of information for this study is the “BIM Guidelines for Vertical and Horizontal Construction”. Although Massport’s website indicates that the guideline was originally issued in 2015 and updated in 2023, the version currently available on the website is the 2015 edition. Accordingly, the information summarized in this section is based on that version. 60

58 Generally refers to large-scale civil engineering projects.

59 Generally refers to large-scale construction projects.

60 [Important Documents | Massport](#)

8.2.7.3 Applicable BIM Standards

International standards such as ISO 19650 and ISO 12006, which are applied or referenced in other projects, are not referenced in this guideline.

8.2.7.4 ISO 19650-Related Initiatives

This guideline is not aligned with ISO 19650, and does not provide descriptions related to information requirements. However, it includes provisions addressing the BIM Execution Plan and Level of Development (LOD), which are summarized below.

(1) BEP (BIMxP)

At Massport, the BIM Execution Plan (BEP) is referred to as the “BIMxP.” The guideline defines eleven (11) objectives and roles of the BIMxP, as shown in Table 8-19.

Table 8-19 Objectives and Roles of the Massport BIMxP

No.	Objectives / Roles
1	Establishes a framework for better communication among BIM parties, and defines a schedule for BIM development.
2	Identifies potential project-specific adjustments to the BIM Guide, subject to review and approval by MPA.
3	Documents project infrastructure requirements, including software, hardware, server environments, and the entities responsible for hosting BIM.
4	Defines BIM roles and responsibilities by team or team member, and communicates expectations to all team members and project stakeholders.
5	Documents the Meeting Schedule for the BIM Manager and BIM Discipline Coordinators. This sub-group is responsible for developing the project template including MPA coordinate systems, project phasing, model organization, multi-user access, and model/sub model ownership.
6	Establishes a structured process and schedule for BIM model checking and validation.
7	Identifies the process flow for BIM Use execution, and its connection to project milestones, model submissions, model progression and LOD.
8	Defines information exchanges, shared access, and model federation.
9	Documents model access and security protocols.
10	Defines procedures to ensure model integrity and data safety plan.
11	Establishes measurable goals for BIM success and team execution. These metrics contribute to project lessons learned, and may be incorporated into subsequent BIM Guide updates.

Source: Prepared by the JICA Study Team based on the BIM Guidelines for Vertical and Horizontal Construction

(2) LOD (Level of Development)

The 2015 edition of the guideline references the “AIA/AGC LOD Specification 2014”⁶¹ with respect to LOD. AIA refers to the American Institute of Architects, and AGC refers to the Associated General Contractors of America. The “AIA/AGC LOD Specification 2014” was subsequently renamed the “BIMForum Level of Development,” as discussed in Section 8.2.6.4(4) in relation to Denver International Airport.

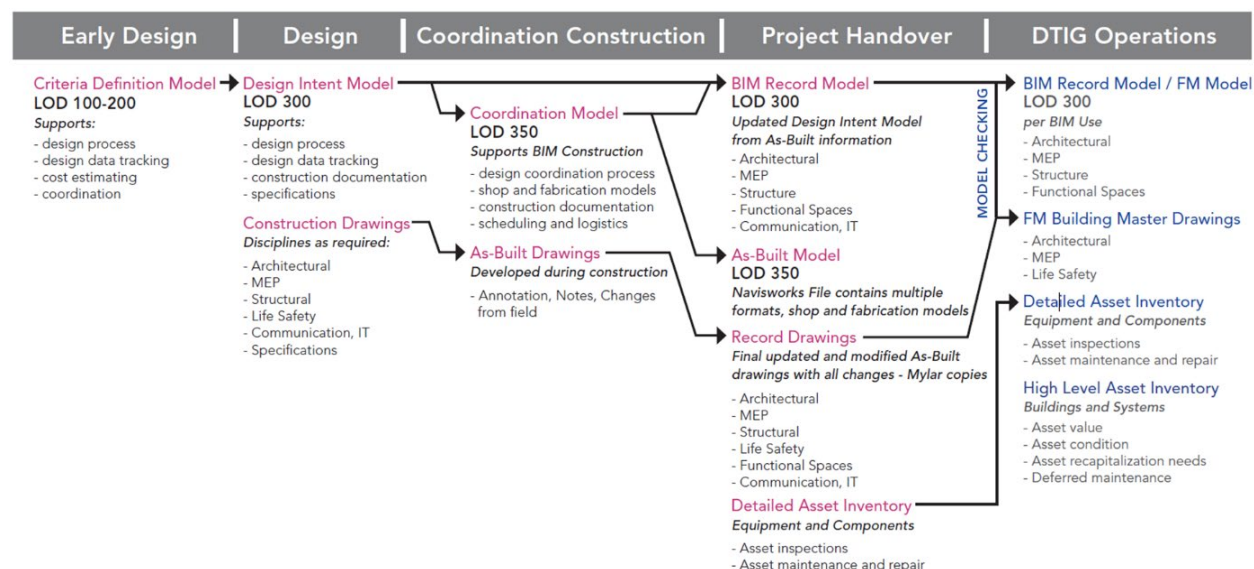
The guideline defines LOD levels from LOD 200 to LOD 400 as shown in Table 8-20. An example illustrating the application of LOD across asset lifecycle phases is presented in Figure 8-36.

⁶¹ [Level of Development Specification](#)

Table 8-20 LOD Definitions for the Project in the Massport BIM Guideline

LOD	LOD Definitions
200	Being generic and suitable for early performance analysis and design options.
300	Being suitable for performance requirements, estimating and procurement. Bid documents are generally LOD 300.
350	Being product specific.
400	Used at project turnover and defines the information on the installed product or building element.

Source: Prepared by the JICA Study Team based on the BIM Guidelines for Vertical and Horizontal Construction

Figure 8-36 Example of Massport’s Concept of LOD in Relation to Asset Phases

Source: BIM Guidelines for Vertical and Horizontal Construction Figure 28

8.2.7.5 Common Data Environment

Within this guideline, the concept equivalent to CDE is referred to as the “Model Collaboration Environment.” In addition, the collaborative workspace—both physical and virtual—used for virtual participation and BIM review is designated as the “Big Room.” The term “Big Room” is also commonly used to describe a co-location approach in which project stakeholders work collaboratively in a shared space. Massport generally requires design consultants to provide both the Big Room and the digital model environment. As the guideline was issued in 2015, prior to the publication of ISO 19650, several aspects differ from the ISO 19650 definition of a CDE. Nonetheless, the chapter addressing the “Model Collaboration Environment” discusses topics such as the use of WIP models and federated models, their role in decision-making, and the definition of model requirements and collaboration protocols within the BIMxP. These elements are broadly aligned with the principles of ISO 19650.

8.2.7.6 Information Classification Systems (e.g., Omniclass)

The 2015 guideline states that Massport utilized UniFormat and MasterFormat at the time, while transitioning toward OmniClass following the integration of these classification systems into the broader OmniClass framework.

8.2.7.7 Data Exchange Formats (e.g., IFC, COBie)

The guidelines require that design models and construction document data be submitted in PDF or XLS formats, using either the Massport Asset Spreadsheet or COBie. The use of COBie is determined at the project initiation and documented within the BIMxP. Additionally, upon construction completion and handover, the contractor's representative is required to prepare and submit a COBie worksheet, with particular emphasis on space, MEP system, and equipment.

With respect to IFC, the National BIM Standard (NBIMS) is identified as the industry data standard, and is documented within the NBIMS framework for information exchange. The guidelines further specify that model submissions are to be delivered in native format (.rvt) and review format (.nwd), with IFC provided as an optional delivery format.

8.2.7.8 Asset Management Policies and Specific Initiatives

The guideline references ISO 55000, stating that Massport seeks to sustain asset value and maintain its mission capability through sound financial management, safe operations, and environmental stewardship. BIM is positioned as a rational and effective tool and process within Massport's asset management practices. However, based on the findings of this study, no evidence was identified to indicate that Massport currently holds ISO 55000 certification.

8.2.7.9 Contractual Framework

From a contractual perspective, the guideline provides provisions governing the hierarchy of drawings. It acknowledges that BIM-based projects comprise both three-dimensional (3D) models and two-dimensional (2D) drawings, and stipulates that 2D drawings—such as plans, sections, elevations, 3D details, and axonometric projections—must be generated from the 3D model.

Massport's Standard Construction Contract specifies in Article 31 ("Plans and Drawings") that, in the event of conflicts within or between design deliverables in a BIM-based project, the following order of precedence shall apply:

- Drawings derived from the Design Model and supplemented with independent or additional graphics and annotations;
- Drawings derived directly from the Design Model;
- Model Element(s) specifically identified as superseding component(s) of the Design Model;
- The Design Model; and
- Drawings developed independently from the Design Model.

8.2.7.10 Education and Training for Project Stakeholders, Including the Supply Chain

Within the chapter addressing the Model Collaboration Environment, the guideline requires that appropriate training and instructional materials (e.g., manuals, PDFs, and video resources) be provided to stakeholders who access and use the model. It also requires that the training plan must be documented within the BIMxP.

8.2.7.11 Other Considerations

Appendix A of the Massport BIM Guideline lists 51 BIM Uses, organized into eight categories: existing conditions modelling; design and building system authoring; analysis and reporting; sustainability, energy, LEED design and analysis; design and constructability reviews and coordination; documentation, drawings, and specifications; commissioning and handover; and facilities management.

These BIM Uses demonstrate significant potential for application in future airport projects financed through Japanese official development assistance (ODA) loans. The list of BIM Uses is presented in Table 8-21.

The software tools associated with each BIM Use include Civil 3D, the Revit suite, AutoCAD, and Navisworks, indicating that Autodesk applications form the core of Massport's BIM environment. Autodesk BIM 360 is also listed as "under evaluation." Deliverables are generally aligned with the file formats of the above software. For BIM Uses related to civil works, site conditions, and disaster-risk considerations, the guideline additionally references the use of GIS.

Regarding data requirements, the guideline specifies the use of OmniClass, citing functional spatial classification (OmniClass Table 13), spatial classification by form (Table 14), and classification of elements (See Table 8-21). The guideline further highlights the role of IFC in facilitating data exchange, and BIM Use No. 42 ("COBie Dataset") provides an explanation of COBie's key features.

Table 8-21 Massport BIM Uses

No.	Item	Field	Spatial Notes
1	BIM Project Site Modeling - Also Infrastructure Modeling	Existing Conditions Modeling	Includes underground utilities such as fuel, heating/cooling pipes (including GPUs).
2	Surrounding Site Modeling		Can be utilized for planning and future master plan considerations.
3	Existing Conditions - Laser Scanning		
4	Existing Conditions Modeling - Building Interior		
5	Geo-technical, Environmental		
6	Site Modeling - Horizontal Construction		
7	Architectural Model - LOD 200-300	Design and Building System Authoring	
8	Space and Circulation Requirements Modeling		Identify security zones within the facility and utilize this information to support emergency response, security, and the movement of staff, passengers, and individuals requiring assistance. This information may be employed to provide briefings to the Transportation Security Administration (TSA) and airport security authorities.
9	Structural Model		
10	HVAC Mechanical Systems		
11	Plumbing and Fire Protection		
12	Electrical, Alarm Systems		
13	Interiors		Passenger terminals may incorporate a specialized furniture within lounges or art installations in concourses, presenting challenges for the accurate modeling of these elements.
14	Tenant Build Out		It is stated that tenants of all sizes, from small shops to hotels, are covered.
15	Area and Space Program Validation (SPV)	Analysis and Reporting	
16	Design Options		
17	Model Checking Program Compliance (Checking)		
18	Clash Avoidance and Detection		This is a required BIM Use
19	Structural Analysis		
20	Equipment Maintenance Clearance Space Modeling		
21	Budgetary Costing Model (LOD 200)		
22	Quantity Take Off (QTO) LOD 300		
23	Energy Modeling, Daylight and Sun Studies	Sustainability, Energy, LEED Design and Analysis	
24	Existing Buildings - Rapid Energy Modeling		
25	Mechanical Analysis		
26	LEED Credit Certification Reporting		
27	Lighting Analysis		
28	Systems Analysis (Retrofitting)		
29	BIM Based Reviews "Big Room" - Project Lifecycle	Design, Constructability Reviews and Coordination	
30	Digital Detail and Mock-Ups		
31	Scheduling - 4D BIM for Project Schedule, Phasing		
32	Site Safety Review		
33	In Field Construction Lay-Out		
34	Laser Scanning - Construction Phase		
35	Pre-Fabrication of Building Components		
36	Construction Drawing Production		

No.	Item	Field	Spatial Notes
37	Shop Drawing Coordination	Documentation, Drawings, and Specifications	
38	As-Built Models		
39	Data Normalization		The basic data standards include: OmniClass Table 13, UniFormat, MasterFormat, and the MPA data fields required in commissioning. In addition, COBie data may be required.
40	As-Built CAD Drawings - Floor Plans		
41	Virtual Handover (Record Model)	Commissioning and Handover	Commissioning of the BIM may also be required in accordance with the specifications outlined in the BIMxP.
42	COBie Data Set		
43	Commissioning		Massport utilizes Maximo as its Enterprise Asset Management (EAM) system.
44	Model Data Supporting Disaster Planning		
45	Model for Maintenance and Maintenance Training		
46	Assessment Models	Facilities	
47	Space Planning - Move Management		
48	Security		The A/E will consider security options and conduct simulations within BIM in accordance with MPA project requirements. Examples include line-of-sight analysis, escape routes, security zones, blast areas, and setbacks, where applicable.
49	CMMS and CAFM Integration		MPA utilizes Maximo for facilities management.
50	Resiliency Modeling		
51	Building Automation Systems BAS Integration		

Source: Prepared by the JICA Study Team based on the BIM Guidelines for Vertical and Horizontal Construction Appendix A

8.2.8 BIM Beyond Design Guidebook⁶²

8.2.8.1 Guideline Overview

A report-style guideline has been published outlining how airport practitioners can develop a business case for the application of BIM in asset management, drawing primarily on case studies from airports in the United States.

While the report does not reference the ISO 19650 series, it contains information useful for examining OIR and other airport-specific requirements. The guideline also includes descriptions of information classification systems, data exchange formats, asset management policies, contractual considerations, and training for project stakeholders; these elements were extracted and organized for this study. In addition, information considered beneficial for the application of BIM in airports has been compiled separately.

8.2.8.2 Description of Information Sources

This research report was compiled and published by the Airport Cooperative Research Program (ACRP). ACRP is an industry-driven research program aimed at proposing practical solutions to challenges faced by airport operators in the United States. It is administered by the Transportation Research Board (TRB) of the National Academies, with additional sponsorship from the Federal Aviation Administration (FAA).

8.2.8.3 Applicable BIM Standards

The report does not reference the ISO 19650 series and provides only a brief introduction to PAS 1192 in the section discussing initiatives in the United Kingdom. Nevertheless, it contains extensive information pertinent to this study, including OIR and AIR, information classification systems, and considerations related to contractual arrangements.

8.2.8.4 ISO 19650-Related Initiatives

Although the guidebook does not reference the ISO 19650 series, several chapters provide information relevant to the consideration of OIR, PIR, AIR, LOD, and related concepts. These elements are summarized below.

(1) From the Chapter on Optimizing BIM Application

The guidebook indicates that the first step in customizing BIM for each airport is to identify facility-information needs and challenges, followed by needs assessment that compares these requirements against BIM functions and benefits. A BIM needs assessment is defined as the identification of the six items listed in Table 8-22. These items are comparable to those typically evaluated in conventional construction projects. Ultimately, the information identified through this process may correspond to AIR required for asset operation.

⁶² Jack Ray, BIM Beyond Design Guidebook (2020) , ACRP Research Report 214, The National Academies of Science·Engineering·Medicine Transportation Research Board, 2020

Table 8-22 A BIM Needs Assessment

No.	Content
1	What facility information, and in what format, is required by each airport stakeholder group to perform its job function?
2	Why is this facility information required, and what alternative sources exist?
3	Who is responsible for the creation and maintenance of this facility information?
4	Where is this facility information stored, and how is it accessed?
5	What are the current obstacles and challenges related to acquiring and maintaining this facility information? What are some specific examples of issues stakeholders have encountered or are currently facing? Where possible, quantify the number of hours these obstacles may be adding to their workload.
6	What opportunities exist to improve an airport stakeholder group's job performance through improved facility information? Identify specific examples of the type of facility information that would benefit existing or upcoming work. Where possible, quantify the number of hours that would be saved if this facility information were easily available.

Source: Prepared by the JICA Study Team based on BIM Beyond Design Guidebook (2020)

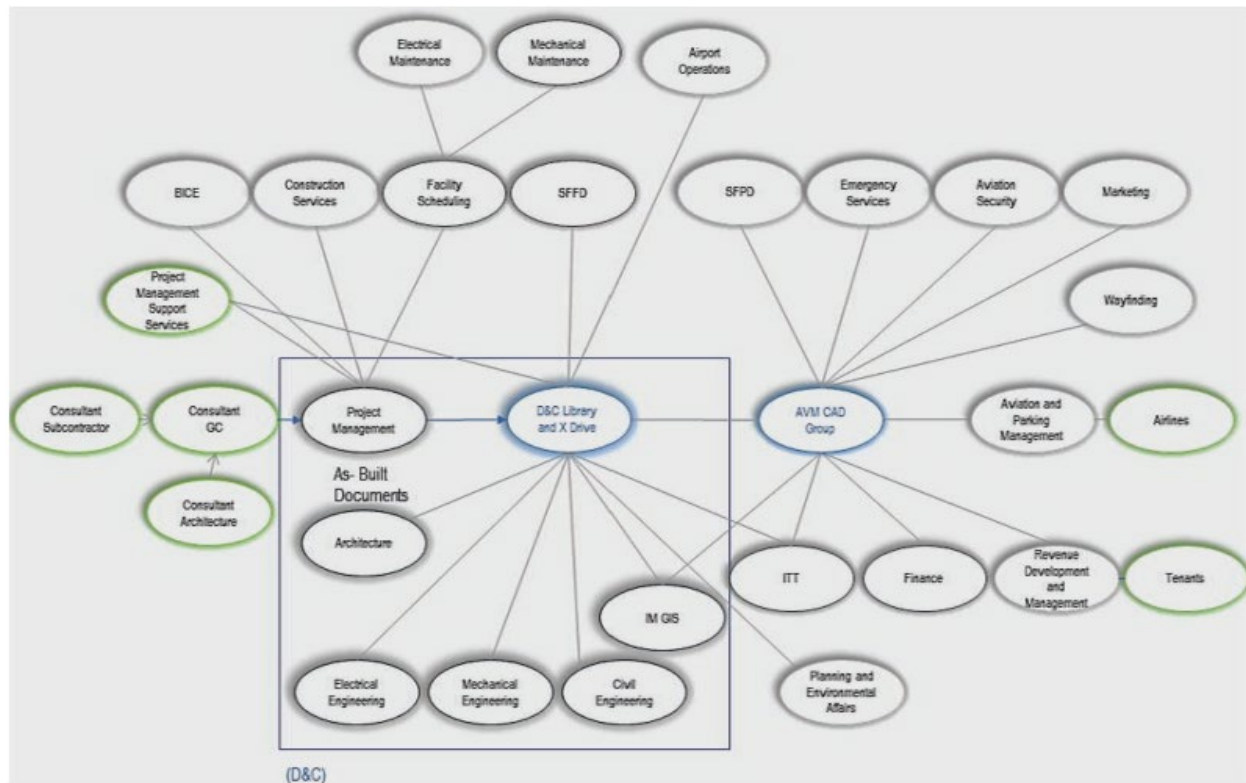
Examples of the types of facility information used in airports are presented in Table 8-23. Among these, subsurface utility information is particularly airport-specific, as above-ground obstructions cannot be installed due to aircraft movement and runway safety considerations.

Table 8-23 Representative Examples of Facility Information Used in Airports

As-built plans	Financial and capital planning data
O&M manuals	Facility floor layout plans
Maintenance history and warranty data	Survey data
Emergency procedures	Geotechnical data
Asset inventory	Underground utility locations
Asset condition	Project management data
Asset valuation	

Source: Prepared by the JICA Study Team based on BIM Beyond Design Guidebook (2020)

After identifying facility-information needs and challenges, the guidebook recommends developing a data-flow diagram that illustrates how facility information is currently collected, stored, maintained, and distributed within the airport. The data-flow diagram highlights the sources and types of data associated with airport facilities, as well as the users of that data. As a reference, Figure 8-37 shows the data-flow diagram for San Francisco International Airport included in the report. Collaborative development of such diagrams among stakeholders is considered an effective method for eliciting information requirements in an airport environment.



Note: AVM = aviation management; D&C = design and construction; GC = general contractor

Source: BIM Beyond Design Guidebook (2020) Figure 2-1

Figure 8-37 San Francisco International Airport Data Flow Diagram

As the final step of the needs assessment, the guidebook recommends prioritizing the results. When establishing priorities, airports should consider not only financial factors (e.g., ROI) but also non-financial considerations, such as safety and security, regulatory requirements, customer satisfaction, and regional economic impacts.

(2) Example of Business Case Development in Airports (OIR, AIR)

The following content is based on a hypothetical business case developed by the authors. While conceptual, it is grounded in airport-specific characteristics, as well as the authors' research and case studies; and is therefore considered relevant for this study.

In the section "Organizational Mission and BIM Vision," the mission of the airport development department is described as follows, which may also correspond to elements of OIR:

- To manage, maintain, repair, and remodel the airport's infrastructure and facilities;
- To provide a safe and comfortable experience for passengers, airlines, concessionaires, contractors, and airport staff; and
- To manage energy utilization and optimize the sustainability of airport facilities.

In addition, the guidebook summarizes program goals, objectives, and priorities for applying BIM in maintenance-planning activities, as presented in Table 8-24. Extracting information related to these goals and BIM uses may facilitate the formulation of AIR for airports.

Table 8-24 Goals and Objectives of the Hypothetical Pilot Program to Use BIM for Maintenance Planning

Priority	Goal Description	BIM Objective
High	Reduce unplanned outages affecting passengers and airlines	Use BIM to reduce preventive maintenance backlog, implement continuous improvement methodologies, and support improved reporting and response
High	Minimize downtime due to unplanned outages	Use BIM to reduce planning and response time to outages
High	Provide rapid response to emergencies	Share BIM with emergency responders to improve their knowledge of a site in preparation for a response as well as their readiness on arrival
Medium	Provide more accurate location data for asset inventory	Use BIM to supplement CMMS asset data with asset coordinates

Source: "Business Case for Organization BIM Integration—Version 1.02" template, BIM Beyond Design Guidebook (2020) Table 4-1

(3) AIR and LOD

The report notes that AIR should include LOD definitions or AIM requirements necessary for integration with asset management, space management, sustainability analysis, emergency-planning operations, and other operational analytics.

It further states that, although LOD 300 or higher is required at delivery, LOD 100 or LOD 200 is often more appropriate for operational and maintenance purposes.

(4) Security Considerations

The report highlights that while BIM introduces benefits in collaborative work, it may also conflict with airport security policies. BIM contains critical infrastructure information for airport staff, however, increased accessibility can elevate the risks of information leakage or misuse. Table 8-25 summarizes BIM benefits, security concerns, and corresponding mitigation measures.

Table 8-25 Benefits of BIM, Security Concerns, and Mitigation Measures

Benefits of BIM	Security Concerns	Mitigation Measures
- Airport staff can easily access information necessary for their duties. - Operational efficiency improves.	- Information exposure increases. - Security concerns arise from potential misuse of information. - Excessively restricting access diminishes BIM effectiveness.	- Establish appropriate access permissions based on department, position, etc. - Develop manuals for information handling procedures. - Implement ongoing training.

Source: Prepared by the JICA Study Team based on BIM Beyond Design Guidebook (2020)

8.2.8.5 Common Data Environment

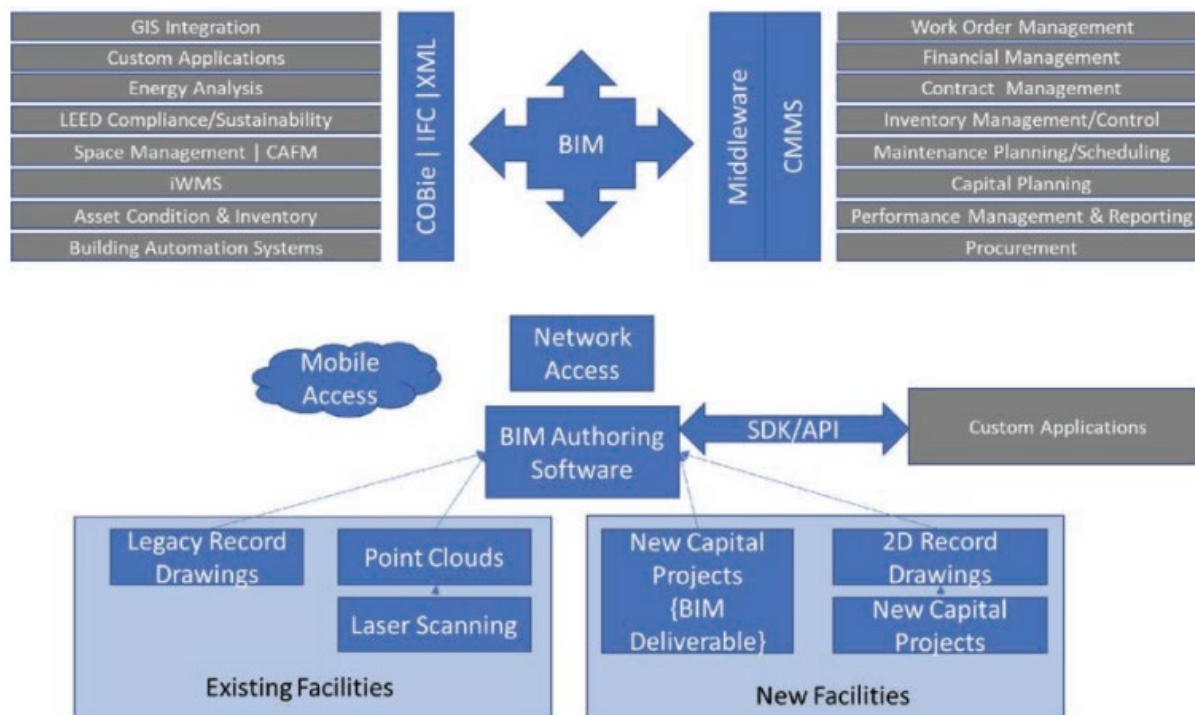
The report contains no descriptions related to CDE.

8.2.8.6 Information Classification Systems (e.g., Omniclass)

The report lists OmniClass, UniFormat, IFC, and COBie as asset-classification systems that can be referenced when no established internal airport standard exists. Among these, OmniClass is described as the most widely used classification system in the United States and a suitable starting point for discussing classification methodologies for airport assets.

8.2.8.7 Data Exchange Formats (e.g., IFC, COBie)

The report introduces COBie as the most well-known Model View Definition (MVD), noting that FM systems such as CMMS, EAM, CAFM, and BAS offer COBie-compliant data interfaces. Figure 8-38 presents the application map included in the report, illustrating data flows from BIM to various airport applications.



Note: SDK = software development kit

Source: BIM Beyond Design Guidebook (2020) Figure 7-4

Figure 8-38 BIM Application Map

The report also provides a high-level data-mapping table between COBie data and IBM Maximo, one of the most widely used CMMS platforms. This mapping is summarized in Table 8-26.

Table 8-26 High-level Mapping of COBie Data to IBM Maximo Data System

COBie Data Type	Maximo Object Type
Contacts	PERSON, COMPANIES, COMPANY CONTACT
Facility	LOCATION
Floor	LOCATION
Space	LOCATION
Component	LOCATION AND ASSET RECORD
Zone	LOCSYSTEM
System	LOCSYSTEM
Attributes	Values in SPECIFICATION TABLE of ASSET TYPE

Source: BIM Beyond Design Guidebook (2020) Table 8-1

Regarding BIM–BAS integration, the report notes that such integration is based on IFC and its subset, the Building Automation Modelling Exchange (BAMie).

Additionally, drawing on commentary from the National Institute of Building Sciences (NIBS), the report introduces an asset-naming methodology structured around space identifiers and asset-type designations. Table 8-27 provides examples of naming conventions applicable to airport facilities, which can serve as a reference for airport-asset nomenclature.

Table 8-27 Examples of Naming Conventions

Case	Naming
General NIBS Recommendation	COBie.Type.Name – COBie.Space.Name – Item Count in Space
Example for lobby lighting fixtures	Lobby.overhead light - 001、Lobby.overhead light - 002
Example with facility added	If the COBie data are going to be combined with several other facilities, then the asset names can be prefixed with the COBie.Facility.Name: TerminalA.Lobby.overhead light - 001

Source: Prepared by the JICA Study Team based on BIM Beyond Design Guidebook (2020)

8.2.8.8 Asset Management Policies and Specific Initiatives

(1) Case Studies

The report presents case studies from five airports: Denver International Airport, San Francisco International Airport, the Massachusetts Port Authority (which manages Boston Logan International Airport and others), John F. Kennedy International Airport, and Heathrow Airport (United Kingdom). A summary of the content introduced in the report is provided in Table 8-28.

Table 8-28 Summary of Five Airports and Organization Case Studies

Category	Denver International Airport Hotel and Transit Center	San Francisco International Airport	Massachusetts Port Authority	JFK International Airport (Terminal 5)	Heathrow Airport (Terminal 5)
Key Issues / Challenges	Time-consuming manual CMMS entry; transcription errors.	Securing BIM-capable contractors; developing internal BIM capability.	Lean BIM process development; standardized asset data; integrated lifecycle FM platform; data for predictive maintenance.	Improve lifecycle asset and space management; faster information management; process automation; communication improvement.	Improve lifecycle asset management; better coordination among diverse airport stakeholders; CDE implementation for lifecycle costs management.
Systems Used	Maximo, BIM 360	Not specified	Maximo, BIM 360, Revit, GIS	Not specified	Maximo
BIM Use Cases	Design and construction; asset management; asset inventory; warranty inspections; maintenance planning; condition assessment.	Asset management; rapid asset creation; energy modeling; BIM–GIS integration; design and construction.	CMMS asset creation; maintenance planning and scheduling; sustainability planning; lean process optimization.	Operational design including passenger flow and acoustic modeling.	Operational design; maintenance planning; root- cause analysis; asset and space management; inventory; condition assessment.
Pilot Projects	All project data made available to inspectors through BIM- enabled tablets.	Not specified	Not specified	Passenger flow simulation; terminal shape optimization; acoustic analysis performed.	Simulation of equipment, passenger flow, baggage; asset common language framework; root-cause analysis.
ROI	Application license USD 70k/yr; training and hardware USD 50k; ROI achieved in 18 months.	ROI varies; indirect cost reduction via schedule compression; handover reduced from one year to months.	No formal BIM financial ROI measurement process.	Not analyzed; potential benefits include reduced wear from congestion mitigation; improved emergency safety.	Not analyzed.
Cost Reduction Details	Eliminated inspector overtime; improved data quality; reduced warranty resolution time; decreased printing cost.	Not specified	Not specified	Not specified	Not specified
Lessons Learned	Staff adopt technology when efficiency improves; BIM pilots build acceptance; work order accuracy improved; printing reduced.	Collaborative BIM environment improves outcomes; early stakeholder engagement; metrics essential for process improvement.	Contract/procurement review is essential; BIM implementation may require schedule extensions; organizational readiness is critical; adopt standards; establish a dedicated BIM team.	BIM improves design for operations and sustainability without requiring changes to O&M procedures or internal training.	BIM and CDE improve design and construction efficiency; reduce future O&M cost through operational design optimization.

Source: Prepared by the JICA Study Team based on BIM Beyond Design Guidebook (2020)

(2) Responsibility for BIM Management

The report analyzes the assignment of responsibility for BIM management and notes that no universally established best practice exist regarding which division within an airport organization should hold primary accountability for BIM oversight. Potential candidates for delegating this responsibility include:

- The engineering department,
- The asset-operations department,
- The ICT department, or
- A newly established BIM-specialist division.

The report further observes that the ICT department typically does not assume responsibility for maintaining data accuracy or completeness. Therefore, if full BIM-management responsibility were to be assigned to ICT, it would be necessary to substantially redefine the department's traditional scope of work and responsibilities.

8.2.8.9 Contractual Framework

The report discusses how the application of BIM enhances communication and collaboration throughout the infrastructure lifecycle while potentially conflicting with traditional approaches in which risk and responsibility are managed through contractual mechanisms. In the United States, two major BIM contract templates have been developed for the design and construction stages: the “BIM Exhibit for Sharing Models with Project Participants” (American Institute of Architects/AIA) and the “Building Information Modelling (BIM) Addendum - 301” (Associated General Contractors/AGC). These templates primarily address the handover process from designer to contractor.

The report further examines document precedence, risk and responsibility allocation, ownership of BIM, and contractual requirements for BIM that account for future operational needs. These elements are detailed below.

(1) Document Precedence

The report presents two perspectives regarding the legal status of BIM: BIM as supporting information to specifications, and BIM as a contractual document. These perspectives are summarized in Table 8-29. The report also notes that when BIM is used, the contractual status of construction-phase documents and data—such as contractor-prepared shop drawings—must also be considered.

Table 8-29 BIM Legal Status

Perspective	Issue		
	Contractual Validity	Contractual Precedence	Remarks
BIM as supporting information to specifications	2D plans and specifications are contractually valid; BIM is regarded as “additional information” with no legal status.		
BIM as a contractual document	BIM exists as a legal document; attention must be paid to added 2D drawing annotations or additional information.		
		When discrepancies arise between BIM, 2D drawings, and specifications, a hierarchy of precedence must be established	No clear best practice has been established; Federal Acquisition Regulation 52.236-21 prioritizes specifications over drawings, whereas AIA proposes the reverse hierarchy

Source: Prepared by the JICA Study Team based on BIM Beyond Design Guidebook (2020)

(2) Risk and Responsibility

The report states that under traditional construction contracts and processes, owners, designers, and contractors each attempt to transfer risk while protecting their own interests, and this intent is reflected in

the contract documents. However, BIM-enabled collaboration may not align with the concepts underpinning these conventional processes.

The report further summarizes the potential shift in conventional concepts introduced by collaborative BIM environments, viewed from the standpoint of contractual protections for designers and design responsibility for contractors. These changes are shown in Table 8-30.

For owners (facility operators), the report emphasizes that, prior to project handover, AIR must be clearly defined to support operational and maintenance activities. Required data and formats should be identified at an early stage, and active participation in the commissioning is essential to verify that data meets specified requirements.

Table 8-30 Changes in Risks for Designers and Contractors

Party	Perspective	Conventional Concept	Potential Outcomes in a Collaborative Environment
Designers	Contractual protection	Under basic legal principles, rights and obligations cannot be imposed on parties not in contract; in DBB, designers have no direct contract with contractors, and are thus shielded from contractor claims.	Under DB, CMAR ⁶³ and IPD ⁶⁴ , architects/engineers enter into shared contracts with contractors, reducing designers' ability to transfer risk; however, improved communication enables earlier identification and resolution of design issues
Contractors	Design responsibility	The Spearin doctrine implies that design documents contain no defects, allowing contractors to recover costs arising from design errors.	Contractor involvement in detailed design within a BIM-collaborative environment may weaken Spearin protections; however, early involvement allows proposals that improve constructability and reduce overall contractor risk.

Source: Prepared by the JICA Study Team based on BIM Beyond Design Guidebook (2020)

(3) Ownership of BIM

In standard AIA-based U.S. contracts, the creator of design documents (e.g., architects or engineers) retains ownership, and such ownership is not transferred. These contracts instead confer only limited licenses for the use or modification of the design documents. This arrangement can present challenges when owners seek to reuse design information for future renovations or to share it with other consultants involved in facility management.

Because BIM datasets may include intellectual property, such as designers' 3D model libraries, sharing BIM with external consultants can introduce risks of unintentional duplication or unauthorized distribution of that intellectual property.

In addition, designers frequently expressed concern about potential liability when BIM models are modified without their consultation. Based on these considerations, the report proposes the following licensing requirements to address potential future issues:

- The facility owner should retain ownership and copyright of the BIM after project handover.
- Designer liability for future use or modification should be minimized.
- Designers' model libraries should be contractually protected against reuse outside the project scope (other consultants may not copy or reuse them).

These requirements would grant facility managers the broadest rights necessary to modify and reuse BIM

⁶³ Construction Management at Risk (CMAR) is a type of Construction Management (CM) approach. It involves contracting both the construction management services and the actual construction work. (Reference: [CM アットリスク方式とは | インデックス株式会社【建設プロジェクトマネジメント】](#))

⁶⁴ The Integrated Project Delivery (IPD) method is a process where the client, designers, contractors, and others work together as a unified team to achieve rational design and construction. (Reference: [\(7\) IPD 推進室を設置！建築設計事務所の顧客志向 | 日経クロステック \(xTECH\)](#))

during operation and maintenance.

(4) BIM Contract Requirements Considering Future Operations

The report states that BIM contractual requirements must define how digital specification data will be delivered to ensure interoperability with existing airport facility-management systems. To achieve this, an AIR must be developed to identify the required asset information and its delivery format.

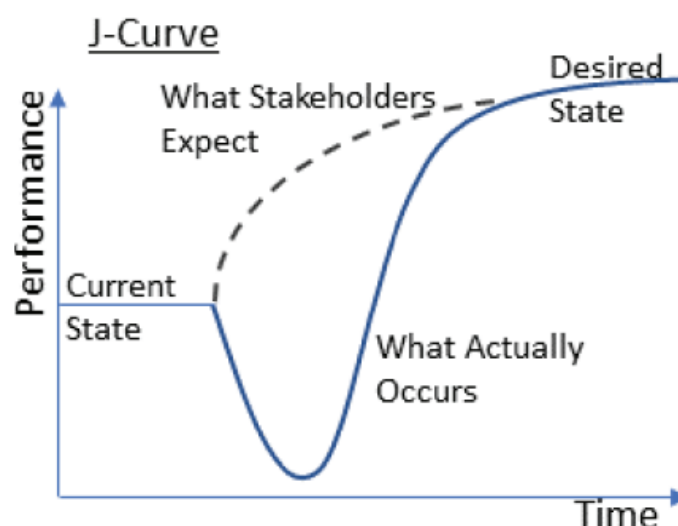
An AIR may be tailored to the organization based on existing airport asset-data lists and facility-management structures, or alternatively, constructed around standardized information-exchange formats such as COBie, to maximize interoperability with other standardized FM tools and systems.

Regardless of which standards are applied, the report contends that to minimize FM-related BIM utilization costs and the time required to integrate digital data, detailed requirements for the delivery of digital data must be incorporated into the project-delivery contract. This recommendation may be interpreted as guidance for the preparation of PIR.

8.2.8.10 Education and Training for Project Stakeholders, Including the Supply Chain

The report positions training in BIM application as an important area of investment, equal in importance to software, hardware, networks, external expertise, and process development. The introduction of new technologies and processes follows the J-curve shown in Figure 8-39, whereby performance declines during the initial learning period, but productivity increases over time.

From a supply-chain perspective, securing local contractors and subcontractors with the skills needed to perform BIM-enabled project delivery is identified as a key challenge. In particular, small-scale consultants and contractors may need to develop BIM capabilities, and it is therefore necessary to provide these entities with training opportunities and appropriate resources. Investment in such training activities yields long-term benefits by cultivating a skilled workforce that supports future airport growth and may also contribute to regional economic development.



Source: BIM Beyond Design Guidebook (2020) Figure 4-3

Figure 8-39 J-curve for New Technology Adoption

8.2.8.11 Other Considerations

(1) Management Perspectives

Return on Investment (ROI)

The report notes that the opportunity cost of not using BIM over the next decade would entail foregoing reductions in airport facility lifecycle costs, thereby missing opportunities to enhance airport competitiveness. In other words, without BIM, airports may be unable to lower landing fees or improve the quality of passenger services.

While the report acknowledges that conducting financial analysis and comparing BIM versus non-BIM through ROI is challenging in an airport context, it identifies several areas in which BIM adoption can be expected to yield a positive ROI:

- Reduction of maintenance costs through improved maintenance planning
- Reduction of downtime through improved asset management
- Increased labor productivity through improved planning, collaboration, and communication
- Increased capital efficiency through reduced construction duration and improved management

As a reference, Table 8-31 shows example indicators and targets for improving work-order planning through BIM application.

Table 8-31 Example Metrics/Goals for Using BIM to Enhance Work Order Planning

Benefit	Goal/Objective	Benefit Calculation	Estimated Value
Average work completion time	Reduction of 2 hours per overall work order	30,000 average work orders/year resulting in 60,000 total maintenance work hours	\$3 million
Average work order planning time	Reduction of 1 hour per work order	30,000 average work orders/year resulting in 30,000 saved work hours in planning	\$1.5 million (included in average work order time savings)
Average # of site visits required to complete work order	Reduction of 50%	Reduced staff and vehicle traffic at the airport related to maintenance activities	Included in average work order time savings
% wrench time	Wrench time increased 15%	Additional 15% of total maintenance technician time available to reduce preventive maintenance backlog	Included in average work order time savings
Reduced preventive maintenance backlog	Average backlog reduced to 4 weeks, All peaks above 8 weeks eliminated	Timely preventive maintenance of assets will result in longer average asset life	10%–15% of total asset value
Total safety incidents related to work orders	Safety incidents reduced by 30%	Fewer trips required per work order reduce at-risk time spent on-site	30% claims reduction and lost hours

Source: BIM Beyond Design Guidebook (2020) Table 4-4

The report also summarizes responses from an airport survey on ROI:

- Nineteen of 29 airports (65%) anticipated a positive ROI from BIM.
- Twenty-two of 29 airports (75%) expected at least break-even results.
- The area perceived to offer the highest ROI was reduction in design and construction cost (70.0%).
- Airports also expressed interest in strengthening preventive maintenance (56.7%) and predictive maintenance (26.7%).
- Additional expectations included improvements in maintainability design (56.7%), operability design (46.7%), disaster and emergency preparedness (20.0%), and safety and security enhancement (16.7%).

Table 8-32 Airport BIM Primary ROI Sources

BIM Uses Contributing to ROI	Responses	
Improved planning	60.00%	18
Reduced design/construction cost	70.00%	21
Improved communication/collaboration	56.67%	17
Improved capital planning	30.00%	9
Enhanced preventive maintenance	56.67%	17
Enhanced predictive maintenance	26.67%	8
Operational efficiencies	33.33%	10
Reduced downtime	30.00%	9
Design optimized for maintenance	56.67%	17
Design optimized for operations	46.67%	14
Enhanced disaster planning and emergency response times	20.00%	6
Enhanced safety and security	16.67%	5
Other (please specify)	6.67%	2
	Answered	30

Source: BIM Beyond Design Guidebook (2020) Table 4-12

Competitive Environment of Airports

The report notes that airports are facing increasingly intense competition—not only from neighboring airports within the same country but also from airports in nearby countries. The performance and management of airport assets are critical determinants of operational success. Factors influencing airport performance include the diversity of airline services and destinations, passenger satisfaction with airport facilities, and the effectiveness of infrastructure and overall airport operations. Specific elements include airport access, terminal facilities, check-in and baggage services, security screening, baggage claim, and food and retail offerings. BIM is considered essential for supporting the investment and asset management strategies required to respond to changing passenger trends and to maintain the physical and human-resource capabilities necessary for all airport stakeholders.

Although airports primarily serve as gateways to destinations rather than destinations themselves, improvements in convenience, safety, and energy efficiency achieved through BIM may enhance the attractiveness of airports as transfer hubs. Such enhancements have the potential to increase passenger numbers, facilitate the deployment of larger aircraft, and support higher flight frequencies.

(2) Supplementary Notes on the Use of GIS

In Section 8.2.8.8(1), the case studies for San Francisco International Airport and the Massachusetts Port Authority include references to the use of GIS. GIS can serve as one of the tools comprising the CDE for airport asset management. Accordingly, supplementary research was conducted on the integration of BIM and GIS in airports. The investigation covered:

- Use-case categories presented by Esri (ArcGIS), and
- Detailed examples of wildlife management supported by GIS.

Esri Use-Case Categories

Esri's official website (Aviation and Airports)⁶⁵ introduces GIS-based solutions in the aviation and airport sectors. The areas covered include airport operations, infrastructure and asset management, planning and development, asset management, safety and security, regulatory compliance, and passenger experience. Concrete airport examples are summarized in Table 8-33.

⁶⁵ [GIS Software for Mapping and Spatial Analytics | Esri](#)

Table 8-33 GIS Solutions by Esri (ArcGIS) and Example Use Cases

Field / Solution Area	Supplement / Case Details
Operational management (Airport Operations); Single dynamic operational view; Real-time performance monitoring; and Collaboration & communication.	Geneva International Airport: Developed a real-time GIS dashboard for aircraft, vehicle, and passenger flows; processed 6 million more passengers than design capacity in 2016. Atlanta International Airport: GIS used for pavement issues, GNSS-integrated pavement monitoring, fire inspection prioritization, Wi-Fi planning, obstruction analysis with 3D tree models, BIM-to-GIS integration.
Infrastructure and asset management; Inspection management; Asset and maintenance management; and Asset performance monitoring.	San Francisco International Airport: Established unified infrastructure management information via BIM–GIS integration; FAA requires airports to provide GIS-format data since 2007.
Planning and development; Planning and environmental management; Engineering; and Construction management.	Includes land/airspace planning, airport access planning, noise analysis, wildlife management; Esri technologies integrated with Autodesk software for planning and design.
Asset and Space management; Lease management; Space management; Asset management	Las Vegas International Airport: Built GIS-based Airport Management System (AMS); visualizes Maximo asset data on maps; integrates GIS with AODB for gate assignment optimization.
Safety and Security; Comprehensive operational view; Incident management; and Mobile device utilization	Los Angeles International Airport: Real-time sharing of incident data (incl. photos) through GIS between control room and field teams; shortened response times.
Regulatory compliance; Obstruction analysis; Noise mitigation; and Wildlife management.	No specific airport case provided.
Passenger experience; Passenger flow analysis; Airport catchment analysis; and Mobile device utilization.	Analyzes passenger behavior and demographic/mobility data to improve customer experience and commercial performance, and expand airport catchment.

Source: Prepared by the JICA Study Team based on reference 66, 67, 68, 69, 70, 71

GIS functionality supports not only the maintenance of airside civil infrastructure but also building design and facility operations. In particular, building 3D models can be imported into GIS and utilized within an integrated environment. Figure 8-40 shows an example of building-model visualization in GIS at Hartsfield–Jackson Atlanta International Airport.

66 [Esri Website] <https://www.esri.com/en-us/industries/airports/overview>, accessed September 2, 2025

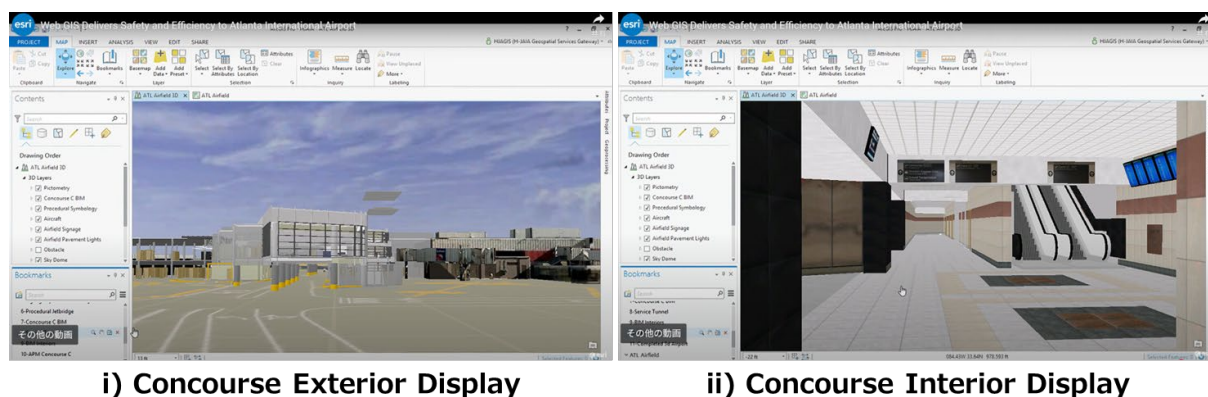
67 [Geneva International Airport Case Study] <https://www.esri.com/about/newsroom/publications/wherenext/location-intelligence-saves-geneva-airport-millions>, posted September 14, 2017, accessed September 2, 2025

68 [Atlanta International Airport Case Study] https://www.youtube.com/watch?v=_i_SNi5AFeQ, posted August 14, 2015, accessed September 2, 2025

69 [San Francisco International Airport Case Study] <https://www.esri.com/about/newsroom/blog/san-francisco-airport-bim-gis-processes>, published October 21, 2021, accessed September 2, 2025

70 [Las Vegas International Airport Case Study] <https://www.esri.com/en-us/lq/industry/transportation/location-strategy-gets-first-class-seating>, posted December 13, 2016, accessed September 2, 2025

71 [Los Angeles International Airport Case Study] <https://www.esri.com/about/newsroom/arcnews/real-time-gis-improves-incident-management-at-lax>, published Winter 2016, accessed September 2, 2025



i) Concourse Exterior Display

ii) Concourse Interior Display

Source: [Web GIS Delivers Safety and Efficiency to Atlanta International Airport](#)

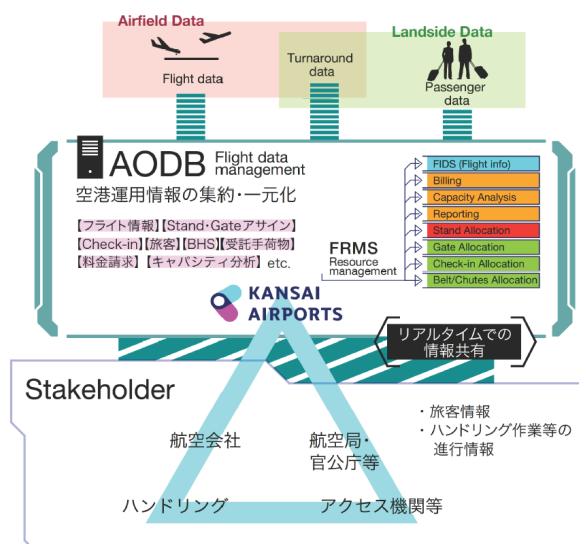
Figure 8-40 Building-Model Visualization in GIS at Atlanta International Airport

The report also provides supplemental explanations regarding the Airport Operational Data Base (AODB) and Airport Management System (AMS) referenced in the Las Vegas example in Table 8-33.

According to a press release from Kansai Airport Co., Ltd. announcing the introduction of AODB,⁷² the system integrates airport-operations information that was previously managed across multiple systems and databases, enabling real-time information exchange with airlines, aviation authorities, and access-related entities (See Figure 8-41). Expected benefits include optimized resource utilization (e.g., gates, check-in counters) and improved passenger flow. The AODB primarily manages flight and passenger-handling information, which differs in purpose and characteristics from asset-management information.

The AMS is a suite of software systems used to manage overall airport operations and often incorporates AODB. Past airport projects in which the study team participated included AODB, FIDS, RMS, BRS, and CUTE as components of AMS.

Although IATA provides standards for information formats and protocols within AODB and AMS, the systems are typically delivered under contractual arrangements between the airport and aviation-IT service providers such as SITA and Amadeus.



Source: [関西国際空港 AODB \(Airport Operational Data Base\) を運用開始](#)

Figure 8-41 Conceptual Image of Airport Operations Using AODB

72 関西エアポート株式会社プレスリリース「関西国際空港 AODB (Airport operational Data Base) を運用開始 ～空港運用情報を一元化し、オペレーションの最適化を目指します～」(2022年2月9日)

GIS-Enabled Wildlife Management

Wildlife management is a critical operational issue for airports, particularly with respect to bird-strike prevention. Other species can also disrupt airport operations, as illustrated by the 2022 incident at Narita International Airport in which a turtle entered the runway and caused operations to be temporarily suspended.

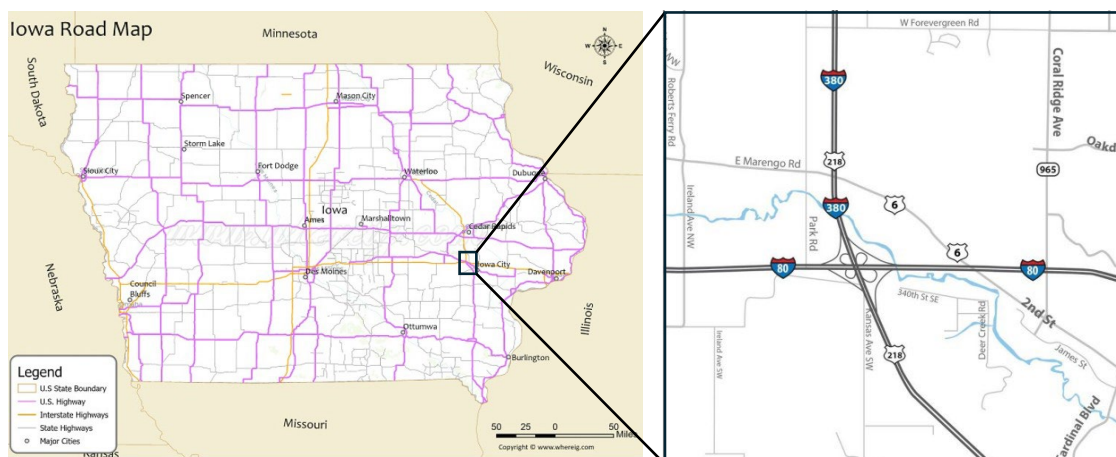
ICAO Doc 9137 Airport Services Manual Part 3—Wildlife Hazard Management describes the applicability of GIS for identifying wildlife hazards. At Gatwick Airport in the United Kingdom, GIS is utilized not only for operational risk mitigation but also for biodiversity conservation, including tracking the distribution of protected species and planning activities to minimize ecological impacts.

8.2.9 I-80/I-380 Systems Interchange Project (USA)

8.2.9.1 Project Overview

This project concerns the system interchange between Interstate 80 and Interstate 380 in the State of Iowa, a major junction located along one of the nation's key freight corridors. The location plays an important role not only for regional traffic, including traffic to and from Iowa City but also for long-distance east-west through-traffic and freight movements toward the Cedar Rapids area.

With increasing economic activity, traffic demand has shown an upward trend, raising concerns about future congestion, accidents, and delays in freight movement. Consequently, the Iowa Department of Transportation (Iowa DOT) has planned a comprehensive reconstruction of the interchange. The project aims to alleviate congestion, improve safety, enhance freight performance, and extend the service life of infrastructure by maintaining traffic on existing structures while sequentially removing and reconstructing them, ultimately converting the interchange into a turbine-type configuration.



Source: Prepared by the JICA Study Team based on the Iowa DOT "I-80/I-380 Systems Interchange Project Overview"

Figure 8-42 Project Location (Before Reconstruction)

8.2.9.2 Description of Information Sources

The main information sources are shown in Table 8-34.

Table 8-34 Sources of Information

Organization	Category	Document	URL
Iowa Department of Transportation (Iowa DOT)	Project overview	Getting You There I-80/I-380 Systems Interchange	https://www.cptechcenter.org/wp-content/uploads/sites/7/2025/03/Better-Conc-Conf-2024.pdf
	Project introduction video	I-80/I-380 Systems Interchange - Rebuilding for the Future: Project Overview	https://www.youtube.com/watch?v=xZipGeJqcG8
Federal Highway Administration/U.S. Department of Transportation)	Case study	I-80 Eastbound Ramps At I-380 3D Model Deliverable	https://www.fhwa.dot.gov/construction/bim/pdfs/BIM_IA_I-80_EB_to_I-380_Ramps_case_study.pdf
	Technical brief	Hybrid Approach to BIM in IOWA BIM as part of the Construction Contract	Hybrid Approach to BIM in Iowa Tech Brief
HRGreen, Inc.	Corporate website	HRGreen, Inc.	https://www.hrgreen.com/about/
HDR, Inc.	Corporate website	HDR, Inc.	https://www.hdrinc.com/portfolio/i-80i-380-system-interchange-reconstruction

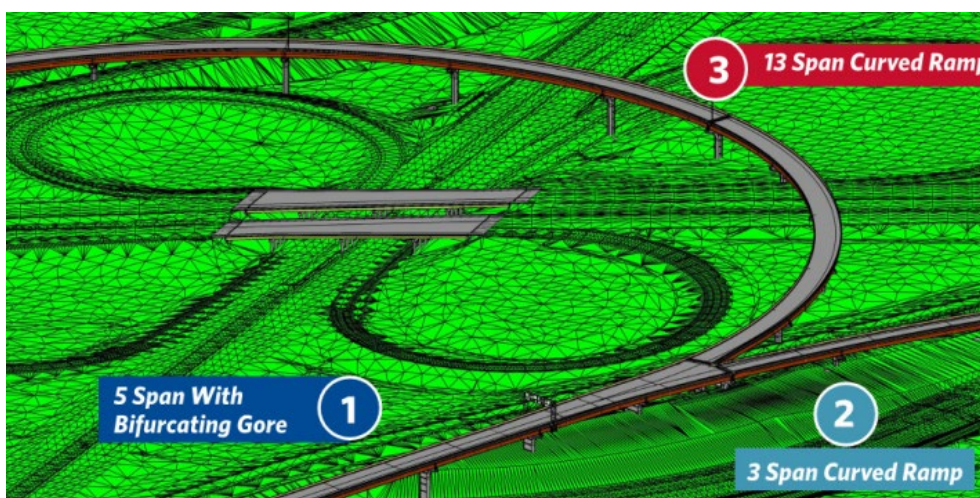
Source: The JICA Study Team

8.2.9.3 Applicable BIM Standards

In this project, BIM models were applied to three major ramp bridges. The structures covered are as follows:

- Ramp 1: Five-span steel bridge
- Ramp 2: Three-span curved bridge
- Ramp 3: Thirteen-span viaduct consisting of three units of curved steel-plate girders

The total length of the bridges is approximately 4,200 feet. Because of curved alignments, super-elevation, and continuous-girder configurations, traditional 2D drawings posed challenges for clash detection and construction planning. Accordingly, Iowa DOT designated the project as a “BIM Design Pilot,” producing models using Bentley products (OpenBridge Modeler, ProStructures, and Navigator CONNECT) to evaluate benefits and challenges from the perspectives of design, fabrication, and construction support.



Source: U.S. Department of Transportation Case Study (August 2020)

Figure 8-43 Overview of the I-80/I-380 Systems Interchange Project

Table 8-35 BIM Models and Software Used

Model	Software Used
Basic bridge superstructure elements, foundations and piles	OpenBridge Modeler™
Reinforcement, inspection walkways, detailed connections, miscellaneous detailing	ProStructures™
Miscellaneous solids modelling and creation of element properties through “Item Types”	MicroStation CONNECT™
Property list filtering for final deliverable	i-Model Transformer™
CDE	ProjectWise™

Source: Prepared by the JICA Study Team based on the U.S. DOT Case Study (August 2020)

The BIM model was designed to enable contractors to verify details during the construction phase. The level of detail (LOD) was set according to the Iowa DOT's design phase classifications (Preliminary/Intermediate/Final), with major structural components generally represented at a precision equivalent to LOD 300. Design, construction, and fabrication elements were sequentially added, and the model was ultimately integrated into a federated model, which was used for clash detection, design review, and quality control.

A hybrid approach was adopted for contractual deliverables. For Ramp 2, the BIM model was formally included as a reference deliverable during the bidding stage. For the remaining ramps, BIM models were used primarily to provide supplementary information alongside traditional 2D drawings. To encourage model use from the bidding stage, a viewing-only tool (Bentley View) was distributed free of charge, enabling contractors to access the models.

8.2.9.4 ISO 19650-Related Initiatives

No references or statements of compliance with the ISO 19650 series were identified in this project. However, this project is positioned as a BIM design pilot by the Iowa DOT, utilizing BIM models throughout both the design and construction phases. It centers on CDE operations using Bentley products (OpenBridge Modeler, ProStructures, and Navigator CONNECT) as the core of CDE operations, model utilization throughout the design and construction phases, and the introduction of model-centric information collaboration methods, such as the “model-as-legal-document” trial on Ramp B. These approaches align with the principles and direction outlined in ISO 19650, particularly in promoting information management based on the CDE and model-based reviews.

Nonetheless, there is no evidence that Iowa DOT formally adopted the ISO 19650 information-management framework, including documented information requirements, binding BEPs as contractual instruments, or task allocation through Master Information Delivery Plan (MIDP) and Task Information Delivery Plan (TIDP).

8.2.9.5 Common Data Environment

As part of Iowa DOT’s BIM Pilot, CDE was established using Bentley ProjectWise as the central platform. A notable feature of the project’s CDE was its focus not on “how detailed the model was,” but rather on “how the created data was shared, reviewed, and responsibly updated.”

Design models, drawings, and related documents were stored and managed within ProjectWise, which served as a platform for model viewing, reviews, and approval workflows. Through ProjectWise, bridge and ramp models generated in different authoring tools (such as OpenBridge Modeler and ProStructures) were consolidated to support federated reviews. These reviews were used for clash detection, design checks, and consultation during bidding and construction.

Data sharing extended beyond the design phase, with efforts made to encourage model use during both bidding and construction. For the bidding stage, Bentley View was distributed free of charge to provide stakeholders with viewing access, enabling them to reference the model during bid preparation and construction planning. In addition, for specific components, a trial was conducted to treat the model as a contractual deliverable (“model-as-legal-document”).

8.2.9.6 Information Classification Systems (e.g., Uniclass)

No use of international classification systems, such as Uniclass or OmniClass, was identified. Attribute management was performed using Bentley’s “Item Types” functionality; however, the standardization of classification codes fell outside the scope of the project.

8.2.9.7 Data Exchange Formats (e.g., IFC, COBie)

No evidence was found indicating the formal adoption of COBie or IFC in this project. Some BIM models created in various software packages to support design and construction, were repackaged into the view-only i-model format to prevent content modification during distribution. These models were provided as part of the final bid package. This distribution format allowed parties (primarily bidders) to reference the model, while restricting the addition or modification of element information within it. Subsequently, after contract award, BIM models in their native format (.dgn) were handed over to the contractor.

Although some documents mentioned consideration of future data utilization using IFC format, no specific implementation or operational examples were confirmed in publicly available materials for this project.

8.2.9.8 Asset Management Policies and Specific Initiatives

No explicit asset-management policies or systematic initiatives were identified in the project. Because the project served as a BIM pilot focused on design and construction, no information was published regarding the operation or maintenance phases.

8.2.9.9 Contractual Framework

Based on publicly available documents, the following division of responsibilities was identified:

- Client: Iowa Department of Transportation (Iowa DOT) oversaw the entire project and managed design and construction contracts.
- Design and Engineering: HDR served as the lead designer, managing design activities and providing technical support for the BIM Pilot.
- Construction Engineering and Inspection (CEI): HR Green performed construction inspection services and supported digital inspection workflows using BIM models.
- Other Discipline Consultants: Braun Interotec (geotechnical investigations), Snyder (trail design), HDR (roadway lighting and ITS), and others contributed across specialized areas.

The contractual delivery method (e.g., Design–Bid–Build, Design–Build) could not be confirmed.

8.2.9.10 Education and Training for Project Stakeholders, Including Those in the Supply Chain

To ensure effective BIM implementation, the Iowa DOT provided phased training to design and construction stakeholders. Technical training focused on the operation of Bentley products (OpenBridge Modeler, ProStructures, and ProjectWise), model-review procedures, and clash-detection workflows.

Key characteristics of the training included:

- Target participants: Iowa DOT staff, design consultants (HDR), CEI personnel (HR Green and others), and prime/subcontractors
- Format: A combination of online briefings and face-to-face workshops using sample models to practice review operations. Emphasis was placed on standardizing information-sharing protocols through ProjectWise. Toward the end of the training program, sessions simulated model use during bidding and construction to promote understanding of procedures for referencing the model alongside contractual drawings.
- Content:
 - Practical procedures for using 3D models in design and review
 - Guidance on ensuring consistency between BIM models and drawings
 - Methods for transferring information for use in construction
 - Techniques for referencing BIM during construction management and inspection

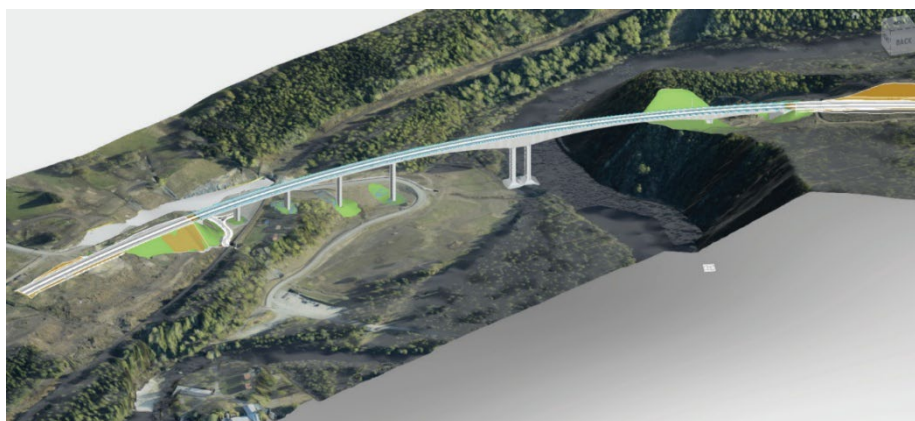
According to the Iowa DOT, the training improved stakeholder's consistency in model interpretation, reduced response times during design reviews, and enhanced construction planning using the model. It also helped identify practical issues associated with integrating BIM data into contractual workflows, contributing to lessons learned for subsequent projects.

8.2.10 Randselva Bridge (Norway)

8.2.10.1 Project Overview

The Randselva Bridge is a seven-span continuous concrete box-girder bridge located near Hønefoss, Norway, crossing the Randselva River as part of the E16 motorway. The bridge has a total length of approximately 634 m, with a maximum height of about 55 m and a main span of roughly 200 m. The construction employed the balanced-cantilever method and a movable scaffolding system. The project is recognized as one of the world's largest bridge projects to adopt a drawing-free approach, in which BIM models served as the official documentation throughout both the design and construction phases, without reliance on traditional 2D drawings.

The client was the Norwegian Public Roads Administration (Statens Vegvesen). The design model was created in Tekla Structures by Sweco teams in Norway, Denmark, Finland, and Poland, using Tekla Model Sharing to enable simultaneous multi-site modeling. Structural design was carried out by Armando Rito Engenharia of Portugal, while construction was executed by PNC Norge of the PORR Group. This resulted in a highly coordinated international modeling and construction-management framework.



Source: Randselva Bridge and Drawingless Projects – Planning and Building Bridges Solely Based on BIM Models (March 2022)

Figure 8-44 Overall BIM Model of the Randselva Bridge

8.2.10.2 Description of Information Sources

The principal information sources are listed in Table 8-36.

Table 8-36 Sources of Information

Organization	Category	Document	URL
Portuguese Journal of Structural Engineering	Technical document	Randselva Bridge and Drawingless Projects – Planning and Building Bridges Solely Based on BIM Models	http://rpee.lnec.pt/Ficheiros/rpee_serieIII_n18/rpee_sIII_n18_pg115_122.pdf
e-mosty	International bridge engineering journal	e-mosty – September 2021 Issue BrIM Caissons for Bridge Construction	https://e-mosty.cz/wp-content/uploads/e-mosty-Sept21.pdf
Sweco	Corporate website / project overview	Randselva Bridge	https://www.sweco.dk/en/showroom/randselva-bridge/
Tekla	Corporate website / project overview	Tekla BIM Awards – Randselva Bridge	https://www.tekla.com/bim-awards/randselva-bridge
PNC Norge AS	Corporate website / project overview	Randselva Bridge	https://pnc-norge.no/en/projects/randselva-bridge/

Source: The JICA Study Team

8.2.10.3 Applicable BIM Standards

The project adopted a model-based approach in which BIM models, rather than drawings, served as the single source of truth for all design and construction information. Tekla Structures was used as the core modeling platform, supported by Trimble Connect, SiteVision, and other tools for model sharing, clash detection, and construction planning. The model contained approximately 200,000 reinforcing bars, 250 post-tensioning tendons, and more than 200 defined concrete-pour phases, with around 50 attribute fields assigned to each object.

The project identified the following objectives for adopting BIM models in design:

- Improving workers' understanding of tasks.
- Reducing costs associated with clash detection and resolution through 3D modeling.
- Enabling rapid and efficient design changes and repetitive tasks through parametric design.
- Improving productivity through a unified format that supports collaboration among multinational teams.
- Eliminating tasks by utilizing attribute-based procurement management.
- Preparing for future AI-assisted design through comprehensive BIM data structuring.

Table 8-37 summarizes the roles of participating organizations. BIM models were created using Tekla Structures and synchronized across multiple locations through Tekla Model Sharing and the cloud-based CDE (Trimble Connect). Detailed geometry, reinforcement layouts, and pour-phase information could be extracted from the models, which were exported in IFC and other exchange formats as required. During construction, the latest model was provided to the site via the cloud, enabling field crews to view the model on tablets (See 8.2.10.5).

Table 8-37 Roles of Participating Organizations

Organization	Main Tasks
Sweco Oslo	BIM model coordination and quality control
Sweco Copenhagen	Parametric design, reinforcement
Sweco Tampere	Parametric design, formwork and post-tensioning
Sweco Katowice	Tekla reinforcement
Armando Rito	Calculations (IFC export files from Tekla)
Multiconsult	Third-party control (IFC export files from Tekla)
Vegdirektoratet	Norwegian road authorities (IFC export files from Tekla)
Statens vegvesen	Project owner (IFC export files from Tekla)
PNC Norge	Contractor (IFC export files from Tekla)

Source: [Sweco, Randselva Bridge | BuildingPoint Scandinavia](#)

The BIM model included User Defined Attributes (UDA), which stored information such as construction phases and LOD, enabling data-driven management directly within the model. The contractor, PNC, utilized UDAs to efficiently prepare construction and procurement plans (See Section 8.2.10.6).

8.2.10.4 ISO 19650-Related Initiatives

No descriptions were identified indicating that the project referenced or complied with the ISO 19650 series.

The project's operational approach—namely, the drawing-free method in which the BIM model served as the sole design and construction document, IFC-based information sharing (covering approximately 95% of all information), distributed modeling across multinational locations, cloud-based CDE data sharing, and direct model use on site—can be regarded as highly consistent with the information-management principles embodied in the ISO 19650 series. However, no publicly available information confirmed the formal application of the ISO 19650 information-management framework, such as explicitly documented

information requirements, contractually binding BEPs, or MIDP/TIDP-based task allocation.

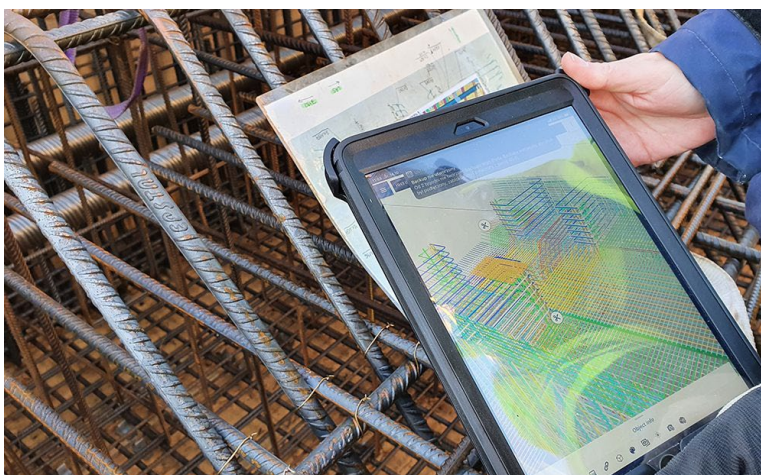
8.2.10.5 Common Data Environment

The project implemented a cloud-based CDE centered on Trimble Connect, enabling model-based information management throughout both the design and construction phases, without reliance on traditional drawings. BIM models were created in Tekla Structures, and through Tekla Model Sharing, engineers across multiple countries and locations could collaborate concurrently on the same model. The workflow allowed local editing with cloud uploads of only modified elements, preventing conflicts while supporting a distributed work environment.

Within Trimble Connect, structural models, reinforcement models, temporary works, and construction-sequence information were managed at the model-file level. Stakeholders could selectively combine or hide models to generate task-specific views. IFC-based model federation facilitated integrated viewing of structural, reinforcement, prestress, and construction-sequence data in a single environment, allowing clash reviews and sequence verification directly within the model.

Issue-tracking was extensively utilized within the CDE. Comments and issues between designers and contractors were pinned to corresponding 3D locations within the model, complete with deadlines, assigned responsible persons, status indicators, and links to related IFC components. Revision histories were automatically recorded, clarifying responsibility for issue resolution.

During construction, the latest model was continuously maintained in the cloud and made available to site personnel, replacing traditional PDF drawings. Field crews accessed Trimble Connect via tablets to check reinforcement diameters and quantities, bending details, formwork dimensions, and pour phases through object attributes. Construction managers used UDA-based construction-phase attributes to generate bar-bending lists directly from the model, enabling procurement, planning, and material management to be fully integrated within the 3D model environment.



Source: [Randselva Bridge - Armando Rito Engenharia](#)

Figure 8-45 Example of On-Site Model Viewing Using Tablets

8.2.10.6 Information Classification Systems (e.g., Uniclass)

This project did not adopt international classification systems such as Uniclass or OmniClass; instead, attribute management was conducted using User Defined Attributes (UDA) within Tekla Structures.

The UDA framework in Tekla Structures allows project-specific information to be assigned directly to model elements in addition to standard attributes. In this project, it was actively used to centralize information required for construction planning, procurement, and schedule management within the model. A key characteristic of this approach was the ability to visualize construction sequences directly within the model (See Figure 8-46), enabling integrated management of schedules and model data.

Reinforcement attributes—including bar diameter, length, bending details, and quantities—were stored as

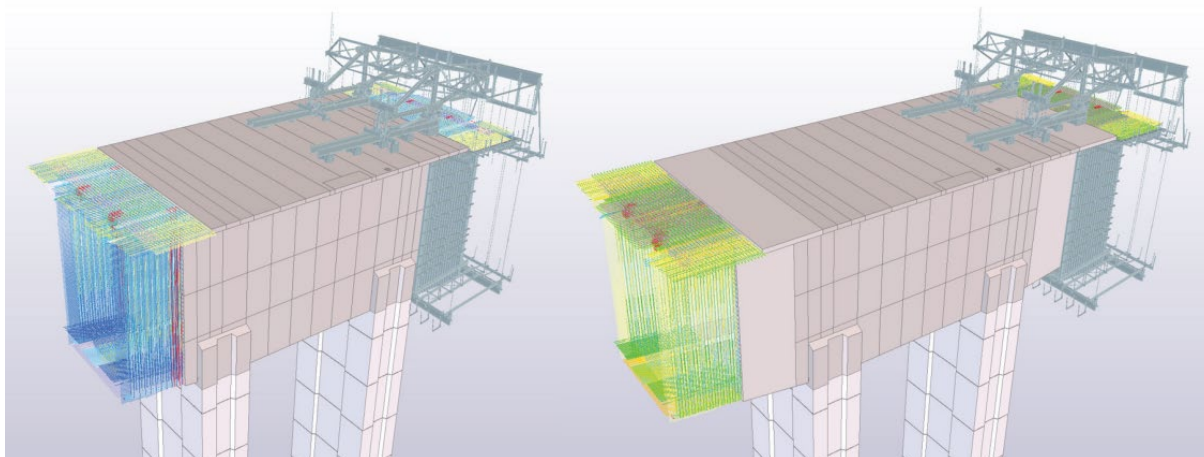
UDA data and used to automatically generate bar-bending lists from the model, supporting procurement and fabrication instructions. Formwork dimensions and member sizing information were also embedded within the model and used for on-site measurement checks and material ordering. Furthermore, procurement status and delivery dates were managed as UDA values and reviewed by construction managers within Trimble Connect, enabling integration between material management and model information.

UDA-assigned attributes were exported via IFC, making them searchable and filterable in Trimble Connect. As a result, even without formal classification systems, centralized information management and efficient construction coordination were achieved through the use of model attributes.

Table 8-38 Examples of UDAs Used in the Randselva Bridge Project

UDA-name	Info example	Name of object
01 Object name	Foundation	More thorough description of object if needed
02 Description	Crane foundation	Object code (In Norway: vegvesen.no)
03 Object code	C2	Main process (In Norway: handbook R762)
04 Process	84410000	Level of detailing
05 LOD	350	Object status
06 Status	3rd party control	Object revision
07 Revision	01	Date of revision
08 Revisions date	2019.05.14	If clashing, what object should be prioritized
09 Placement priority	1	Material quality
10 Material	C45	Dimension (only if not clearly given by the object)
11 Dimension	Tube Ø120	Construction sequence / pour phase of object
12 Con. sequence	3C01-01	Drawing name and number
13 Free attribut_01	K01-005 -	Link to drawing (required by NPRA)
14 Free attribut_02	https://a360.co/DSFJDF	...
...	...	Name of object

Source: [Randselva Bridge and Drawingless Projects – Planning and Building Bridges Solely Based on BIM Models](#)



Source: [Randselva Bridge and Drawingless Projects – Planning and Building Bridges Solely Based on BIM Models](#)

Figure 8-46 UDA-Based Visualization of Construction Sequences (Segment 01 and Segment 02 Phases)

8.2.10.7 Data Exchange Formats (e.g., IFC, COBie)

IFC was adopted as the primary data-exchange format for this project and was used consistently throughout the project.

Models created in Tekla Structures were exported in IFC format and centrally managed within Trimble Connect. This enabled structural models, reinforcement models, prestressing components, and construction-phase data from different sources to be viewed within a single federated environment, allowing clash detection and construction-sequence verification to be completed entirely within the model.

Approximately 95% of shared project information was provided in IFC format. Model objects retained their attributes—such as reinforcement diameter, lengths, bending details, and pour-phase information—when exported to IFC. The model included roughly 200,000 reinforcement bars, and these data were directly used for construction management and procurement through the IFC-based workflow.

8.2.10.8 Asset Management Policies and Specific Initiatives

The project primarily focused on the drawing-free approach and use of BIM models during the design and construction phases. No explicit policies or systematic initiatives related to O&M phase were identified. Likewise, no examples were found that indicate direct use of the model during O&M or integration with asset-management systems.

8.2.10.9 Contractual Framework

The client for the project was the Norwegian Public Roads Administration (Statens vegvesen). Design work was undertaken collaboratively by Sweco teams in Norway, Denmark, Finland, and Poland, together with Armando Rito Engenharia of Portugal. Construction was carried out by PNC Norge, part of the PORR Group.

The project was delivered under a Design-and-Build (D&B) contractual method, with a notable feature being the use of BIM models as the sole official source of information instead of traditional drawings. Although publicly available information did not confirm the adoption of a specific standard form of contract such as NEC or FIDIC, Norway's public infrastructure projects commonly utilize NS 8407, the standard conditions for design-and-build contracts, and it is therefore likely that this standard applied to the project. However, details regarding contractual clauses, BIM deliverable requirements, and the allocation of responsibilities specific to BIM were not confirmed in publicly available materials.

8.2.10.10 Education and Training for Project Stakeholders, Including those in the Supply Chain

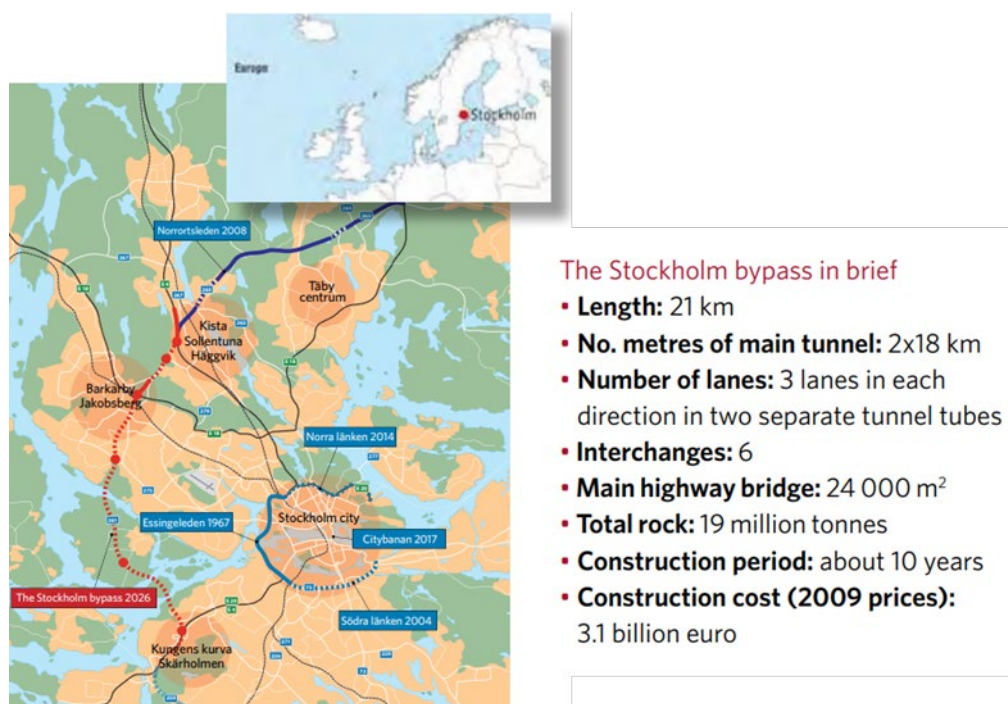
No materials were identified that explicitly documented “training programs” or “education sessions” for stakeholders, including the supply chain, in relation to this project.

8.2.11 E4 The Stockholm Bypass Project (Sweden)

8.2.11.1 Project Overview

The E4 Stockholm Bypass Project is a major motorway development located on the western side of Stockholm, Sweden. The route extends approximately 21 km, of which about 18 km consists of underground tunnels, making it one of the longest urban-adjacent road-tunnel projects in the world. The alignment passes beneath Lake Mälaren, reaching depths of approximately 70–100 m below ground level. The project includes six interchanges and three lanes in each direction along the main section, with anticipated traffic volumes of around 140,000 vehicles per day upon opening.

The initial estimated project cost of the project was approximately SEK 41.7 billion (2021 prices). The Swedish Transport Administration (Trafikverket) is the client for the project, which is being delivered through a large-scale design and construction framework involving a joint venture comprising multidisciplinary and multinational team members responsible for the full design of tunnel and interchange sections. The project is scheduled to open to traffic in 2030.



Source: [procurement_fs_webb.pdf](#)

Figure 8-47 Overview of the I-80/I-380 Systems Interchange Project

8.2.11.2 Description of Information Sources

The main information sources are listed in Table 8-39.

Table 8-39 Sources of Information

Organization	Category	Document	URL
Swedish Transport Administration (Trafikverket)	Transport Administration website	Trafikverket	https://bransch.trafikverket.se/Procurements - E4 The Stockholm bypass Project - Bransch
BIM Alliance (buildingSMART Sweden)	Event summary	openBIM och IFC för väg och järnväg – leverantörsträff 2024	openBIM och IFC för väg och järnväg – leverantörsträff 2024 - BIM Alliance
	Case study / technical report	Förbifart Stockholm visar vägen mot BIM	forbifart stockholm visar vagen mot bim nytt.pdf
	Presentation	Förbifart Stockholm Digitala hjälpmedel i Förbifart Stockholms planering, projektering och byggande	Förbifart Stockholm Digitala hjälpmedel i Förbifart Stockholms planering, projektering och byggande
	Presentation	Trafikverket openBIM och IFC Leverantörsträff	Trafikverket openBIM och IFC Leverantörsträff
Bentley	Technical article	Bentley Technology Drives Joint Venture's Collaboration on E4 Stockholm Bypass	d4434e21f2c6a6d713dc20fc36f653492fd23c6f413a87369f830286c2db2efc.pdf
EU BIM Task Group	Handbook	A Case Study of Virtual Design and Construction and BIM in the Stockholm Bypass, Europe's Largest Road Tunnel Project	EU BIM Task Group Handbook FIN AL.PDF
International Tunnelling Association (ITA)	Technical paper	Trafikverket	A case study of Virtual Design and Construction and BIM in the Stockholm bypass, Europe's largest road tunnel project - ITA Bookshop

Source: The JICA Study Team

8.2.11.3 Applicable BIM Standards

In this project, BIM was adopted as a core tool from the early design stages. The design of major structures—including the mainline tunnels, interchanges, and roadway infrastructure—was undertaken by AECOM and ÅF Consult using a 3D model environment built on Bentley Systems' product suite. This enabled multidisciplinary coordination across geology, structural engineering, drainage, traffic, and ventilation within a single platform, facilitating clash detection, alignment and structural arrangement reviews, and constructability assessments.

The design of the Akalla/Häggvik Interchange was carried out by a joint venture between URS and ÅF Consult JV, in which both Bentley and Autodesk products were used. The integration of Digital Terrain Model (DTM) data, data exchange through LandXML, and interoperability with 2D/3D CAD tools contributed to improved efficiency in cross-disciplinary design involving terrain, structures, and roadway elements.

Examples of BIM products used by each JV are presented in Table 8-40.

Table 8-40 BIM Products Used by URS

Product	Main Tasks
AECOM – ÅF Consult JV (Design of 18 km Mainline Tunnel)	
Bentley Navigator	Viewing 3D models, integrated views, clash detection, design review
Bentley InRoads	Road and tunnel alignment/profile design, terrain data import
Bentley MicroStation	Creation of 2D/3D design models, editing of base drawings and geometric information
Bentley MXROAD	Civil-road design, DTM creation, alignment and cross-section modeling
Bentley ProjectWise	CDE management, document control, access management, version control, design-team collaboration
URS – ÅF Consult JV (Design of Akalla/Häggvik Interchange)	
Bentley MXROAD	Road and interchange design, terrain modeling, integrated alignment and cross-section design
Bentley PowerCivil	Earthworks and terrain model creation, road cross-section processing, earthwork calculations
Bentley InRoads Suite	DTM (Digital Terrain Model) creation/editing, alignment design, import of geological/soil data
Bentley MicroStation	2D/3D drawing creation, editing of design documentation and base geometries
Autodesk AutoCAD	Autodesk AutoCAD

Source: The JICA Study Team

8.2.11.4 ISO 19650-Related Initiatives

No descriptions were identified indicating that the project referenced or complied with the ISO 19650 series. The client, Trafikverket, has been promoting the industry-wide adoption of openBIM (IFC) and the principles of ISO 19650, and this project is positioned within that broader policy framework.

In November 2024, Trafikverket co-hosted an industry seminar, “openBIM and IFC för väg och järnväg (openBIM and IFC for road and rail)”, in collaboration with BIM Alliance, focusing on ISO 19650, IFC, and openBIM workflows and addressing topics such as improving design and construction quality and enhancing information-exchange efficiency. The Stockholm Bypass Project was included as one of the discussion cases in this session.

Within the project, Trafikverket’s initiative to establish contractual and operational structures through the “BIM Lab,” resulted in the assignment of BIM coordinators to manage model quality, attribute organization, and BIM-related contractual/operational arrangements.

Other practical measures consistent with ISO 19650 principles—such as specifications that treat 3D models as contractual deliverables, defined BIM-coordination procedures, and CDE operation—were also confirmed.

Additionally, the Stockholm Bypass Project is referenced in the European BIM Handbook as an example of a project that “requires 3D models as contractual deliverables,” with delivery of 3D models, including as-built information, incorporated into the contractual conditions.

8.2.11.5 Common Data Environment

The CDE for this project was established on the Bentley ProjectWise platform. Trafikverket, the client, designated ProjectWise as the standard environment for model and document management in large-scale, long-term projects, and all design data produced by the design joint ventures (AECOM–ÅF and URS–ÅF) were managed within ProjectWise.

Within ProjectWise, version control for design models, drawings, and documents, was implemented alongside access-rights management, and the sharing of review files, with reviews and distributions governed through controlled approval workflows. Data created in multiple native tools used during the design stage—including MicroStation, MXROAD, and InRoads—were stored in ProjectWise, where update histories and approval statuses were fully traceable.

Bentley Navigator was used for model reviews, enabling the integration and visualization of

multidisciplinary models stored in ProjectWise and supporting clash detection and design verification. Through this arrangement maintained consistency and transparency of design information within a collaborative environment comprising multiple companies and technical disciplines.

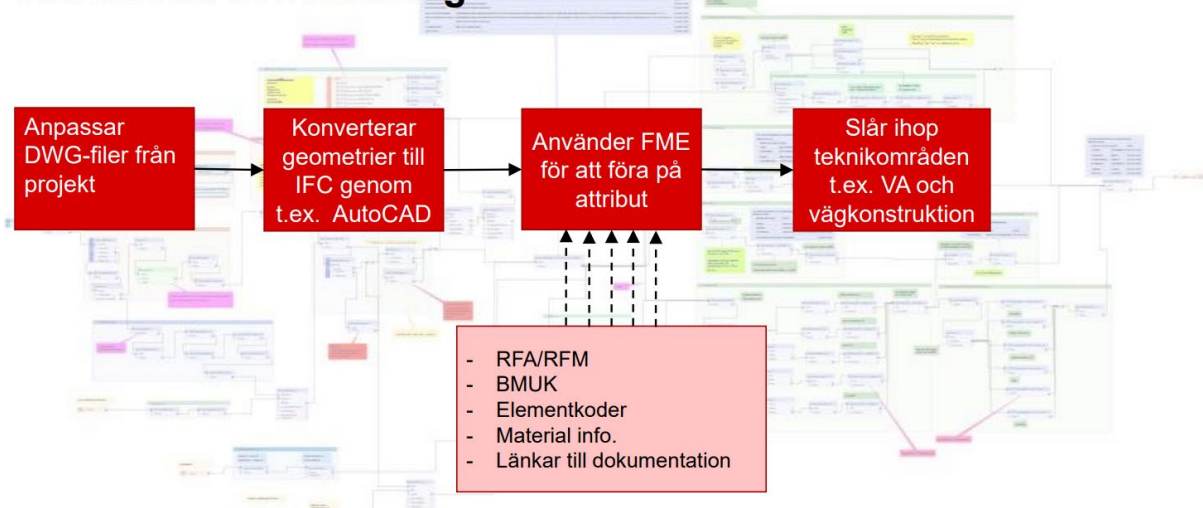
8.2.11.6 Information Classification Systems (e.g., Uniclass)

No descriptions were identified indicating the adoption of international classification systems such as Uniclass or CoClass. Classification and attribute management were conducted according to Trafikverket's model-specification framework (RFA/RFM) and project-specific coding systems.

Trafikverket's RFA (Redogörelse för Anläggningsmodell)⁷³ and RFM (Redogörelse för Modell)⁷⁴ served as the fundamental framework for defining the content and attribute of delivered models. Based on these documents, project deliverables were exported in IFC format (See 8.2.11.7).

Within the models, attributes were assigned using element-specific codes such as elementkoder, BMUK (byggnadsverksmodells uppbyggnadskod), and Material Info, which reflected project-specific or Trafikverket-internal coding systems. However, detailed specifications or complete structures of these coding systems were not publicly available, and their comprehensive logic could not be fully ascertained from accessible documentation.

Arbetsätt konvertering



Source: [Trafikverket openBIM och IFC Leverantörsträff](#)

Figure 8-48 Workflow for Converting Project Deliverables

8.2.11.7 Data Exchange Formats (e.g., IFC, COBie)

The project adopted IFC as the core format for information exchange and deliverables, supplemented by LandXML for the transfer of road-alignment and terrain data. Although multiple native CAD/BIM formats were used during the design process, final deliverables were standardized in IFC and LandXML. Attribute information was assigned in accordance with Trafikverket's RFA/RFM specifications and project-specific coding systems.

(1) Role of IFC and Version Trends

During the initial planning period (2009–2015), Trafikverket's model-delivery specifications (RFA/RFM) designated IFC2x3 as the standard exchange format.

In the 2020s, Trafikverket began introducing IFC4 and IFC4.3 within selected workflows as part of its

⁷³ Specify the content, structure, and source data format of the infrastructure model. This serves as supplementary documentation indicating the model's usage conditions and required element enablement (object enabler).

⁷⁴ Specify whether the delivered model conforms to the requirements specification or, if deviations exist, detail their nature.

openBIM initiative; however, no documentation indicated full project-wide implementation of IFC4.3.

IFC was used for:

- Creating integrated views of discipline models (geology, earthworks, structures, MEP, etc.)
- Model exchange between JVs
- Reference during inspection and review
- Final deliverables, including as-built models

IFC files contained attributes based on project-specific code systems (elementkoder, BMUK, material info), supporting the centralized structuring of model information.

(2) LandXML

LandXML was used as the required exchange format for road-design data.

In workflows based on Bentley MXROAD, InRoads, and PowerCivil, LandXML supported:

- Exchange of horizontal and vertical alignment data
- Import and export of DTM (Digital Terrain Model) data
- Integration of data for earthwork calculations and terrain analysis
- Sharing of terrain information for construction planning

Unlike IFC, LandXML had matured as a dedicated format for road design, establishing a clear division of roles: LandXML for exchanging linear and terrain models, and IFC for exchanging structural and element models.

(3) Native CAD/BIM Formats

Design JVs used multiple native tools, which served as intermediate deliverables. Final submissions were standardized in IFC or LandXML. Key tools and their roles are summarized in Table 8-41.

Table 8-41 Native Formats Used in the E4 Stockholm Bypass Project (Extract)

Product	Primary File Format	Main Roles
Bentley MicroStation	DGN	Core platform for 3D/2D base design, structural/tunnel modeling, drawing generation, and model integration
Bentley MXROAD	MX/LandXML	Road-alignment design, terrain and cross-section modeling, earthwork calculations, LandXML-based data exchange
Bentley InRoads	DGN/LandXML	Detailed road-design profiles, terrain analysis, integration with MXROAD
Bentley PowerCivil	DGN	Design of road auxiliary structures, terrain-model processing, earthwork modeling
Autodesk AutoCAD	DWG	2D drawings and reference to existing drawings

Source: The JICA Study Team

8.2.11.8 Asset Management Policies and Specific Initiatives

The project is currently in the construction phase. No publicly available information was identified regarding asset-management policies or specific initiatives, and no documents were found indicating the use of BIM models for asset maintenance or performance evaluation, or integration with an asset-management system.

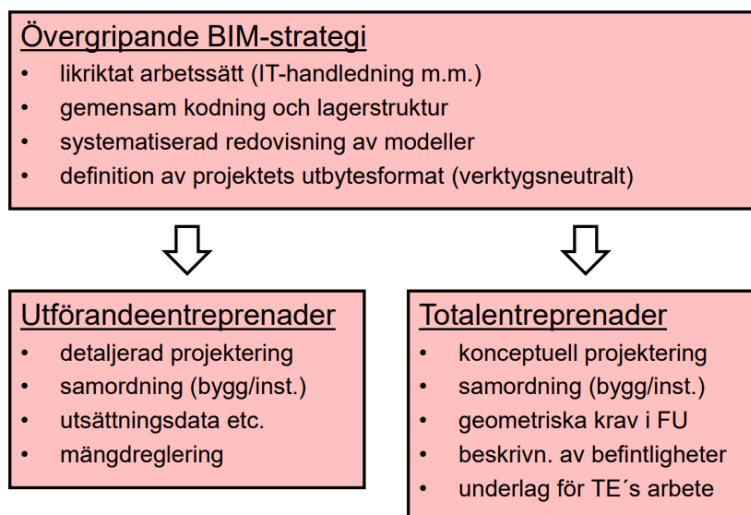
8.2.11.9 Contractual Framework

The contractual framework for the project is based on Trafikverket's comprehensive BIM strategy, which defines standardized model-delivery requirements and work procedures. The strategy is intended to standardize information management across the entire project and includes unified work methods, common coding and layer structures, prescribed model-reporting formats, and a tool-agnostic operational framework.

Contract types for the project are broadly classified into execution contracts (*Utförandeentreprenader*) and design-build contracts (*Totalentreprenader*).

Under execution contracts, requirements include detailed design, coordination of construction and installations, survey data, and quantity management.

In contrast, design-build contracts encompass conceptual design, coordination of construction and installations, geometric requirements specified in the bid documentation, descriptions of existing conditions, and base information required for the contractor's work.



Source: [Förbifart Stockholm Digitala hjälpmedel i Förbifart Stockholms planering, projektering och byggande](#)

Figure 8-49 Reflection of the BIM Strategy in Bid Specifications and Contract Forms

Publicly available documents do not confirm that the BIM model was stipulated as the sole official source of information, nor that delivery of 3D models was explicitly mandated as a contractual requirement. However, the project is cited in the European BIM Handbook as an example where “3D models are required as contractual deliverables,” indicating that the delivery of 3D models, including as-built models, was incorporated into the contract conditions.

8.2.11.10 Education and Training for Project Stakeholders, Including Those in the Supply Chain

No publicly available information was found describing specific policies or initiatives related to training or capacity building for stakeholders, including those within the supply chain. Further details may become available in the future as additional documentation is released or as the project transitions into its operational phase.

9 TECHNICAL ELEMENTS FOR ISO 19650 IMPLEMENTATION AND GUIDELINE RECOMMENDATIONS

This chapter proposes an application policy for Official Development Assistance (ODA) loan projects, based on the technical elements required for the implementation of ISO 19650 as summarized in Chapter 4, and the implementation practices observed in representative international projects as reviewed in Chapter 8.

These technologies are intended to ensure continuity of information management and to maximize asset value across the entire lifecycle of projects.

Furthermore, integrating these technical elements into the project-management framework enhances the effectiveness of contract management, progress control, and risk management. By referencing real project cases, this chapter clarifies which technologies should be applied in each project phase and provides strategic guidance for achieving information management that are aligned with international standards.

However, not all technologies currently have fully established methodologies. Certain tools and approaches are still undergoing refinement through practical application in individual projects. For this reason, the proposed recommendations are designed to allow flexible adaptation and iterative improvement.

9.1 Application and Recommendations for Construction Information Classification Systems (ISO 12006-2/Uniclass, etc.)

9.1.1 Considerations Based on Domestic and International Case Studies

It is essential to standardize construction information classification systems for the improvement of information management efficiency and ensuring international interoperability.

A structured classification system compliant with ISO 12006-2 functions as a common language across all project phases—design, construction, operation, and maintenance—and serves as a core information infrastructure alongside exchange formats such as Industry Foundation Classes (IFC).

At present, Uniclass 2015 is considered to be the most practical option for real-world implementation. However, project characteristics and national or regional requirements may sometimes necessitate the simultaneous use of local or complementary code systems.

Moreover, beyond new-build projects, some asset-management organizations are now strengthening lifecycle information by linking existing asset registers with Uniclass 2015—as seen in cases (3) and (4).

The major international project examples analyzed in Chapter 8 are summarized below.

(1) Rail Baltica (Baltic States)

Rail Baltica adopts Uniclass 2015 as the classification system for contract specifications, BIM models, and quantity take-off documentation. Interoperability across multiple countries is ensured by linking Uniclass codes to IFC and COBie attributes. To ensure strict alignment with the asset register, a system-code-based operational approach has been implemented.

(2) High Speed 2 (United Kingdom)

High Speed 2 (HS2) uses Uniclass 2015 as its base classification but uses bespoke asset codes to accommodate railway-specific asset categories that exceed the standard Uniclass coverage. By mapping bespoke codes to Uniclass, HS2 ensures both consistency with international standards and fulfilment of project-specific requirements.

(3) KiwiRail (New Zealand)

KiwiRail uses Uniclass 2015 as the foundation of its Digital Engineering strategy. To enable improved searchability in the CDE and integration with IFC models, traditional asset-register codes are supplemented with Uniclass codes. Through integration with maintenance-management systems, information from design, construction, operation, and maintenance is centrally managed, supporting full asset-lifecycle optimization.

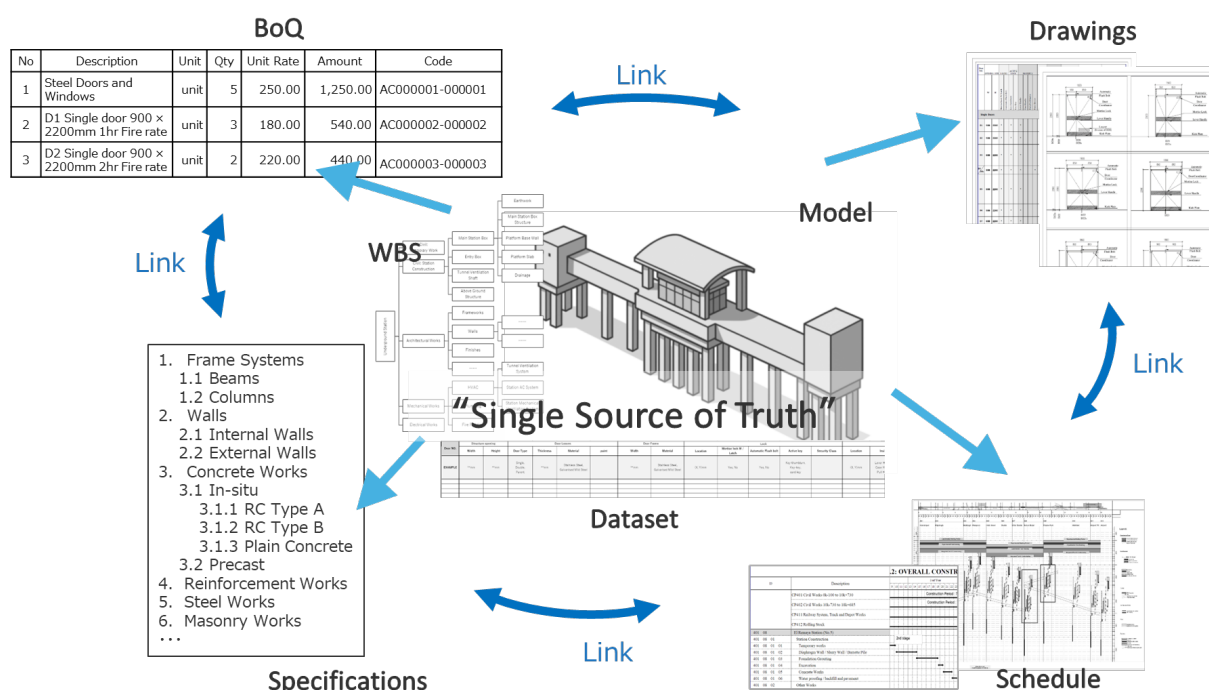
(4) Australian Road Projects (Austroads)^{1,2}

As part of the road-authority asset-data standardization project, Austroads has developed the Road Asset Data Standard to integrate existing inventory data with Uniclass 2015 and IFC. But since legacy specification systems such as NATSPEC and AUS-SPEC were not ISO-aligned and contributed to siloed information, the introduction of Uniclass has accelerated the integration of lifecycle-wide information.

By adopting these classification systems, information generated across all phases—such as quantity take-off sheets, specifications, drawings, schedules, BIM models, and asset registers—can be centrally managed and linked via common classification codes.

Figure 9-1 illustrates the concept of a Single Source of Truth built on a construction information classification system. By linking all artefacts through a unified classification code, the consistency, traceability, and reusability of information are dramatically improved.

This framework also contributes to clearer responsibility allocation, progress management, and quality assurance from a project-management perspective, and is therefore expected to be highly beneficial for ODA loan projects.



Source: The JICA Study Team

Figure 9-1 Conceptual Model of Information Integration Using a Construction Information Classification System

As noted in Chapter 4, several initiatives are underway in Japan, including mapping studies between Uniclass and domestic cost-estimation systems conducted by the Japan Association of Quantity Surveyors, as well as studies on linking Uniclass with FM systems.

These developments indicate that Uniclass 2015 is already widely tested and used in Japan, making it an extremely appropriate option for application in ODA loan projects as well.

¹ Technical Report AP-T333-18: Asset Data Harmonization Stage III BIM IFC Alignment Review, Austroads, 2018

² Research Report AP-R673-22: Austroads Road Asset Data Standard Ver.4, Austroads, 2022

9.1.2 Recommendations and Considerations

(1) Recommendation: Adoption of Uniclass 2015

It is essential to ensure alignment with international standards while considering integration with existing asset-management processes and operational systems when applying a construction information classification system in ODA loan projects. It is therefore recommended that Uniclass 2015 be adopted as the primary construction information classification system.

Uniclass 2015 complies with ISO 12006-2 and functions as a common language across all project phases—design, construction, operation, and maintenance—which ensures information consistency and international interoperability. Its information structure is designed to work seamlessly with IFC, COBie, and other exchange formats, which offers significant advantages regarding searchability within the CDE and integration with asset-management systems.

In practical terms, the policy for applying Uniclass 2015 should be explicitly stated in document—such as the EIR, BIM Execution Plan (BEP), and deliverable templates—and Uniclass codes should be mandated for BIM models and quantity take-off documents.

This enables clear quality assurance, role allocation, and progress management from a project-management perspective.

(2) Considerations

As noted in Chapter 4, all Uniclass 2015 tables follow a uniform four-level hierarchical structure.

This structure ensures alignment among tables and avoids excessive specification of materials or product information during planning and design.

Therefore, Uniclass codes do not necessarily map one-to-one to the level of detail required for cost estimation, tender documentation, or asset-register coding.

The United Kingdom addresses these differences in detail through mapping approaches, and ODA loan projects will require similar measures.

For example:

- Rail Baltica supplements Uniclass 2015 codes with additional identifiers such as “Type” to achieve finer classification and strict mapping the asset register.
- Although Uniclass 2015 is updated quarterly, it does not yet fully cover all civil and infrastructure asset types. Since existing Uniclass codes cannot fully represent required classifications, a practical solution is to define project-specific codes based on the closest available Uniclass categories.

Balancing the use of standard classification systems with flexible adaptation for project-specific requirements is critical to ensure both compliance with international standards and effective real-world implementation.

9.2 Application and Recommendations for Data Exchange Formats (IFC/COBie)

For infrastructure projects under ODA loan schemes involving multiple countries and long-term operational horizons, the adoption of internationally standardized data-exchange formats is essential to ensure interoperability and future scalability of project information.

As established by the international project cases reviewed in Chapter 8, IFC and COBie are widely adopted as standard formats for information exchange in global infrastructure projects.

However, due to requirements that are specific to linear infrastructure, the usage of IFC alone is often insufficient for full representation of certain information structures.

As a result, to compensate for its limitations, it has become a common practice to use IFC in combination with LandXML or project-specific schemas.

9.2.1 Considerations Based on Domestic and International Case Studies

(1) Rail Baltica (Baltic States)

Current practice adopts a hybrid approach where:

- LandXML is used for terrain and geometric alignment data; and
- IFC is used to manage structures and equipment information.

Quantity take-off documents and asset classification follow Uniclass 2015, complemented by the project's own Element Breakdown Structure (EBS).

These codes are stored in IFC Property Sets, enabling strict linkage with the asset register.

Moreover, for a standardized handover process, COBie is used for transferring asset and equipment information into the asset-management system.

The project is actively promoting the adoption of IFC 4.3 for a unified management of linear infrastructure and structures, and ultimately supporting the creation of a comprehensive digital twin.

(2) High Speed 2 (United Kingdom)

HS2 fully adopts Uniclass 2015, but due to the complexity of railway assets, the project supplements it with a bespoke Asset Data Classification System (ADCS).

Implementation follows this pattern:

- Uniclass codes are embedded in IFC as Classification References; and
- ADCS codes are stored in Property Sets.

HS2 is advancing the adoption of IFC 4.3 to ensure long-term data interoperability throughout this multi-decade project. While COBie is used as the standard deliverable format from handover to operations.

(3) Australian Road Projects (Austroads)

Austroads adopts a functional separation where:

- LandXML is used for road alignment and terrain; and
- IFC is used for structures and bridges.

For maintenance-data standardization, the usage of COBie is being extended to road-related assets (lighting, drainage, etc.).

In the Guide to Digital Engineering 2024³, the primary data-exchange format for infrastructure assets is IFC 4.3, and its implementation has begun across state agencies.

Across these examples, the adoption of IFC 4.3—which expands IFC coverage to civil and infrastructure domains—is progressing in major projects and asset-management initiatives. This demonstrates a broader shift toward IFC-based information exchange in the global infrastructure.

For ODA loan projects, IFC should form the primary data-exchange format. A practical combination is:

- IFC for structures and equipment models; and
- LandXML for linear-infrastructure geometry (railway track, road alignment, etc.)

IFC should follow buildingSMART's ISO-compliant schema (IFC 4.3) through phased adoption, and COBie should be used for handover of equipment and asset information to the operations phase.

These requirements should be explicitly stated in the EIR, the BEP, and relevant contract documents, while IFC models/COBie sheets must be incorporated into the deliverable schedule.

³ Guide to Digital Engineering 2024 Edition, Austroads

For integration with asset-management systems, IFC Property Sets should be mapped to the key fields of the asset register, and a hierarchical structure combining Uniclass codes and project-specific codes should be established.

9.2.2 Recommendations and Considerations

(1) Recommended Use of Data Exchange Formats (IFC/COBie, etc.)

It is recommended that the primary data-exchange format shall be Industry Foundation Classes (IFC). For standardizing structural and equipment models, IFC should be the default choice, with gradual adoption of the latest buildingSMART schema, which is compliant with ISO 16739 (IFC 4.3.) It is also essential that information management practices adhere to the ISO 19650 series.

From a project-management perspective, IFC models and COBie sheets must be incorporated into the deliverable schedule and explicitly defined in contract documents.

COBie should be used to standardize the handover of equipment and asset information to the operations and maintenance phase, supporting the structured preparation of attribute data for future FM and asset-management systems. Furthermore, its combined use with LandXML is important.

For infrastructure projects such as railways, roads, and airports, a hybrid approach is recommended such that terrain and alignment data are managed using LandXML while structures and equipment are standardized using IFC.

For integration with asset-management systems, it is effective to map IFC Property Sets to key fields in the asset register. Drawing on examples from Rail Baltica and HS2, a hierarchical structure combining:

- Uniclass 2015 for defining asset types; and
- Project-specific codes aligned with on-site asset-management practices,

should be considered to support consistent management of individual assets and their locations.

(2) Considerations

- Schema Extensibility:
Because IFC has historically been developed with a focus on building-sector use, the latest infrastructure-focused extensions (IFC 4.3 and beyond) is essential when applying IFC to linear infrastructure.
- Information Strategy from Early Design:
To ensure the effective use of COBie and project-specific codes, information requirements must be defined at the early design stage—particularly attribute definitions and identification rules.
- Alignment with International Standards:
Information must be managed in accordance with the ISO 19650 CDE framework, ensuring immutability and traceability of information throughout the lifecycle.

From the very beginning of the project, it is essential to clearly define construction classification systems and data-exchange formats and embedding them into the project's information requirements.

To support this structuring, a relevant framework—such as the BIM Object Standard—is available, as explained in the next section.

9.3 Application and Recommendations for a BIM Object Standard (BOS)

9.3.1 Considerations Based on Domestic and International Case Studies

To correctly implement construction information classification systems and data-exchange formats such as IFC and COBie, it is essential to clearly define geometric and attribute information at the outset of design and construction and to establish rules for their creation in advance.

The digital data representing the components of buildings or infrastructure—such as windows, doors, air-

conditioning units, lighting fixtures—are collectively known as BIM objects.

The BIM Object Standard (BOS) defines the rules governing their creation and representation.

By adopting BOS into a project and clearly specifying object-creation requirements, project teams can ensure the quality of BIM models and reliably implement ISO 19650-aligned workflows and the technical elements described in Chapter 4.

The main benefits of implementing BOS are as follows:

- **Alignment with International Standards:**
Because BOS is designed to interoperate with international standards—such as the ISO 19650 series, IFC, and COBie—it enables smooth BIM data exchange even when stakeholders, countries, or software platforms differ.
- **Improving Efficiency and Enabling Digital Transformation:**
Using BOS-compliant BIM objects greatly improves efficiency by reducing the need for re-entry and cross-checking of information across the design, construction, and maintenance stages. It also provides a foundation for digitalization and automation, including AI-assisted workflows and simulation-based analysis.
- **Integration with Level of Information Need (LOIN):**
By organizing attribute lists and classification tables within BOS and linking them with deliverable requirements—such as EIR and BEP—LOIN tables can be easily compiled. This supports smoother project progress and clarity regarding required deliverables at each stage.
- **Compatibility with Classification Systems, IFC, and COBie:**
As an example, the BOS standards developed by NBS (UK) and BLCJ (Japan) support mapping to classification systems (e.g., Uniclass), IFC classes, and COBie schemas. This enables efficient creation of BIM objects using the tools and methods described in Chapter 4 and contributes to greater project-wide productivity.

Representative BOS examples include the NBS BIM Object Standard⁴ (UK), which inspired the creation of Japan's own BIM Object Standard developed by the BIM Library Consortium Japan⁵ (BLCJ). The NBS BIM Object Standard comprises five sections, the overviews of which are presented below.

General Requirements:

Defines the foundational rules necessary to ensure that BIM objects can be interpreted consistently across different software platforms. This includes specifying: object type (generic/manufacturer-specific; component/layer), IFC type classification, and methods for structuring assemblies.
These requirements ensure that the object behaves consistently and predictably regardless of authoring or viewing software.

Information Requirements:

Establishes a unified data structure to ensure that BIM objects are easy to locate, compare, and use within the model, and that information can be exchanged seamlessly across all lifecycle stages without omission or redundancy. This section defines property assignment rules, rules for values and allowed formats, unit conventions, and the priority of information structures such as IFC and COBie.

Geometry Requirements:

Sets out the geometric requirements necessary to communicate essential information for design, construction, and facility management, while maintaining usability and avoiding excessive geometric detail that could degrade performance. This includes required levels of geometric detail, scale conventions, insertion points, parametric constraints, symbolic representations, and handling of space data.

Functional Requirements:

Specifies the behavioral aspects of BIM objects so that they mimic the real-world behavior of the physical product within the model, while avoiding overly complex parametric functions that could reduce model performance. This includes object behavior and constraints, connectivity and relationships, usability requirements, and scope of parametric capabilities.

⁴ NBS BIM Object Standard Guidance Version 2.2 July 2023

⁵ BLCJ BIM オブジェクト標準 Version 2.0

Metadata Requirements:

Defines naming rules and metadata structures to ensure that object names and metadata are unique and machine-readable, thereby enabling stable integration with external systems and databases, as well as efficient search, interoperability, and export processes. This covers file naming, object naming, attribute naming, material metadata, and image and ancillary-data conventions.

9.3.2 Recommendations and Considerations

When applying a BIM Object Standard (BOS) to a project, it is essential to defer the usage of standards “as-is”—such as NBS or BLCJ. Instead, the standard must be edited and localized to reflect the requirements of the specific country, region, appointing organization, and project. This is due to the varying representation of information required depending on factors such as: national and local regulations (e.g., building codes, fire-safety regulations); rules governing public procurement; materials, units, and conventions used in each region; the construction information classification system adopted (e.g., Uniclass 2015, local systems); cost-estimation systems (e.g., CI-NET in Japan, Uniclass/NRM/SfG20 in the UK); languages and terminology; and the needs and policies of the appointing organization (international agency, national government, private client, etc.) Based on these reasons, when applying BOS, the project team must analyze project requirements and client needs in detail, then customize BOS by clearly defining the following:

- Required information fields and attributes
- Classification and coding systems
- Deliverable formats
- Model-creation rules

Doing so ensures that the standard aligns with contractual requirements, project goals, and local practice.

Furthermore, BOS should be operated in conjunction with:

- LOIN definition tables
- Construction information classification systems
- COBie delivery matrices
- Supporting standards and documents referenced in Chapter 4

These documents should be compiled systematically into a BIM manual, which can be referenced in the EIR and BEP. This ensures common understanding and consistent implementation among project stakeholders. Through structured implementation, the benefits of BOS can be maximized and results to:

- Improved overall information quality
- Enhanced project-wide efficiency
- Strong alignment with international standards

and ultimately contributing to higher project performance and lifecycle value.

9.4 Application and Recommendations for Common Data Environments (CDE) during Design and Construction**9.4.1 Considerations Based on Domestic and International Case Studies**

Under the ISO 19650-based information management, the Common Data Environment (CDE) functions as the “single source of truth” for project information. Although a single CDE platform is commonly used in medium-scale projects, major international projects operating at ISO 19650 Stage 2 (BIM Stage 2), as analyzed in Chapter 8, increasingly adopt multi-CDE configurations. Instead of relying on one system, these projects combine multiple CDE platforms—each selected for its functional strengths—and has become the standard practice for large-scale programmes.

(1) Crossrail/HS2 (United Kingdom-Railway)

To manage large volumes of drawings and diverse workflows, Bentley ProjectWise is operated as the master CDE. At HS2, suppliers maintain their own internal CDEs for production, while metadata management linked to the Asset Data Classification System (ADCS) is strictly enforced. Information status (WIP/Shared/Published/Archive) is rigorously controlled within the system in accordance with ISO 19650.

(2) Rail Baltica (Baltic States)

Rail Baltica also adopts Bentley ProjectWise as the master CDE. Suppliers use Autodesk BIM 360 for internal work and submit validated data to the shared area of ProjectWise. ISO 19650-aligned status management is strictly operated, and metadata such as applicability codes and QC checklists are mandatory at submission. Rules for CDE operation and submission requirements are defined in the BIM Manual and EIR, making them contractually binding.

(3) E4 Stockholm Bypass (Sweden – Road)

ProjectWise is used for drawings and model management, while Trimble Connect is used for real-time sharing of survey data and construction progress. This case demonstrates separation of systems depending on requirements for robust design workflows versus field mobility.

(4) Airport Projects

For simultaneous 3D modelling and cloud-based design coordination (clash detection), platforms such as Autodesk BIM 360/ACC are often selected for their usability. ProjectWise is sometimes used in parallel for document and drawing management.

In selecting a CDE for ODA loan projects, it is important to consider not only global project practices but also local technical-support availability, project scale, and use-case flexibility. A realistic approach is to combine multiple CDEs based on functional characteristics, as shown below.

Table 9-1 Examples of CDE Categories Expected in ODA Loan Projects

Category	Typical Use Cases
3D model collaboration platforms	Collaborative modelling, clash detection, design coordination
Document and drawing management systems	Centralized management of large drawing/document sets, version control
Contract and correspondence management systems	Contract documentation, formal communication management

Source: The JICA Study Team

When selecting CDE solutions, additional factors for consideration are: Japanese and local-language support; local technical-support infrastructure; internet/communication environment; security requirements; compliance with international standards (e.g., ISO 19650)

These considerations are critical to ensure an effective system operation and successful information management throughout the project lifecycle.

9.4.2 Recommendations and Considerations

(1) Allowing and Defining Multi-CDE Operations

For large-scale projects implementing model uses equivalent to ISO 19650 Level 2, it is recommended to operate separate CDE environments: one for model-authoring work (working CDE) and another for official approval and archival (master CDE). However, the IDM (Information Delivery Manual), or equivalent documentation, must explicitly define which environment constitutes the final Single Source of Truth (SSoT).

From a project-management perspective, it is important to embed the CDE approval workflow into the Gantt chart and align information status (WIP/shared/published/archived) with progress-management processes.

(2) Consideration of Local Communication Environments

The CDE platform selection must account for constraints such as unstable or limited communication infrastructure in certain regions. Measures may include:

- Installing local cache servers at on-site or regional offices;
- Selecting CDE platforms designed for low-bandwidth environments; and
- Preparing offline-first workflows with later synchronization.

(3) System Implementation of ISO 19650 Information-Management Processes

The CDE must include functionality that enforces unique ID-based naming conventions for information containers (e.g., folders, files), and mandatory metadata such as status, revision, and classification codes.

These requirements must be agreed upon in the IDM and the EIR and must be enforceable by the system to ensure compliance and prevent uncontrolled naming or versioning practices.

9.5 Application and Recommendations for the Common Data Environment (CDE) in the Operations and Maintenance Phase

9.5.1 Considerations Based on Domestic and International Case Studies

As shown in the literature review in Chapter 4, CDEs used during the construction phase are primarily designed to support information creation and approval and are often not optimized for asset management and operations. In response to this limitation, several airport projects and long-term O&M initiatives have established operation-oriented CDEs through the integration of BIM, GIS, and maintenance-management systems (CMMS/EAM).

These examples offer useful reference models for designing CDEs that support post-construction and asset-management workflows.

(1) Schiphol Airport (Netherlands)

BIM models from contractors are automatically transformed using ETL tools and visualized in 3D on a GIS (Web-3D) platform, enabling management of approximately 80,000 assets. Mobile scanning is used to generate as-built models without halting airport operations, which reduces modelling costs by approximately 68%. Maximo is used for CMMS/EAM, while BIM–GIS integration through ETL tools such as Feature Manipulation Engine (FME) is becoming the standard approach for major European airport projects.

(2) Heathrow Airport (United Kingdom)

Based on a 25-year roadmap, Heathrow has created an integrated environment that links M-Files for document management, Maximo for asset management, GIS platforms, Autodesk Construction Cloud (ACC), and BIM viewers via API integration.

Field technicians access an “operations view” on mobile devices which enables the immediate retrieval of asset specifications, locations, maintenance history, and spatial constraints.

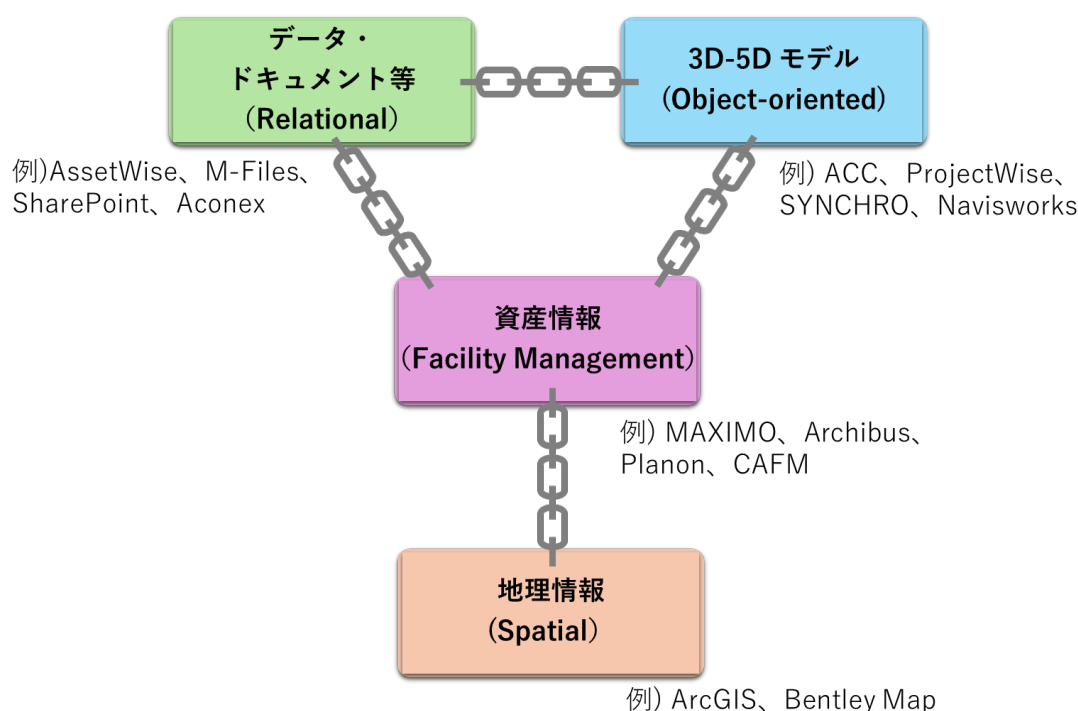
9.5.2 Recommendations and Considerations

In the operations phase, LOD400-level detail from construction is often unnecessary. Instead, it is crucial to restructure BIM model information into an Asset Information Model (AIM) that includes only the LOIN appropriate for asset management, which is then load into the CMMS/EAM.

Systems such as SCADA, BMS/BAS, and CMMS/CAFM have already been applied in past ODA loan projects. Given the need to integrate these systems, the purpose of data usage in the project should be clearly defined at the outset, and the CDE must be designed accordingly.

Moreover, experience across infrastructure projects shows that GIS plays a critical role as a spatial database. Integrating BIM, CMMS, and GIS to construct the CDE significantly enhances information utilization

during operation and maintenance.



Source: The JICA Study Team

Figure 9-2 Example Configuration of a CDE

9.6 Application and Recommendations for GIS

9.6.1 Considerations Based on Domestic and International Case Studies

As shown in the international project examples from Chapters 4 and 8, GIS plays a critical role as a spatial database for linear and area-based infrastructure such as roads, railways, and airports.

In recent years, there has been an increase in the adoption of CDE configurations that integrate GIS as a core component, enabling a secure linkage between BIM and geospatial information. However, as noted in Chapter 4, BIM–GIS integration and data-conversion technologies remain under development and challenges remain in its standardization and operational rule-setting.

At present, majority of implementations utilize Esri’s ArcGIS, which has expanded features supporting BIM integration (e.g., preserving IFC attributes, embedding 3D BIM models in GIS space). This setup still has differences in data structure between IFC and GIS, creating conversion overhead and inconsistencies in coordinate systems and attribute definitions. Therefore, alignment with ongoing standardization initiatives—such as ISO/TR 23262 and ISO/TS 19166—is essential.

(1) Schiphol Airport (Netherlands)

Schiphol is developing a large-scale digital twin integrating BIM and GIS. BIM-to-GIS conversion is performed using FME, and assets (approx. 80,000 items) are visualized via Web-3D GIS. Mobile scanning enables continuous as-built model updates without interrupting airport operations, which reduces modelling costs by approximately 68%. Maximo is used as the CMMS/EAM system, while BIM-GIS integration with ETL tools is becoming the standard for European airport projects. Key challenges include cross-format conversion efforts and the need to establish an organizational culture of data utilization, highlighting the importance of CDE governance and standardization.

(2) Heathrow Airport (United Kingdom)

Heathrow integrates BIM and GIS for asset management and maintenance planning. In the operational

design processes, human-flow simulation and acoustic analysis are performed using the integrated spatial model. A common asset-language framework is used to manage aircraft, passenger flows, security, safety, and utilities in a unified, spatially contextualized environment.

(3) Other Airport Cases (Denver, San Francisco, etc.)

These airports use BIM-GIS integration to streamline asset inventory and condition assessment. GIS is linked with systems such as Maximo and BIM 360 to support maintenance planning and predictive maintenance workflows.

(4) Linear Infrastructure Projects (Roads/Railways)

Projects such as Rail Baltica and Austroads manage linear data (LandXML) on a GIS foundation. Overlaying GIS and BIM enables terrain/environment visualization, construction-planning optimization, and improved coordination.

9.6.2 Recommendations and Considerations

- **Early Definition of Information Requirements:**
GIS coordinate systems, attribute structures, and API-integration specifications must be defined in the EIR and reflected in the BEP from the outset.
- **Standardization Alignment:**
Use ISO/TR 23262 (conceptual model for BIM–GIS integration) and ISO/TS 19166 (IFC–GIS conversion) as references to ensure data-model consistency.
- **Integrated CDE Design:**
GIS should be positioned as part of the CDE, with planned integration of BIM, document-management systems, and asset-management systems from the early project stages.
- **Strengthening O&M-phase Utilization:**
GIS functions as a “spatial asset register,” playing a central role in maintenance, risk assessment, and preventive maintenance applications.

9.7 Summary of Recommendations

This chapter examined the application and recommendations on the use of key information-management technologies—including construction information classification systems, data-exchange formats, CDEs, and GIS.

These technical elements cannot be considered separately from project management as they are integrated into contractual documentation, responsibility allocation, progress management, and risk management—which are essential for project success. This section summarizes the major perspectives.

(1) Early Definition of Information Requirements

Across all technical domains (classification systems, IFC/COBie, CDE, GIS), it is essential to develop the EIR at an early stage and have it reflected in the BEP. Elements that are difficult to change far along the project phase—such as coordinate systems, attribute structures, classification codes, and API-integration specifications—must be defined clearly during the initial project phases.

(2) Application and Localization of International Standards

ISO 19650 should be used as the foundation, with Uniclass 2015 serving as the base classification system. Mapping for quantity take-off sheets and asset registers should be adjusted per project, and IFC (ISO 16739) and COBie should be used to standardize data exchange during design, construction, and operations. For BIM-GIS integration, ISO/TR 23262 and ISO/TS 19166 should be referenced to develop consistent conversion rules.

(3) Phased Development of the CDE

During the delivery phase, platforms with local distributor support should be prioritized to ensure a unified management of design and construction information. Multi-CDE configurations should be considered depending on project scale and requirements.

In the operation and maintenance phase, it is rare for a single CDE to meet all requirements. As such, an integrated architecture combining multiple systems—document management, facility-management systems, BIM models, and GIS—must be designed.

(4) Strengthening BIM–GIS Integration

For linear-infrastructure and airport projects, GIS should function as a spatial asset register, with BIM-GIS integration supporting enhanced maintenance, disaster response, and preventive maintenance. GIS platforms should be leveraged to enable real-time data integration and advanced operational support.

(5) Continuous Monitoring of Standardization Trends

As these technologies continue to evolve, it is essential to regularly monitor updates on international standards and best practices, and to develop a governance framework that ensures prompt reflection of such updates in project requirements.

Integrating these technical elements of information management with project-management practices is indispensable for the successful implementation of ODA loan projects and other international infrastructure programmes.

10 PERSPECTIVES ON DEFINING INFORMATION REQUIREMENTS IN THE RAILWAY, ROAD, AND AIRPORT SECTORS

This chapter outlines the perspectives on defining information requirements in the railway, road, and airport sectors, while accounting for differences in business structures and operational frameworks. Since each sector exhibits distinct facility configurations, management structures, stakeholder involvement, applicable standards, and procurement approaches, an optimized approach to information management is required for each domain.

Building on international frameworks and templates for information requirements analyzed in the previous chapters, this chapter clarifies sector-specific characteristics and challenges, and provides concrete perspectives on the required level of information granularity, formats of deliverables, and optimization of responsibilities across the design, construction, operation, and maintenance phases.

Furthermore, this chapter examines the feasibility of implementation in official development assistance (ODA) loan projects and addresses common sector-specific challenges, with an aim to offer practical guidance for employers and project stakeholders.

10.1 Perspectives on Defining Information Requirements in the Railway Sector

10.1.1 Characteristics of Business Structure and Information Management

The railway sector constitutes a complex infrastructure domain requiring diverse technical response depending on transport mode and operational characteristics—urban rail, freight rail, inter-city rail, and high-speed rail—as well as spatial configuration. Key characteristics of the railway business structure and its information management include the complexity of facility configurations, the need for advanced coordination across multiple technical disciplines, and the involvement of numerous stakeholders requiring high-level coordination. These characteristics are detailed below.

(1) Diverse Facility Configuration

Under the Railway Business Act and its Enforcement Regulations, railway facilities are defined as “facilities used for railway business as specified by the Ministry of Land, Infrastructure, Transport and Tourism.” Facilities that must be included in the construction plan when applying for approval of railway construction works include: railway track (bridges, tunnels, level crossings, trackwork), stations (stations, signal stations, marshalling yards), depots and rolling-stock inspection/repair facilities, train protection systems (signaling, communication-based protection, level-crossing protection), substation facilities (substations, distribution stations), and power distribution systems (transmission lines, distribution lines, feeder systems).

In addition to these, actual railway operations require more facilities, such as traffic control centers, various maintenance facilities, training centers, research and development facilities, and commercial facilities. The required diversity of facilities and equipment configurations is one of the defining characteristics of the railway sector.

Table 10-1 presents the main types of railway facilities and their characteristics.

Table 10-1 Types and Characteristics of Railway Facilities

Type	Characteristics
Railway Track	- Linear infrastructure extending over long distances, consisting of track components (rails, sleepers, ballast) and civil structures (bridges, tunnels). - While structural cross-sections can be standardized to some extent at the design stage, linear structures have a continuous and interdependent nature where local modifications may have substantial downstream impacts. - It is common to divide works into multiple sections due to the extensive construction area, making information-sharing mechanisms critical for coordination among work sections.
Train Protection Systems	- Includes signaling, communication-based protection, and level-crossing protection systems. - These systems are often co-located or closely interfaced with railway track and power distribution systems, resulting in significant interdependence across design, construction, and maintenance phases.
Power Distribution and Substation Facilities	- Includes transmission/distribution equipment, feeder systems, substations, and distribution stations. - Similar to train protection systems, many installations are located along the track, creating strong interdependence across project phases.
Stations	- Includes stations, signal stations, and marshalling yards. - Composed of diverse elements such as trackwork, ticket gates, platforms, concourses, and commercial areas. - Must satisfy a broad range of requirements: operational functionality, accessibility, disaster resilience, and quality architectural aesthetic. - Stakeholder relationships are complex, comprising involvements with landowners, municipalities, transport operators, and commercial tenants.
Depots and Rolling-Stock Inspection/Repair Facilities	- Facilities for rolling-stock stabling, formation, inspection, and repair. - Within limited premises, trackwork, power systems, protection systems, buildings, paved areas, lighting, substations, water supply/drainage, and communication facilities are intricately arranged above and below ground. - Frequently co-located with maintenance and training facilities.
Others	- Numerous additional facilities essential for railway operations fall outside the statutory definition, such as training/education centers, maintenance facilities, R&D facilities, and commercial buildings. - Some facilities connect directly to mainline infrastructure or share common systems.

Source: The JICA Study Team

For each railway facility type, the information requirements differ depending on the respective characteristics and construction processes involved (design, construction, and maintenance). At the same time, railway operations can only be achieved when these diverse facilities and systems function as an integrated whole. It is therefore critical to ensure interoperability and consistency of information across systems.

(2) High Capital Intensity and Long-term Asset Characteristics

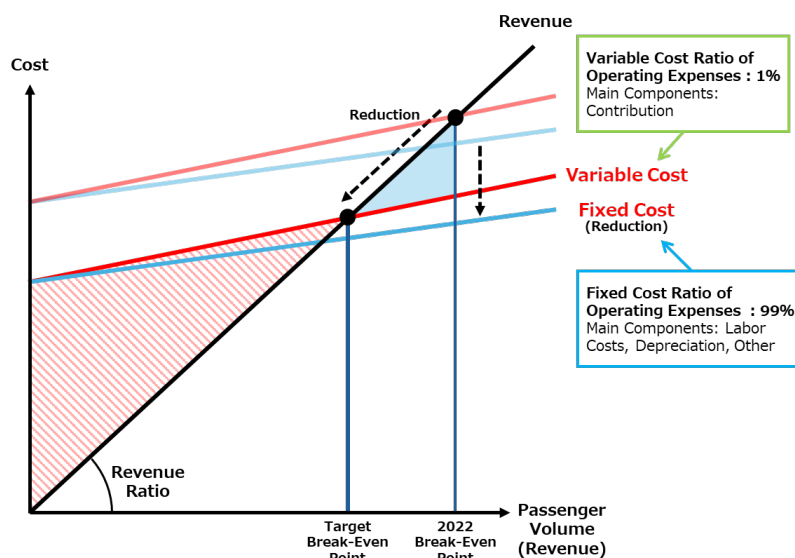
Compared with other public transport infrastructures such as roads and airports, railway infrastructure is characterized by significantly high initial capital expenditure. This results from several factors:

- The construction of dedicated railway lines over long distances;
- Significant design constraints on gradients and curves that increase the proportion of tunnels and viaducts; and
- The large number of ancillary systems required (signaling, communication, power, protection systems, etc.)

Once operational, railway assets must be maintained over extremely long periods. Track components such as rails and sleepers, civil structures such as tunnels and bridges, and architectural structures such as station buildings and platforms are commonly used for several decades with appropriate maintenance. As a result, maintenance, renewal costs, and associated personnel expenses continue over a long period following the

start of operations.

In summary, the railway sector features high initial investment, a high proportion of fixed costs, and long-term accumulation of lifecycle costs due to the longevity of infrastructure assets. Consequently, it is critically important to prevent long-term adverse impacts arising from design or construction defects, as well as minimizing maintenance and renewal costs. Achieving these objectives requires robust information management at each stage of the asset lifecycle.



Source: Prepared by the JICA Study Team based on [Osaka Metro Group 2018-2025 年度中期経営計画 \(2023 年改訂版\)](#)

Figure 10-1 A Case of High Fixed Cost Ratio (Osaka Metro Group)

(3) Integration Across Multiple Technical Disciplines

Railway systems are developed through the integration of numerous technical disciplines, and the breadth of these disciplines is significantly greater than other public infrastructure sectors. Civil engineering, architecture, mechanical systems, electrical systems, piping, trackwork, traction power, signaling, communications, and rolling stock all require close collaboration among specialists and contractors throughout the design, construction, and maintenance. Consequently, it is essential to ensure cross-disciplinary consistency in information management and to systematically organize and integrate the vast amount of information that increases in proportion to the number of disciplines involved at every project stage. Efficiently structured information management systems are therefore indispensable.

From this standpoint, the use of information exchange formats and tools—such as construction information classification systems, IFC, and COBie, as described in Chapter 4—is highly beneficial in the railway sector, as also demonstrated in the case studies presented in Chapter 8.

Another defining characteristic of the railway sector is the system integration process required to coordinate these multiple disciplines. Because railway systems must integrate numerous subsystems into a coherent whole, it is particularly important during the design and construction stages to implement system integration based on overarching safety policies and business plans. This process aligns with the hierarchical structure of information requirements outlined in Figure 6-1 of Chapter 6, and its effectiveness is further confirmed in the case studies summarized in Chapter 8.

(4) Diverse Stakeholders and the Need for Advanced Coordination

Railway development involves a wide variety of schemes—PPP models, vertical separation, private-sector-led or public-sector-led approaches—and typically engages numerous organizations across development, construction, operations, and maintenance. The complexity of stakeholders is itself a defining characteristic which can easily lead to fragmented information and ambiguous allocation of responsibilities. Therefore, in information management aligned with ISO 19650, it is crucial to clearly identify stakeholders

according to the project scheme, define responsibilities, establish standardized data structures, ensure traceability, and embed information requirements within contractual conditions. These measures enable consistent data exchange and decision-making among diverse stakeholders, thereby ensuring the long-term safety, efficiency, and sustainability of railway assets.

Furthermore, the diversity of stakeholders results in a wide range of coordination requirements across the design, construction, and maintenance phases. For instance, in the planning and construction of urban rail systems, land acquisition must be progressed amid complex stakeholder interests while simultaneously addressing advanced spatial and functional coordination with existing public and private facilities and infrastructure. To support the simultaneous requirements of these processes, the use of visually intuitive 3D models can facilitate consensus-building, and centralized management of land and building attribute data can help clarify land-use conditions and rights relationships. In other words, advanced and systematic information management becomes a mechanism for enhancing the project's ability to manage its complexity.

(5) Diversity in Railway Development Contexts

Railway infrastructure development encompasses not only the construction of entirely new lines but also the expansion of existing infrastructure, such as extending individual routes or expanding the railway network. While establishing an appropriate information management system that anticipates future expansion is crucial for entirely new line development, ensuring consistency with the information management of existing infrastructure becomes a key challenge when expanding existing infrastructure. As an example, Kiwi Rail—featured as a case study in Chapter 8—is undertaking information management through initiatives involving the upgrade of existing railway facilities under the banner of digital engineering. While they are advancing asset classification using Uniclass 2015, they manage asset information by mapping existing classifications in Uniclass 2015 for assets where they have already established their own classification systems.

10.1.2 Application Examples of OIR, AIR, PIR, and EIR in the Railway Sector

Based on the preceding review of BIM application in the railway sector, key considerations for developing OIR, AIR, PIR, and EIR in this domain are summarized below.

(1) OIR

To inform the formulation of OIRs in the railway sector, the study team collected information—mainly from the medium- to long-term management plans of Japanese railway operators—regarding their strategic objectives and the business environments behind those objectives. Items commonly identified across multiple operators are summarized in Table 10-2.

Regardless of business scale or service area, many railway companies identify the following as strategic objectives: enhancing safety, strengthening disaster resilience, improving profitability, addressing social issues, advancing technological innovation, improving operational efficiency, and work-style reform. These can therefore be regarded as widely shared challenges among railway operators, and are expected to serve as important perspectives in ODA loan projects as well.

Using the abovementioned categories of strategic objectives as a basis, and with reference to the OIR template proposed in Chapter 6, it is considered effective to define project-specific strategic goals that are consistent with the conditions of the target project.

Table 10-2 Strategic Objectives and Policies of Japanese Railway Operators

Category	Examples of Railway Operators' Strategies/Policies	Underlying Business Environment	KPI Examples
Safety Enhancement	JR East: Pursuit of "ultimate safety"; strengthening safety through individual responsibility and integrity; and adopting advanced technologies. Tokyo Metro: Prioritizing passenger safety, we relentlessly pursue safety and provide high-quality service from the customer's perspective, delivering peace of mind to all passengers. Osaka Metro Group: Pursuit of the highest level of safety and security. JR Central: Prioritizing safe and stable transport on the Tokaido Shinkansen and regional lines while developing the Chuo Shinkansen as a redundant arterial route.	Fundamental mission of railway operators	Osaka Metro Group: Number of installed facilities, construction locations, etc.
Disaster Countermeasures	JR East: Strengthening resilience against increasingly severe natural disasters; enhancing both soft and hard countermeasures; and improving organizational readiness. Tokyo Metro: Measures against earthquakes and large-scale flooding. Osaka Metro Group: Enhancing the robustness of facilities to prevent severe damage during disasters.	Increasing disaster severity	Tokyo Metro and others: Specified schedules for related capital investments
Profitability Improvement	JR East: Creating high-value travel experiences and attractive destinations; and promoting regional attractions internationally. Tokyo Metro: Expanding inbound ridership; expanding business domains including global O&M. JR Central: Improving services through technology and ensuring revenue through appropriate pricing.	Quantitative and qualitative changes in passenger demand; and shifting social values	JR East: Numerical revenue targets
Addressing Social Issues	JR East: Reducing peak-hour congestion; enhancing social infrastructure; and reducing equipment failures. Tokyo Metro: Promoting integrated station-area development, universal access, and sustainability initiatives. Osaka Metro Group: Enhancing value of mobility services; and undertaking DX and renewable energy initiatives. Meitetsu Group: Realizing a mobility network centered on public transport.	Mobility disparities; decarbonization; SDGs; and shifting social values	Tokyo Metro: Barrier-free development targets Osaka Metro: Renewable energy generation targets

Category	Examples of Railway Operators' Strategies/Policies	Underlying Business Environment	KPI Examples
Technological Innovation	Tokyo Metro: Improving stability and transforming transport systems through CBTC and automation. Osaka Metro Group: Introducing world-class technologies such as AI on-demand and autonomous driving.	ICT, AI, robotics advancements; and declining working population	Osaka Metro: Autonomous driving achievement level and deployment areas
Operational Efficiency	Tokyo Metro: Operating with 9,000 staff by fiscal year 2030; implementing CBM, automation, and DX; extending tunnel life; and optimizing renewals. Osaka Metro: Improving daily operations through rationalization and efficiency. JR East: Streamlining operations with new technologies and DX. JR Central: Long-term cost-reduction target of JPY 80 billion annually. JR Hokkaido: Improving safety and work efficiency through ICT. Meitetsu Group: Strengthening business resilience.	Demographic changes; infrastructure aging; and shifting passenger characteristics	Tokyo Metro: Specific organizational size/targets JR Central: Quantified cost-reduction goals
Work System Reform	JR East: Automation and AI-based traffic management: flexible workplaces, robot-assisted maintenance, and drone-based inspections. JR Central: Enhancing employee capabilities; improving workplace environments; building resilient organizations capable of adapting to change; and promoting business process reform through the use of cutting-edge technologies such as ICT.	Declining workforce; technological advancement; SDGs; and changing values	Labour-related indicators

Source: Prepared by the JICA Study Team based on references 1, 2, 3, 4, 5, 6

(2) AIR

In a systematic manner, AIR defines the asset information required at project completion to support future asset operations, maintenance, and renewal decision-making. For AIR in the railway sector, it is necessary to incorporate general AIR considerations while also reflecting the characteristics of railway business structures—namely diverse asset compositions, long asset lifecycles, high capital intensity, multi-disciplinary integration, stakeholder complexity, and varying development contexts.

From the perspective of diverse asset compositions, the effective maintenance of vast railway assets requires comprehensive information on asset locations and attributes (materials, service life, maintenance frequency, etc.), along with mechanisms for accumulating time-series data such as maintenance, failure,

- 1 [JR 東日本グループモビリティ中長期戦略 *Pride and Integrity*](#)
- 2 [JR 東海グループの「ありたい姿」～30年後の未来に向けて～](#)
- 3 [東京メトロ 2025～2027 中期経営計画”Run!～次代を翔けろ～”](#)
- 4 [Osaka Metro Group 2018-2025 年度 中期経営計画 \(2023 年改訂版\)](#)
- 5 [JR 北海道グループ中期経営計画 2026](#)
- 6 [新・名鉄グループ経営ビジョン](#)

and renewal histories. From the standpoint of long asset lifecycles, it is essential to ensure the long-term preservation of design drawings, as-built drawings, and amendment histories; and to maintain multi-decade traceability of maintenance and renewal activities.

Given the involvement of multiple technical disciplines and stakeholders, it is crucial that the CDE structure, responsibility boundaries, information exchange formats, data classification systems, LOIN definitions, and related frameworks are properly established and operated among all participants. For example, since in the mainline track maintenance, various equipment—including track materials, signaling and communication systems, and traction power systems—are densely installed or buried within limited spaces, track staff must accurately understand what, where, and how is something installed to carry out inspection, maintenance, or renewal without affecting adjacent systems. Properly structured information frameworks make management of various equipment both effective and efficient.

Although classification systems are essential due to the complex asset structures of railways, existing systems may not cover railway-specific assets or may conflict with operator-specific internal coding systems. Therefore, it is necessary to select the optimal classification approach for each environment or use a combination of different methods, as appropriate.

Accounting for these characteristics is essential when developing AIR. Based on the strategic objectives categorized in Table 10-2, Table 10-3 summarizes specific challenges that railway operators may face and the corresponding information required for asset management.

Table 10-3 Examples of Railway Operators' Challenges and Required Asset Management Information

Category	Organizational Challenges	Required Asset Management Information
Safety Enhancement	Early detection of failure precursors; reduction of major accident risks; and ensuring operational safety.	Information on protection systems (interlocking, regulations, inspection cycles, parameters); failure/accident/replacement histories and root-cause data; and sensing and monitoring data (track displacement, catenary tension, onboard data, etc.)
Disaster Countermeasures	Strengthening disaster resilience; faster damage assessment; and accelerating restoration.	Hazard and disaster-resilience design information for each facility (earthquake, wind, rainfall, etc.); locations and readings of environmental monitoring devices (rain gauges, wind sensors, landslide sensors); and evacuation and BCP-related facility data (evacuation routes, emergency power, emergency stores)
Profitability Improvement	Optimizing passenger flows and increasing facility utilization.	Usage data for stations, lines, and commercial spaces; tenant and advertising operation data
Addressing Social Issues	Compliance with barrier-free standards; carbon-neutral initiatives; and regional collaboration and maintenance of public transport networks.	Installation status of barrier-free facilities (lifts, escalators, universal toilets); energy consumption of railway facilities; and intermodal connectivity information
Technological Innovation	Developing digital twins; implementing autonomous operation; and advancing CBM.	Foundational data for digital twins (high-accuracy 3D models, GIS); operational system data (track circuit data, ATO parameters); and sensor data for various equipment
Operational Efficiency	Streamlining maintenance and optimizing work scheduling.	Asset data required for maintenance optimization (maintenance cycles, service life and remaining life); and workflow data (depot locations, equipment used, operational constraints)
Work System Reform	Transitioning from visual inspection to drone-based inspection and reducing inspection frequency	Location information and inspection item data for inspection points

Source: The JICA Study Team

(3) PIR

In a systematic manner, PIR defines the information required at each project stage to support appropriate decision-making. PIR is formulated based on OIR and AIR, and is in accordance to the project's objectives, scope, and constraints. In the railway sector, PIR development must fully reflect the intrinsic characteristics of railways—long life cycles, high capital intensity, multi-functional integration, and multi-stakeholder collaboration.

In railway systems—where track, civil, power, signaling, communications, rolling stock, and station systems are interconnected—it is essential to define information requirements that ensure integrated management of interface information and design assumptions. Under diverse schemes such as PPPs and vertical separation, participants differ across stages, requiring contractual provisions that clearly define responsibility boundaries and deliverable formats to minimize the risk of data discontinuity.

Given the long lifecycles of railway assets, PIR must incorporate information directly usable for post-opening maintenance and renewal planning—such as structural histories, equipment specifications and performance, maintenance conditions, inspection cycles, and risk factors—and ensure consistency with the operator's OIR and AIR. Thus, PIR in the railway sector should be conceived not merely as a set of data requirements but as the “information infrastructure” supporting value creation throughout design, construction, operation, and maintenance.

(4) EIR

In defining the EIR, the AIR and PIR considerations discussed in this section are expanded in accordance with the concepts of ISO 19650 and the EIR template (draft) examined in Section 6.7.

10.2 Perspectives for Defining Information Requirements in the Road Sector

10.2.1 Characteristics of Business Structure and Information Management

10.2.1.1 Characteristics of Business Structure

The road sector is one of the oldest public infrastructure domains, having been developed and maintained over many decades in countries all over the world. As a result, most roads are administered by public authorities and are generally free for public use. Reflecting these characteristics, road-sector stakeholders are diverse, but primary actors can be organized into the following three groups:

- Road Authorities: Administrative bodies or road corporations who are responsible for ensuring road functionality and for undertaking improvement, repair, and reconstruction works.
- General Users: Individuals who use roads by vehicle or on foot, who do not hold authority for undertaking improvement works but require information regarding safety and travel conditions.
- Utility Operators Using Road Space: Water, gas, power, telecommunications, and other utility providers that install their infrastructure within the road corridor. Although they may undertake certain modification works, they do not hold responsibility for managing roads as a whole.

(1) Road Management Frameworks

Roads possess an inherently high degree of public interest and are typically administered by government agencies. However, the institutional frameworks and allocation of responsibilities differ significantly from country to country. In many jurisdictions, roads are classified by strategic importance, with relevant authorities designated accordingly. Still, there is a wide variety of responsibility for construction versus maintenance, as well as regional-level management practices. Representative examples—including those from countries eligible for ODA loan projects—are outlined as follows:

- Japan: A hierarchical management system is used where national highways are administered by the national government, prefectural roads by prefectures, and municipal roads by municipalities.
- Uganda: In the Kampala Flyover Project, construction is undertaken by the national road authority (UNRA) and maintenance falls under the capital city authority (KCCA), resulting in the separation of

construction and maintenance responsibilities.

- United States: In certain limited-access highway sections, individuals, local communities, or specific public bodies are responsible for maintenance, resulting a decentralized management model.

Such variations in management structures have a direct impact on the formulation of information requirements. For example, when the responsible entities for construction and maintenance differ, mechanisms to ensure clarity in information handover and responsibility boundaries become indispensable.

(2) Positioning of General Users

Roads are public infrastructure that can be freely used by anyone at no cost, therefore, all road users are considered potential stakeholders. For general users, the principal value of a road lies in being able to travel safely and smoothly to their destination, and their interests are mainly concentrated in the following types of information:

- Safety information: accident occurrence, disaster risks, visibility (lighting, signage, road markings, etc.).
- Driving-condition information: traffic congestion, road closures, pavement deterioration (e.g., rutting).

Because general users do not directly undertake road improvement or maintenance, such information holds importance from the perspective of information provision from the road authority to the user. From the standpoint of defining information requirements, it is essential that such user needs are appropriately reflected in the OIR, and that the operating authority establishes mechanisms to continuously monitor and evaluate safety and driving conditions, and to disclose or provide this information as necessary.

In addition to ordinary road users, there are also businesses and individuals who utilize road space for operational or commercial purposes—for example, entities installing occupation structures, roadside construction contractors, and event organizers. These parties require detailed information regarding occupation permits, construction coordination, work conditions, and time restrictions issued by the road authority. Accordingly, it is effective to distinguish them from general users and to organize the relevant information within the AIR and EIR.

(3) Cross-Sector Infrastructure Coordination in Road Management

Road corridors function not only as transport infrastructure but also as shared spaces accommodating diverse lifeline utilities such as water pipelines, gas pipelines, power lines, and telecommunications cables. These assets are installed either aboveground or underground and involve multiple authorities and utility operators; therefore, road management inherently requires coordination among numerous stakeholders. Under current systems, each utility operator may obtain an occupation permit from the road authority to conduct construction or renewal works. However, because they are not responsible for managing the road as a whole, they do not have comprehensive access to asset information managed by other operators. As a result, information such as the locations and attributes of existing assets or future construction plans tends to become fragmented across organizations.

Fragmentation of construction activities often leads to inadequate coordination between construction plans, resulting in inefficiencies such as multiple operators working independently within the same road section, repeated or prolonged traffic restrictions, and increased disruptions for users and society. In Japan, a typical case involved separate gas-pipe renewal works and telecommunications cable installation activities within the same road section, causing repeated traffic control measures.

To address these challenges, it is essential to develop an integrated information platform that consolidates occupation-permit data, existing asset location/attribute data, and construction-plan information. This platform should be accessible to all relevant operators. By leveraging an Asset Information Model (AIM) to centrally manage asset information within the road corridor, project stakeholders can improve advance coordination of construction plans, enhance risk assessments during execution, and understand the extent of potential impacts. Moreover, the platform should integrate the information needs of both utility operators and road authorities in the OIR, and establishing clear guidelines for information-sharing related to

occupation permits and construction coordination at the contractual stage, are critical.

Cross-sector infrastructure coordination is a core element of AIR and PIR in the road sector. Establishing mechanisms to standardize related information and share it via a CDE enables a shift from personnel-dependent, procedure-driven coordination to information-driven management. This transformation is expected to reduce social costs and minimize the impacts on road users.

(4) Differences Between Toll Roads and Public Roads

The most significant difference between toll roads and publicly managed free roads lies in the level of emphasis placed on profitability and return on investment (ROI). From the user's perspective, the basic information required—such as safety, drivability, and traffic restrictions—is broadly similar for both road types. However, the managing entity's risk perception and underlying assumptions for decision-making differ considerably.

For toll roads, even partial closures or reductions in functionality directly affect toll revenue and may significantly impact overall business performance. Consequently, risk assessments associated with maintenance and renewal works tend to be more stringent and prioritise business continuity. Additionally, toll road operators typically manage shorter road sections compared with national or local governments; disruptions occurring within limited sections may therefore have proportionally greater impacts on the entire business. This results in higher expectations for the accuracy and frequency of information management.

These differences in priorities and risk perceptions directly influence the formulation of information requirements. Within OIR and AIR, toll roads are likely to place greater emphasis on information items related to revenue protection and service continuity. Examples include:

- Forecasting risks associated with traffic restrictions,
- Early indicators of equipment failures, and
- Emergency response planning.

Such information items play an increasingly critical role because they are directly linked to the continuity of operations and financial sustainability.

10.2.1.2 Characteristics of Information Management

Information management in the road sector is characterized by significant variation in the required level of detail and update frequency depending on asset types, spatial configurations, and operational criticality. Road assets extend linearly over wide geographic areas, include elements that are difficult to assess visually, and have operational conditions where functional degradation or closures can immediately affect society. For these reasons, uniformly managing all assets with high granularity is unrealistic, and a risk-based approach to information management is essential.

The following sections summarize key considerations for representative road assets.

(1) Earthwork Structure

Earthwork structures—including cut slopes, embankments, and natural/artificial slopes—constitute extensive and large-scale road assets for which efficiency in information management is particularly important. Monitoring all sections frequently and in high detail is not feasible; therefore, a tiered management approach is effective. This involves assessing risks using screening indicators such as topographic and geological conditions, past deformation history, and external-force indicators (e.g., rainfall), identifying priority sections, and applying additional measurements or monitoring to those sections. In essence, the core of information management lies in strategically determining “where,” “how frequently,” and “with which indicators” monitoring should be conducted.

While bridges and tunnels generally benefit from well-established inspection and maintenance systems, earthwork structures are often assumed to exhibit long-term stability from the time of construction. As a result, inspection and maintenance may not always be conducted with the same level of rigor. In Japan,

documents such as the Guidelines for Inspection of Road Earthwork Structures and the Guidelines for Periodic Inspection of Sheds and Large Culverts define inspection scopes; however, these scopes are likely to vary across countries.

The final decision regarding which parts of earthwork structures should be monitored rests with the managing authority, but expanding the monitoring scope entails substantial budget and operational burden. Therefore, it is essential that the OIR and AIR clearly specify the management scope, required information types, and update frequency, and that for sections excluded from monitoring, potential risk information is still documented.

(2) Long Rads Tunnels

Road structures are generally designed for long service lives, with typical design life spans of approximately 100 years for bridges and 15–20 years for pavement and ancillary components. In many cases, minor damage does not immediately hinder traffic, allowing for comparatively long maintenance cycles.

Long road tunnels, however, possess distinct operational characteristics. Although their main structural body is also designed for 100 years or more, internal systems—ventilation, lighting, fire detection, and emergency response systems—require continuous and high-frequency monitoring and management. Failures in these systems can lead to severe safety risks, such as:

- Accumulation of toxic gases,
- Impaired visibility,
- Delays in emergency response, and
- Forced, immediate tunnel closure.

Therefore, information requirements for long tunnels must be more stringent and operationally focused than those for general road structures. In the AIR, detailed definitions are required for information related to:

- Equipment operating conditions,
- Indicators of deterioration and potential failure,
- Inspection and renewal histories, and
- Emergency response plans.

Furthermore, these information items must be consistently shared and updated among stakeholders through the CDE in accordance with the ISO 19650 framework.

10.2.2 Application Examples of OIR, AIR, PIR, and EIR in the Railway Sector

Information requirements are essential for systematically establishing an information-management framework within road projects. This section presents practical application examples of each requirement type, drawing on policy and operational practices observed in the Japanese road sector.

(1) OIR

To organize the information requirements necessary for road operations, the JICA Study Team analyzed the basic policies at the national level (Ministry of Land, Infrastructure, Transport and Tourism), prefectural level (Tokyo Metropolitan Government and Niigata Prefecture), and corporate level (NEXCO East Japan). The results, as shown in Table 10-4, can be categorized into five areas: “Network Enhancement,” “Road-Space Utilization,” “Digitalization,” “Disaster Countermeasures,” and “Management & Work-Life Balance.” Among these, the Management & Work-Life Balance perspective was identified only at NEXCO East Japan, a corporate entity.

When formulating the OIR, it is important to reference these categories and prioritize them according to road type, project conditions, and the maturity level. In Japan, the basic policies do not always explicitly state “safety”, as a certain level of road safety has already been achieved. However, in many developing countries, safety remains the highest priority and must be clearly positioned within the OIR.

Table 10-4 Basic Policies Related to Wide-Area Road Networks

Category	MLIT (National Government)	Tokyo Metropolitan Government	Niigata Prefecture	NEXCO East Japan
Network Enhancement	Eliminating commuting-hour congestion; strengthening arterial network functions; enhancing international competitiveness	Developing transport infrastructure to support one of the world's largest metropolitan areas; creating smooth, congestion-free mobility; enhancing and strengthening transport networks to improve Tokyo's convenience and competitiveness.	Achieving road transport that allows the smooth movement of people and goods; strengthening hubs linked with airports, ports, and railway terminals	Development and enhancement of expressways; improving network functionality through four-lane expansion
Road-Space Utilization	Enhancing the amenity of road spaces	creating spaces where people can gather and relax	Urban development focused on regional characteristics and people	Improving user convenience in line with diverse customer needs
Digitalization	Automation/unmanned movement of people and goods; development of road-based services	Creating new value for Tokyo's future	Using ICT to achieve safe, vibrant regional environments	Realizing safe, comfortable expressways supporting innovations such as autonomous driving
Disaster Countermeasures		Strengthening preparedness for increasingly severe rainfall and major earthquakes	Ensuring road functionality even under heavy snow conditions; enhancing multifunctional disaster-response hubs	Improving reliability of expressway infrastructure through ageing-countermeasures and disaster-response measures
Management & Work-Life Balance				Strengthening management capacity in the post-COVID-19 era; realizing workstyles aligned with new norms

Source: Prepared by the JICA Study Team based on references 7, 8, 9, 10

(2) AIR

In the road sector, AIR must incorporate not only general asset-management requirements but also information definitions aligned with the unique characteristics of extensive, linear road networks. It is therefore essential to clearly establish and continuously operate the CDE structure, responsibility boundaries, information-exchange formats, data classification systems, and LOIN definitions among all stakeholders.

In addition to general AIR considerations, information requirements must also reflect sector-specific elements of road-network management—such as network enhancement, addressing social issues, digitalization, disaster resilience, and safety. Based on the strategic objectives of Japanese road authorities categorized in Table 10-4, Table 10-5 presents examples of anticipated challenges and the corresponding

7 [2040 年、道路の景色が変わる～人々の幸せにつながる道路～](#)

8 [東京都広域道路交通ビジョン](#)

9 [新潟県新広域道路交通ビジョン](#)

10 [NEXCO 東日本グループ中期経営計画](#)

asset-information needs.

Table 10-5 Examples of Challenges Faced by Road Authorities and Required Asset Management Information

Category	Organizational Challenges	Required Asset Management Information
Safety	- Traffic accidents - Visibility - Pavement deterioration - Structural soundness	- Accident locations - Lighting-system operational status - IRI¹¹ and rutting data - Structural inspection, repair, and rehabilitation records
Network Enhancement	- Increasing traffic volumes - Congestion mitigation - Eliminating missing links - Responding to inbound tourism and an ageing society	- Traffic volume - Congestion status - Travel time - Transportation demand
Road-Space Utilization	- Enhancing road-space amenity	- Data on road-space usage - Pedestrian and movement-flow data
Digitalization	- Real-time traffic information	- Remote sensing traffic data
Disaster Countermeasures	- Disaster information and risk - Facility improvements - Post-disaster safety	- Results of risk analysis - Locations of disaster prevention facilities - Records of disaster response activities

Source: The JICA Study Team

(3) PIR

In road design, the integration of Geographic Information Systems (GIS) and terrain models plays a critical role. Through geo-referencing technologies, accurate geographic positioning can be obtained and linked with design data, thereby enabling designs that appropriately reflect physical and environmental conditions. For example, simulations based on terrain data are effective for identifying obstacles that obstruct driver visibility, locating areas susceptible to landslide hazards, and assessing road alignment or structural configurations in accordance with topographical constraints.

During the construction stage, the use of such data enables advanced ICT-based construction and machine-guided execution, such as those promoted under initiatives like i-Construction. In addition, it contributes to visualizing progress and managing quantities, as well as facilitating information sharing and smooth progress monitoring where multiple work packages and multiple contractors operate concurrently.

Furthermore, geographic information remains critical during the maintenance phase. GIS-based data provide foundational support for road monitoring, inspections, and rapid response during disaster events, thereby enabling efficient asset management.

In the PIR, the necessity of these information items must be explicitly defined, ensuring alignment with the OIR and AIR, while being formulated according to the project's objectives, scope, and constraints. Geographic data also remains essential during the maintenance phase, where their use in monitoring, inspections, and emergency response contributes to efficient lifecycle asset management.

(4) EIR

In defining the EIR, the AIR and PIR considerations discussed in this section should be further developed in alignment with the ISO 19650 framework and with reference to the draft EIR template examined in Section 6.7.

10.2.3 Information Handover to the O&M Phase and Asset Register Development

Road-sector projects typically focus more on the improvement and renewal of existing networks than on

¹¹ International Roughness Index (IRI): An international metric for evaluating road surface smoothness proposed by the World Bank in the 1980s. Calculated from the longitudinal profile of the road surface, lower values indicate smoother surfaces with higher ride comfort and safety. Widely used in pavement management and maintenance planning.

completely new construction. Accordingly, information utilization during the O&M phase should not be limited to individual projects but should ideally be carried out collaboratively and horizontally across municipalities and road authorities. For this reason, it is essential to reliably hand over information developed during the design and construction stages and to manage it systematically within a comprehensive road asset register.

The method for developing an asset register varies depending on the maintenance strategy and scope defined by the road authority. When maintenance is conducted for entire routes or network-level units, an integrated register covering bridges, tunnels, pavements, and ancillary facilities is effective. Conversely, where only specific critical structures are subject to maintenance, it may be appropriate to develop an asset register dedicated solely to those structures. In the case of long road tunnels, for example, operation and maintenance requirements are often driven more by electromechanical systems—such as ventilation, lighting, and emergency equipment—than by the main structure itself; therefore, a standalone asset register focusing on these systems may be equally valid. In all cases, it is essential to define information-handover rules based on the OIR and AIR, ensuring that required information items, update frequencies, and responsibility boundaries are clearly established.

10.2.4 Information Sharing with Government Agencies and Local Authorities

Considering the diverse stakeholders and information needs in the road sector, establishing robust information management practices and promoting coordination among stakeholders is essential.

Information sharing with government agencies and local authorities is particularly important. Traffic volume data, accident records, and environmental impact data form the foundation not only for road management activities but also for regional disaster prevention plans, security measures, urban planning, and development policies. Therefore, properly organizing and sharing this information can enhance the quality and effectiveness of policy decisions.

Ensuring transparency also requires critical information sharing with local communities. Regular public hearings and workshops provide opportunities to clearly communicate project information and foster trust between road management authorities and residents.

Furthermore, coordination with other infrastructure sectors, such as water supply/sewerage and power grids, is indispensable. Cross-sectoral information sharing improves project efficiency, and integrating spatial information through GIS is an effective means to achieve such interdisciplinary collaboration.

10.2.5 Other Considerations (Digital and Smart Mobility, Autonomous Driving)

Looking ahead, the road sector is expected to play a central role in realizing smart mobility ecosystems built on integrated data platforms. Demonstration and research projects—such as Toyota Woven City¹² and the Tsukuba Smart City Consortium¹³—are progressing both in Japan and internationally, reflecting expectations for road infrastructure to interconnect with diverse mobility services and autonomous driving technologies. Achieving these advancements will require data-integration platforms that span not only road-management information but also data from transportation, urban systems, and energy sectors. Although many municipalities have already identified “digitalization” as a policy priority, the scope and granularity of information to be stored and shared within such platforms remain under discussion in many regions.

As autonomous driving and advanced traffic management become more widespread, information requirements in the road sector are likely to expand beyond traditional maintenance-focused perspectives to include real-time data needs and integration with external systems. Accordingly, when defining OIR and AIR, it is important to ensure sufficient flexibility to accommodate future data utilization.

¹² [Toyota Woven City | About](#)

¹³ [スーパーシティ型国家戦略特区／つくば市公式ウェブサイト](#)

10.3 Perspectives for Defining Information Requirements in the Airport Sector

10.3.1 Characteristics of Business Structure and Information Management

10.3.1.1 Characteristics of Business Structures

Key characteristics of business structures in the airport sector include:

- Wide range of stakeholders involved during both development and operational phases;
- Possibility that airport development and operations are carried out by multiple entities;
- Importance of environmental and social considerations, as well as coexistence with local communities; and
- Phased development aligned with changes in aviation demand.

The details of each characteristic are described below.

(1) Diversity of Stakeholders in the Development and Operational Phases

During the development phase of airport infrastructure, a wide variety of facilities must be delivered, including airside civil works (runways, taxiways), architectural facilities such as passenger terminal buildings, utility infrastructure (fuel supply, power, water and wastewater), and security-related installations. These facilities are not always developed under a single client entity; often, different contracting authorities and agencies are responsible for different facility types.

For architectural components, coordination with Customs, Immigration, Quarantine (CIQ) authorities, and—where airports operate under concession schemes—the airport operator, is required. For utility systems, coordination may be necessary with aviation fuel suppliers, electric power companies, telecommunications providers, and water and wastewater utilities. Table 10-6 provides examples of responsibility boundaries and challenges encountered in past ODA loan airport development projects in which the JICA Study Team participated. Given this stakeholder diversity, it is essential in airport projects to clearly design and implement BIM processes and information-sharing rules from the earliest stages.

During the operational phase, an even greater number of organizations are involved in airport operations, including facility owners and operators, CIQ agencies, utility service providers, commercial tenants, air-traffic control, ground transport operators, fire and police services, among others. Section 3.1 of ICAO's Airport Service Manual Part 7: Airport Emergency Planning (Second Edition, 1991) lists the 26 organizations involved in airport operations, as presented in Table 10-7.

Table 10-6 Responsibility Boundaries in Past Yen-Loan Airport Development Projects

Field	Organization	Responsibility Boundaries and Issues Encountered
Civil Works	Road Authority	During girder installation for the access viaduct between the national highway and the passenger terminal (under the ODA loan project), partial traffic restrictions were required. Coordination with the road authority was required to secure approval for lane closures.
Architecture (Passenger Terminal Building)	Customs	In this case, the X-ray inspection system was procured and installed by Customs (outside the scope of the ODA loan). Delays on the part of Customs impacted test operations under the ODA loan project.
	Immigration	Under the ODA loan project, counter furniture, electrical and telecommunications systems, and the internal airport network were procured/installed, while Immigration procured terminal equipment and immigration-system components.
Utilities	Aviation fuel supplier	For the hydrant fuel system, the ODA loan project covered the procurement and installation of pipes, valves, pits, and control/monitoring systems. The fuel supplier was responsible for installing additional tanks, filters, and pumps at the fuel farm. Delays by the supplier affected the ODA loan schedule. After opening, the fuel supplier is responsible for O&M of the entire system.
	Electric power company	Under the ODA loan project, transformers and downstream electrical equipment inside the airport were procured, while the power company provided the high-voltage transmission line from the city to the airport. Issues with the power company's installation resulted in additional coordination.
	Telecom company	The ODA loan project secured antenna locations, space on cable racks, and power connection, and installed telecommunications systems up to the router. The telecom company installed antennas and fiber-optic cables.

Source: The JICA Study Team

Table 10-7 Organizations Involved in Airport Operations

Air Traffic Services	Airport Tenants	Customs
Fire and Rescue	Transport Authorities (Land/Sea/Air)	Health Authorities
Police and Security	Rescue Coordination Centre (RCC)	Utility Service Providers
Airport Authority	Civil Defense	Postal Services
Medical Services	Mutual Aid Organizations	Veterinary Services
Hospitals	Military	Coroner
Airlines	Coast Guard	Volunteer Organizations
Government Authorities	Clergy	International Relief Services (Red Cross, Red Crescent)
Communications Services	Public Information Office	

Source: Prepared by the JICA Study Team based on "Airport Service Manual Part 7 Airport Emergency Planning"

(2) Environmental Measures and Coexistence with Local Communities

Environmental issues associated with airports have traditionally focused on aircraft-noise mitigation and harmonization with surrounding natural environments. Noise mitigation has been addressed through measures such as the introduction of quieter aircraft and restrictions on operating hours.¹⁴ As described in Chapter 8, airport projects have also undertaken initiatives related to ecosystem protection and preservation of views and landscapes in surrounding areas.

In recent years, decarbonization has become a major challenge, as international aviation accounts for approximately 1.8% of global carbon dioxide (CO₂) emissions.¹⁵ In Japan, practical initiatives include reducing taxiing distances through provision of additional taxiways, upgrading ground support equipment (GSE) and ground power units (GPU), and installing on-site renewable-energy systems such as solar panels.

14 財団法人 港湾空港建設技術サービスセンター「空港工学」(2010)

15 国土交通省「令和4年度版国土交通白書」

On the social side, airport development is typically a large-scale undertaking and requires land acquisition, resettlement, compensation and livelihood restoration, and consensus-building with local communities.¹⁶

These considerations underscore the importance of ensuring environmental, social, and community coexistence to support the long-term sustainability of airport operations.

(3) Phased Development According to Aviation Demand

Airport development is often carried out in phases, expanding terminal buildings or extending/adding runways and taxiways in response to increases in aviation demand. When executing construction works during ongoing airport operations, the key challenge is to complete works within short windows while ensuring no disruption to airport operations.¹⁷ Developing construction plans therefore requires extensive coordination with airport operators, airlines, air-traffic control, security authorities, and other stakeholders. These coordination processes can be time-consuming. In this context, the use of BIM models for visualization and sharing of construction sequences can serve as an effective means of improving stakeholder understanding and facilitating consensus-building.

10.3.1.2 Characteristics of Information Management

The characteristics of information management in the airport sector can be considered across the following four dimensions: diversity of stakeholders and assets; underground utilities; handling of security-sensitive information; and information beyond asset management.

(1) Diverse Stakeholders and Assets

As described in Section 10.3.1.1, airport development and operations involve a wide range of stakeholders, including facility owners, operators, CIQ authorities, utility providers, airlines, and commercial tenants. The assets subject to management are equally diverse: airside civil infrastructure (runways, taxiways), architectural facilities (passenger terminal buildings), utility systems (fuel supply, power, telecommunications), security and screening equipment, and various mechanical, electrical, and ICT systems.

Successful BIM implementation requires systematically capturing the perspectives of these diverse stakeholders and identifying the information needed for each. However, the scale and diversity of both stakeholders and assets inherently increase the complexity and initial implementation burden of BIM. Therefore, in the early stages of BIM introduction, it is advisable to narrow the scope by prioritizing assets aligned with the airport's operational goals and challenges. This helps reduce the barriers to BIM adoption.

(2) Underground Utilities

At aprons, taxiways, and runways, many critical systems such as fuel pipelines, outdoor fire-fighting water mains, power distribution and telecommunications cabling—are installed underground to ensure safe aircraft operations. Consequently, it is difficult to identify their exact locations through visual inspection alone. Representing these underground utilities in three-dimensional BIM models, along with precise location and attribute information, improves the efficiency of daily operations and maintenance activities. Existing BIM models also support future rehabilitation or expansion projects by facilitating design studies and construction planning, thereby reducing risks.

In areas where terminal buildings and access facilities are concentrated, the presence of underground utilities owned by other organizations can be discovered during construction works, leading to work delays. In previously ODA loan projects involving airport development, unidentified underground telecommunications cables for airfield lighting and underground utilities (including high-voltage cables and communications cables) belonging to other organizations were discovered near the terminal-side boundary after construction commenced, resulting in design changes and schedule impacts. It is essential to gather information from stakeholders and collect existing documentation as far as possible, and to reflect all known underground assets within the airport BIM model to reduce project risks and support smooth

16 国土交通省 航空局「空港脱炭素化推進のための計画策定ガイドライン（第二版）」（2022）

17 国土交通省港湾局・航空局「港湾・空港工事の工期の設定に関するガイドライン」（2025）

project implementation.

(3) Security-Sensitive Information

Since the terrorist attacks in the United States in 2001, aviation security has become an issue of paramount global importance, and stringent security measures are required in information management within the airport sector. Due to security considerations, information such as CCTV camera locations, access control system configurations, and floor plans of airport buildings is considered security-sensitive. Such information must be evaluated and classified from the delivery stage, with clear definitions of access rights and handling procedures. Continuous implementation of information-security measures is required during the operational phase as well, including the secure updating, sharing, and storage of security-sensitive information.

(4) Information Beyond Asset Management

In ODA loan airport projects, development scopes often include check-in counters and baggage-handling systems necessary for passenger processing, as well as the construction of control towers required for aircraft operations. The systems used in these facilities also fall within the project scope. The information needed for these systems differs from that required for asset management; as noted in Section 8.2.7.11, such information relates more directly to passenger processing and air-traffic management.

For BIM application in ODA loan airport projects, defining only the information necessary for asset management as mandatory requirements represents a practical and foundational approach during early adoption. However, integrating passenger-processing and air-traffic management systems with BIM models and asset-management systems has the potential to enhance airport operations. Such advanced and integrated BIM applications should be explored through detailed study of practices in BIM-mature countries and developments among aviation IT service providers.

10.3.1.3 Key Considerations When Defining Information Requirements in the Airport Sector

Based on the above analysis, the following points should be given particular attention when defining information requirements from the perspectives of business structure and information management in the airport sector:

- Extract information requirements with the premise that diverse stakeholders are involved across both delivery and operational phases.
- Consider information requirements related to environmental measures and coexistence with local communities.
- Where projects are implemented while the airport remains operational, ensure that information is available to assess potential impacts on airport operations.
- Model underground assets to support efficient operations, maintenance, and future project execution.
- Define security-sensitive information and establish appropriate information-management measures.

At the early stage of BIM introduction, it is advisable to prioritize assets that correspond to the airport's operational goals and challenges—taking into account constraints such as personnel, schedule, and cost—and limit the initial BIM application to these assets. Expanding the management scope or integrating BIM models with passenger-processing and air-traffic management systems should be considered advanced BIM applications.

10.3.2 Application Examples of OIR, AIR, PIR, and EIR in the Airport Sector

Based on the preceding review of BIM application in airport projects, key considerations for developing OIR, AIR, PIR, and EIR in the airport sector are summarized below.

(1) OIR

To analyze perspectives relevant to OIR in airports, the JICA Study Team reviewed the corporate philosophies of Narita International Airport Corporation, Kansai Airports (operator of Kansai International,

Osaka International, and Kobe Airports), and the Central Japan International Airport Group (operator of Chubu Centrair). As shown in Table 10-8, their corporate philosophies encompass themes such as safety, customer satisfaction, environmental stewardship and coexistence with local communities, sound management, social responsibility, competitiveness, culture, and human resources. These perspectives are considered relevant when formulating OIR for ODA loan airport projects.

Taking into account findings from Chapter 8, the more concrete initiatives that support achievement of an airport's corporate philosophy are illustrated in Table 10-9.

Table 10-8 Corporate Philosophies of Japan's Three Major Airport Operators

Airport Companies	Narita International Airport Corporation	Kansai Airport Co., Ltd.	Centrair Group
Safety	We relentlessly pursue safety, aiming to be a trusted airport.	We operate the airport with safety and security as our top priority.	
Customer Satisfaction	We pursue customer satisfaction and provide services that exceed expectations.	We achieve the highest customer satisfaction through swift operational processes and customer service leveraging our extensive experience.	Guided by the principle of "Customers First," we contribute to the development of 21st-century domestic and international aviation networks by providing attractive services.
Environment and Community Coexistence	We aim to be an environmentally conscious airport that coexists with the community.	We will actively collaborate with local communities and continue to be an airport that contributes to the realization of a sustainable society, starting with environmental considerations. Through advanced airport operations, we will contribute to the development of local communities and the regional economy.	As a company rooted in the community, we will strive to be environmentally conscious and contribute to building a prosperous local society.
Sound Management	Through efficient and transparent corporate activities, we pursue sound management and further growth.		We strive for efficient business operations to achieve sound management.
Social Responsibility	We respond to societal expectations with keen sensitivity and flexible, swift action.		We base our corporate conduct on "openness and fairness," striving to be a trusted corporate citizen.
Competitiveness			We gather the world's latest technology and knowledge to build a competitive international hub airport for the 21st century, offering superior convenience and economic efficiency.
Culture			Become a symbol of Japanese and Kansai culture and industry, projecting its appeal to the world.
Human Resources		Develop world-class specialized personnel and foster a culture where employees share a sense of joy and pride in their work.	Strive to develop human resources, establish a free, open, and transparent corporate culture, and maximize the company's vitality.

Source: Prepared by the JICA Study Team based on references 18, 19, 20

18 [経営理念・経営ビジョン | 会社情報 | 成田国際空港株式会社](#)

19 [私たちがめざすもの | 関西エアポート](#)

20 [基本理念 - 方針 | 中部国際空港 セントレア](#)

Table 10-9 Examples of Specific Measures to Realize an Airport's Corporate Philosophy

No.	Measure
1	Promote coordination and agreement with relevant companies to provide passengers with a safe and comfortable experience.
2	Implement continuous maintenance, repairs, renewal, and reconstruction of facilities.
3	Conduct construction works safely without compromising user convenience.
4	Ensure that passengers can remain safe and secure even during emergencies (natural disasters, aircraft accidents).
5	Minimize downtime caused by disruptions in lifeline services or internet connectivity.
6	Improve efficiency in energy use.
7	Reduce lifecycle costs.

Source: The JICA Study Team

(2) AIR

Based on the measures in Table 10-9 and the findings from Chapter 7, key points for developing AIR in the airport sector are summarized in Table 10-10. Moreover, general considerations when applying the AIR template (draft) developed in Section 6.6 to airport projects are presented in Table 10-11.

Table 10-10 Key Considerations for Developing AIR in Relation to Airport Corporate Philosophies

No.	Specific Measures to Realize the Corporate Philosophy	Key AIR Considerations
1	Promote coordination and agreement with relevant companies to provide passengers with a safe and comfortable experience.	- Identify the information required by each stakeholder for facility use and operational activities through meetings and by developing data-flow diagrams. - Organize the information to be submitted during regulatory inspections.
2	Implement continuous maintenance, repairs, renewal, and reconstruction of facilities.	- In accordance with airport management manuals, define information requirements for 3D/2D data, still images/video captured during inspections, damage drawings, and laboratory test data. - Model underground assets.
3	Conduct construction works safely without compromising user convenience.	- From the perspective of operators and users, key concerns include construction schedules, occupied areas, and noise/vibration; reflect these aspects when deriving information requirements for PIR.
4	Ensure that passengers can remain safe and secure even during emergencies (natural disasters, aircraft accidents).	- Where a Business Continuity Plan (BCP) is in place, refer to the BCP to identify related information requirements.
5	Minimize downtime caused by disruptions in lifeline services or internet connectivity.	- Required information may include pending preventive-maintenance items, response manuals for service outages (troubleshooting procedures), available response personnel, notifications of failure locations, and access methods to affected areas.
6	Improve efficiency in energy use.	- Particularly during expansion projects, confirm the existence of current FM systems and evaluate whether to integrate with existing systems, upgrade systems, or operate a separate independent system.
7	Reduce lifecycle costs.	- Consider total cost reduction across design/construction, operations/maintenance, and decommissioning, including methods for improving efficiency and perspectives from operational and maintenance planning.

Source: The JICA Study Team

Table 10-11 General Considerations When Developing AIR for Airport Projects

No.	Title	Key AIR Considerations
2	AIR Item List	Based on practices in BIM-mature countries, IFC should be adopted as the default file format in airport projects.
3	Asset Classification and Deliverable Structure	Based on international precedents, classification systems such as Uniclass or OmniClass should be used in airport projects. The deliverable types should follow COBie standards, in line with practices in BIM-mature countries. The level of detail for deliverables should be set to LOD 100–200 for the operational phase, consistent with international benchmarks.
4	Information-Management Structure and Responsibilities	Airport projects involve a wide range of stakeholders. To prevent future disputes regarding responsibility allocation, records of coordination meetings (minutes) should be stored within the BIM environment. From a security perspective, appropriate access permissions should be set within the CDE in consultation with relevant authorities and departments.
5	Information Update, Review, and Governance	Information required to verify alignment with applicable laws and guidelines should be identified, and such information should be handled within the BIM environment.

Source: The JICA Study Team

(3) PIR

When formulating the PIR based on the measures in Table 10-10 and the associated AIR considerations, no airport-specific exceptions are required. PIR can be developed by identifying the information that must be acquired during delivery and handed over to the employer, following the principles of ISO 19650.

Taking into account the PIR template (draft) developed in Section 6.6, the findings in Chapter 8, and the characteristics of airport projects discussed earlier, general considerations for PIR in airport projects are summarized in Table 10-12.

Table 10-12 General Considerations When Developing PIR for Airport Projects

No.	Title	Key AIR Considerations
3	Information Delivery Milestones	In consideration of handover to the operating entity, decision-making schedules and required information should be discussed and clearly defined in advance.
4	Information Purposes and Information Requirements	As noted in Table 10-11, IFC should be adopted as the default file format. Classification systems should be based on Uniclass or OmniClass, and deliverable types should conform to COBie. The level of detail for deliverables should follow international best practices: LOD 300 at the design stage, approximately LOD 350 during construction, and LOD 400 at completion.
7	CDE Operation Policy	Airport construction sites are extensive, and aircraft movement takes priority over construction vehicles. From a productivity perspective, active use of mobile devices is recommended.

Source: The JICA Study Team

(4) EIR

In defining the EIR, the AIR and PIR considerations described above should be further developed in accordance with the concepts of ISO 19650 and the EIR template (draft) presented in Section 6.7.

10.3.3 Reference to ICAO/IATA International Standards

During both project delivery and airport operations, it is necessary to reference international standards issued by ICAO, IATA, and other bodies, and ensure that the information required under these standards is included in the BIM information requirements. As noted in Section 6.6.4, such international documents may be incorporated into national legislation or airport-management manuals in some countries; therefore, it is essential to confirm the presence of relevant national documents.

It is also important to confirm which standards are referenced by the regulatory authority. Accordingly, at the start of the project, it is imperative to identify all documents that must be complied with during the delivery and operational phases when compiling BIM information requirements.

10.3.4 Use of GIS for Environmental Measures and Coexistence with Local Communities

When organizing information related to environmental measures or coexistence with local communities—such as noise, ecosystems, and landscape/visual-impact considerations around the airport—GIS may serve as a valuable component of the CDE. As identified in Chapter 8, certain GIS products can be integrated with BIM models. Where environmental and community-related measures are addressed within BIM, it is advisable to consider the use of GIS.

11 IMPLEMENTATION OF BIM INFORMATION MANAGEMENT REQUIREMENTS IN CONTRACT DOCUMENTS FOR ODA LOAN PROJECTS

11.1 Institutional Challenges in Integrating Information Management Requirements into Contract Documents

As discussed in the preceding chapters, the ISO 19650 series provides a robust framework for enhancing information management in official development assistance (ODA) loan projects. It serves as the foundation for structuring information requirements, standardizing deliverables, and designing the operation of the Common Data Environment (CDE), thereby supporting seamless information flows throughout the project lifecycle.

However, translating these information management requirements into practice requires institutional arrangements within the contract documentation. Implementing the ISO 19650 series is not merely a technical intervention as it involves clarifying contractual rights, obligations, and responsibilities, and establishing a legal framework that enables consensus between the Employer and the Contractor.

In ODA loan projects, which are implemented under an international contractual environment based on FIDIC Conditions of Contract, a key challenge is how to incorporate ISO 19650 requirements within the contract documents. Although current bidding documents often include technical requirements related to Building Information Modeling (BIM), contractual elements concerning information management—such as obligations for information submission, conditions for CDE use, procedures for verification and approval of deliverables, and intellectual property (IP) arrangements—are not often formally articulated. As a result, inconsistencies in project information, unclear allocation of responsibilities, and disputes over the reuse of deliverables may arise during project execution.

11.2 Incorporation of the Information Protocol into Contract Documents Under ISO 19650

The ISO 19650 series defines the “Information Protocol” as the contractual foundation for information management. While ISO 19650-2 establishes the “Project Information Protocol” and ISO 19650-3 defines the “Asset Information Protocol.” These documents cover the requirements related to CDE usage, submission, approval and reuse of information, intellectual property rights, security, and licensing conditions.

Both standards require Information Protocol to be incorporated into all contractual appointments—positioning it as a mandatory component of contract documentation.

Among its contents, the treatment of intellectual property rights is particularly critical for mitigating contractual risks related to the submission, reuse, and third-party sharing of BIM deliverables. BIM generates a wide variety of information—models, attribute data, specifications, and processes—each associated with various IP rights, such as copyright, trade secrets, and trademarks. Contract documents must clearly define the ownership of copyright, scope of permitted use, conditions for reuse, and restrictions on third-party provision.

For ODA loan projects, a key requirement is to ensure alignment with FIDIC Conditions of Contract while formalizing the Information Protocol within the contract documentation.

11.3 International Trends in Contractual Implementation of Information Management Protocols

Considering the increase in adoption of the ISO 19650 series, many countries have developed or updated information management protocols in line with the standard, embedding them into contract documents to establish a legal basis for information management.

11.3.1 United Kingdom: Information Protocol under the UK BIM Framework

The “Information Protocols supporting the delivery phase and the operational phase of assets” (Edition 3, August 2022) developed under the UK BIM Framework are widely used as ISO19650-compliant contractual instruments. These documents replaced the former CIC BIM Protocol and can be given legal effect through an incorporation clause within contract documents.

The template (provided in Word format) can be customized to suit project-specific EIRs and information management arrangements. It covers information management responsibilities, formats for information exchange, CDE operation rules, security requirements, and treatment of intellectual property rights.^{1, 2}

11.3.2 United States: AIA and Consensus Contract Addenda

In the United States, the American Institute of Architects (AIA) discontinued its previous “E203–2013: Building Information Modeling and Digital Data Exhibit” and issued a new suite of contract documents in 2022. These documents are designed to be attached as Exhibits to design and construction contracts rather than as independent documents. They define project-specific BIM requirements, including information management responsibilities, BIM model sharing, intellectual property arrangements, and Levels of Development (LOD). The main documents are listed in Table 11-1.

Table 11-1 AIA 2022 BIM and Digital Practice Contract Document Suite

Document Code	Description
E201–2022	BIM exhibit for listing model versions as contract documents
E202–2022	BIM exhibit for projects where model versions are not listed as contract documents
E401–2022	BIM exhibit for model sharing within the design team only
E402–2022	BIM exhibit for model sharing within the construction team only
G203–2022	BIM Execution Plan: information exchange, naming conventions, update frequency, security
G204–2022	Model Element Table (detailed) indicating LOD and responsibility assignment
G205–2022	Model Element Table (simplified) providing simplified LOD/responsibility management
C106–2022	Digital Data Licensing Agreement (IPR management)

Source: The JICA Study Team

These documents do not explicitly reference ISO 19650, but they include key concepts such as EIR, CDE, LOD, and information management responsibilities.

11.3.3 Australia

According to the NATSPEC BIM Guide³, there is no formally developed or approved standardized information management protocol for the Australian and New Zealand markets. The Guide highlights potential risks arising from inconsistencies between terminologies used in AS ISO 19650 and those used in local contracts. As an interim measure, NATSPEC recommends referring to the following documents:

- United States: AIA and ConsensusDocs Contract Document Suites

¹ [Guidance-about-the-Information-Protocols-supporting-the-delivery-and-operational-phase-of-assets.pdf](#)

² [Information protocols supporting the delivery phase BS EN ISO 19650-2 and the operational phase BS EN ISO 19650-3 of assets-Guidance Edition-3.pdf](#)

³ [NATSPEC BIM - NATSPEC National BIM Guide](#)

(Note: At the time of publishing the NATSPEC BIM Guide, E203-2013, G201-2013, and G202-2013 were referenced, however, as noted in Section 11.3.2, E203-2013 has since been withdrawn and replaced by the updated 2022 document suite listed in Table 11-1.)

- United Kingdom: BIM Task Group Project Documentation (including the CIC BIM Protocol)
- Australia: AIA-CA BIM and Legal and Procurement Report

11.3.4 Hong Kong

In Hong Kong, the “CIC BIM Standards – General” developed by the Construction Industry Council (CIC) serves as a widely adopted ISO 19650-aligned information management framework. The standards are fully consistent with the principles, workflows, and requirements of ISO 19650 and include the Hong Kong Local Annex to ISO 19650-2:2018, thereby establishing a mechanism for adapting international standards to the local context.

In terms of contractual application, the CIC BIM Standards are designed for use as contractual supporting documents and are typically applied together with the CIC BIM Exchange Information Requirements (EIR) template and the Appendix D information requirements templates.⁴ Additionally, the CIC has issued BIM Special Conditions of Contract (SCC) and BIM Services Agreements, which complement implementation as binding contractual provisions.⁵

11.4 Status of BIM and Information Management Protocol Development under FIDIC Conditions of Contract

At present, FIDIC has not issued a formal Information Protocol aligned with the ISO 19650 series. While FIDIC’s post-2017 editions encourage the addition of BIM requirements through Special Provisions, there is still limited guidance, and practical challenges persist regarding the reflection of requirements in contract documents.

The BIM Advisory Note published in November 2022 represents FIDIC’s first attempt to formally organize contractual considerations related to BIM. However, its contents are mainly conceptual and advisory, and do not provide concrete clause examples or methods for integrating BIM requirements into contract documents. Consequently, practitioners have pointed out that it is difficult to apply the document directly at the contract administration level.

Although the Advisory Note appropriately recognizes BIM not merely as a technical tool but also as an institutional framework involving contractual aspects—such as information sharing, responsibility allocation, intellectual property rights (IPR), and security—FIDIC has yet to develop specific contractual supplementary documents (e.g., Information Protocols or Technology Guidelines) that are fully aligned with ISO 19650.

FIDIC has established a BIM Task Group (TG) under the Digital Transformation Committee (DTC), which is currently revising the Advisory Note. The revision aims to update BIM definitions and technological context and to examine methods for integrating ISO 19650-aligned requirements into contract documents. However, even the revised edition—planned for submission to the FIDIC Board by the end of February 2025—may not necessarily provide detailed implementation guidance, and its level of specificity remains uncertain.

In summary, although FIDIC has indicated a future direction for integrating BIM and information management frameworks, it has not yet provided clear, actionable methods for incorporating these elements into contract documents. For ODA loan projects, this implies a need to supplement FIDIC contracts with country-specific practice, international examples, and ISO 19650 principles to address gaps in current contractual arrangements.

The BIM Advisory Note identifies the following contract clauses that require special attention in

⁴ [CIC BIM Standards - General \(2024\)](#) , with templates in [Appendix D](#) | [Publications](#) | [Resources](#) | [BIM](#)

⁵ [CIC BIM Special Conditions of Contract for BIM \(in line with ISO19650\)_2021](#)

BIM-enabled projects:

1.1	Definitions
1.3	Notices and Other Communications
1.5	Priority of Documents
1.10	Employer's Use of Contractor's Documents
1.11	Contractor's Use of Employer's Documents
1.15	Limitation of Liability
2.3	Employer's Personnel and Other Contractors
2.5	Site Data and Items of Reference
3.2	Engineer's Duties and Authority
4.1	Contractor's General Obligations
4.4	Contractor's Documents
4.6	Co-operation
4.7	Setting Out
4.9	Quality Management and Compliance Verification Systems
4.20	Progress Reports
6.8	Contractor's Superintendence
6.10	Contractor's Records
8.3	Programme
9.1	Contractor's Obligations (Tests on Completion)
13.3	Variation Procedure
17.3–17.6	Intellectual and Industrial Property Rights and Indemnities
19.2.6	Other insurances required by Laws and by local practice

These provisions illustrate that FIDIC is gradually expanding its treatment of BIM and information management. However, the absence of a fully developed and ISO 19650-aligned contractual supplement means that ODA loan projects must adopt complementary measures that reflect international best practices while addressing project-specific and country-specific needs.

In particular, future standardization of a contractual document equivalent to the ISO19650 “Information Protocol” would provide a practical foundation for clarifying roles and responsibilities between employers and contractors, and would significantly support effective BIM implementation in ODA loan projects.

11.5 Analysis of ISO 19650 Implementation Cases under FIDIC Contracts

11.5.1 Implementation of BIM Requirements in Contract Documents for the Rail Baltica Project

Rail Baltica is a high-speed railway development project connecting Estonia, Latvia, and Lithuania, implemented under EU funding and international contractual arrangements. Under FIDIC standards, the civil and architectural works adopt a Design–Bid–Build approach based on the FIDIC Red Book and the railway system works adopt a Design–Build approach based on the FIDIC Yellow Book. Procurement and contractual information for Rail Baltica can be accessed through the project's official portal.⁶

In the Rail Baltica mainline construction project in Latvia, the FIDIC Red Book (2017, 2nd Edition) is used as the General Conditions, and BIM-related provisions are included across Particular Conditions Part A (Contract Data) and Particular Conditions Part B (Special Provisions).

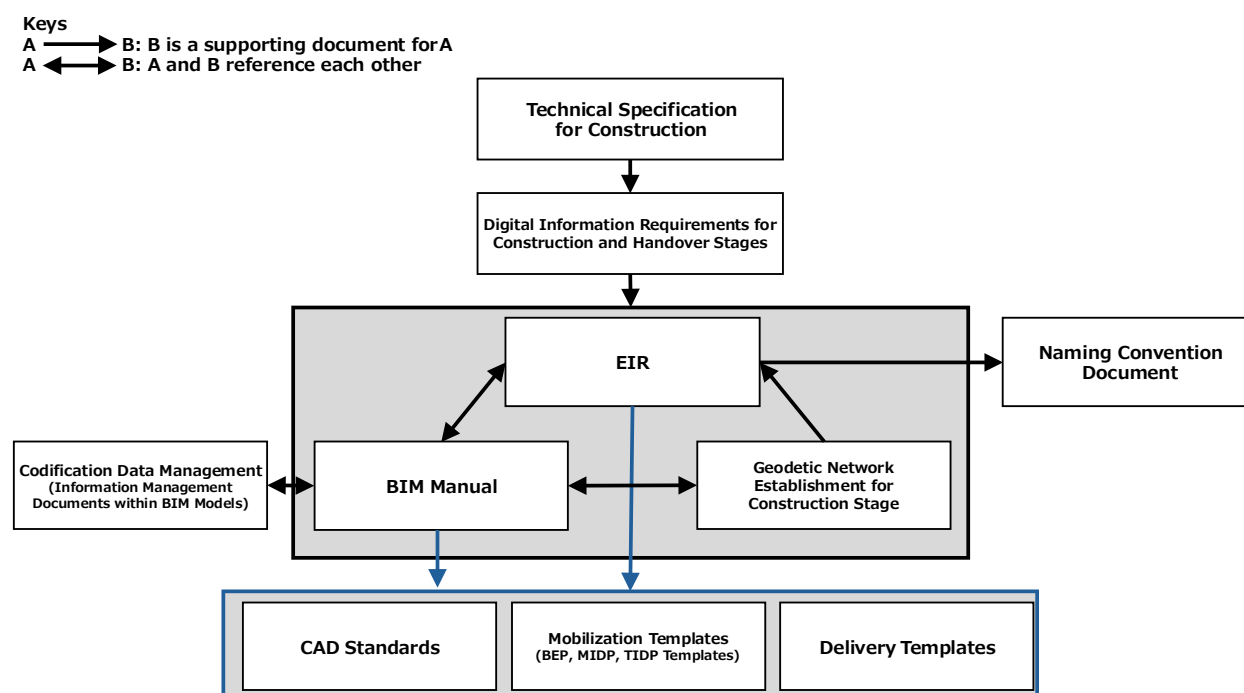
Key contractual mechanisms demonstrating alignment with the ISO 19650 series include:

- Sub-clause 1.3 (Notices and Other Communications):
Specifies the use of ProjectWise as the document management system, thereby establishing a contractual framework for operating the Common Data Environment (CDE).
- Sub-clause 1.10 (Employer's Use of Contractor's Documents):
Stipulates conditions under which the Employer may use documents and designs produced by the

⁶ [E-Procurement system - RB](#)

Contractor. This provision clarifies intellectual property rights and the scope of usage. Notably, where specified in the Technical Requirements, the Employer is granted an exclusive license for documents produced under the contract. The term royalty-free has been removed, implying that use of such documents may require payment.

Detailed BIM-related requirements are set out in the Technical Specifications. The “Technical Specification for Construction” references two additional documents—Digital Information Requirements and Exchange Information Requirements—that collectively serve as the equivalent of the ISO 19650 Information Protocol. These documents codify requirements concerning information submission, approval, reuse, intellectual property rights, and information security.



Source: Prepared by the JICA Study Team based on Rail Baltica documentation

Figure 11-1 Relationship Between Technical Specifications and Key BIM-Related Documents

Additionally, the Rail Baltica contract contains multiple provisions designating BIM models as contractual deliverables. These provisions define contractual processes for model submission, approval, modification, and usage. This aligns with the ISO 19650 principle of treating models as formal information deliverables, ensuring that BIM carries legal effect within the contract documentation.

Overall, the Rail Baltica project demonstrates a comprehensive approach to embedding the ISO19650 Information Protocol within both the technical specifications and contract clauses, thereby achieving contractual implementation of information management requirements.

11.5.2 Analysis of ODA Loan Project Examples in the Railway, Road, and Airport Sectors

ODA loan projects have also started establishing BIM-based information management frameworks, particularly in the railway, road, and airport sectors. Several projects have attempted to incorporate BIM requirements into contract documents based on FIDIC Conditions of Contract. Representative examples are summarized below.

(1) Project A (Railway)

This project adopts a contract structure based on the FIDIC Yellow Book. Although Particular Conditions Part B (Special Provisions) do not include explicit BIM clauses, BIM requirements are incorporated within the Technical Specifications. These specify the establishment of an information management framework aligned with ISO 19650 principles of which includes project naming conventions, use of a CDE, model

submissions based on LOD, and information submission requirements—which are documented in a separate EIR-equivalent annex. As a result, BIM-based information management is implemented, though explicit contractual statements outside the Technical Specifications are limited.

(2) Project B (Railway)

This project uses contract documents based on the FIDIC Red Book. As with Project A, Particular Conditions Part B do not contain explicit BIM clauses, however, sections of the Technical Specifications specify BIM model submission requirements, LOD definitions, and deliverable verification processes. Although there are limited references to the usage of CDE, the Employer has prepared documentation equivalent to an EIR, presenting the information management policy for the design and construction phases. There are also partial provisions related to intellectual property rights and information security.

(3) Project C (Railway)

This project adopts a contract structure based on the FIDIC Yellow Book. Similar to the previous cases, explicit BIM clauses do not appear in Particular Conditions Part B, but BIM-related scope, submission procedures, and approval processes are defined within the Technical Specifications. Provisions align closely with ISO 19650-2 requirements and include conditions for model reuse, update frequency, and naming conventions. However, key aspects—particularly the allocation of responsibilities between contracting parties during model development—are not explicitly defined and are left to the Contractor’s proposal.

(4) Project D (Airport)

This project adopts the FIDIC Pink Book (MDB Harmonized Edition). Although Particular Conditions Part B do not include explicit BIM clauses, BIM-related requirements are organized within the Technical Specifications. These requirements include project milestones, LOD-based model submissions, CDE usage, COBie-based equipment data recording, verification of IFC interoperability, schedules for coordination meetings, hardware/software specifications, and allocation of responsibilities among stakeholders.

11.6 Contractual Integration of BIM Requirements in JICA Standard Bidding Documents

The institutional development of BIM and information management protocols under the FIDIC Conditions of Contract is ongoing, and future standardization trends continue to attract attention. However, as of today, FIDIC has not formally established any contractual supplementary documents within its core suite, such as an ISO 19650-compliant information protocol. Consequently, the practical method for incorporating ISO 19650 requirements into contract documents is still left largely to the discretion of the Employer.

This section organizes how information management requirements based on the ISO 19650 series should be allocated within JICA’s Standard Bidding Document for Works (SBD), distinguishing the roles of the contractual clauses (Particular Conditions of Contract), technical specifications (Works Requirements), and bidding-stage documents (Bid Data Sheet and Bidding Forms).

11.6.1 Structure of JICA Standard Bidding Documents and Policy for Positioning Information Management Requirements

The structure of JICA SBD has the following characteristics:

- Additional contractual clauses are stipulated in the Particular Conditions of Contract.
- Technical specifications are described in the Works Requirements.
- The Instructions to Bidders are, in principle, not subject to modification; project-specific conditions are supplemented through the Bid Data Sheet.

Based on this structure, the information management elements defined in the ISO 19650 series can be aligned with the JICA SBD documentation framework and organized into a three-layer structure, as shown in Table 11-2, consisting of: legally binding contractual obligations, practical technical specifications, and bidding-stage verification of capability and planning.

Table 11-2 Positioning of ISO 19650 Information Management Elements within JICA SBD

JICA SBD Documents Group	Corresponding ISO 19650 Information Management Elements	Notes
Particular Conditions of Contract	- Information Protocol (contractual information management obligations) - IPR, digital data usage rights, allocation of responsibilities	Defines legal obligations, rights, and risk allocation. Establishes the requirement to comply with technical specifications.
Works Requirements	- Exchange Information Requirements (EIR) - Information Standard (naming conventions, classification systems, attribute requirements) - Information Production Methods and Procedures (CDE rules, submission procedures) - Post-contract BEP (information management plan after contract award)	Sets out technical requirements related to content, formats, procedures, and CDE operation.
Bid Data Sheet/ Bidding Forms	- Pre-contract BEP - Capability and capacity assessment (information management competency)	Submissions required from bidders to demonstrate capability, resources, and information management proposals.

Source: The JICA Study Team

From the above information, applying ISO 19650-based information management requirements to ODA loan projects requires:

- Include the Information Protocol as a contractual clause in the Particular Conditions of Contract;
- Clearly define technical requirements such as the EIR and Information Standard in the Works Requirements; and
- Specify required submissions within the Bid Data Sheet and Bidding Forms.

These measures ensure legal enforceability, technical clarity, and proper evaluation of bidders' information management capacity, enabling consistent and ISO 19650-aligned implementation of BIM within ODA loan project contracts.

11.6.2 Proposed Supplementary Clauses for Inclusion in the Particular Conditions of Contract

Table 11-3 presents proposed supplementary clauses related to BIM and information management for inclusion in the Particular Conditions of Contract (Part B – Specific Provisions). These have been prepared with reference to the ISO 19650 implementation examples under FIDIC contracts summarized in Section 11.5.

Table 11-3 Proposed Supplementary Clauses for the Particular Conditions of Contract

Sub-clause (PC)	Proposed Supplementary Clauses
1. General Provisions Sub-Clause 1.3 [Communications]	Add the following paragraphs at the end of the Sub-Clause: "Any communication, including any Notice, approval, consent, determination, request, statement or submission, which is transmitted using any of the agreed systems of electronic transmission stated in the Contract Data, including the Employer's designated Common Data Environment (CDE) , shall be deemed to have been delivered to and received by the recipient on the day following the day on which such communication is transmitted through that system, unless otherwise expressly stated in the Contract. For the avoidance of doubt, transmission of any communication through the Common Data Environment shall constitute transmission "in writing" for the purposes of this Sub-Clause."
1. General Provisions Sub-Clause 1.10 [Employer's Use of Contractor's Documents]	1) Replace sub-paragraph (b) of the second paragraph of the Sub-Clause with the following: "(b) entitle the Employer and any person in proper possession of the relevant part of the Works to copy, reproduce, adapt, modify, grant access to, translate, use in any existing or known mode and communicate the Contractor's Documents (and such other design documents, if any) for the purposes of completing, operating, maintaining, altering, adjusting, improving, repairing and demolishing the Works, or completing any analogous works and/or arranging for any other entities to do so;" 2) Replace sub-paragraph (c) of the second paragraph of the Sub-Clause with the following: "(c) in the case of Contractor's Documents (and such other design documents, if any) which are in the form of electronic or digital files, computer programs and other software, permit their deployment on, use on, or access from any computer or device on the Site and/or at the locations of the Employer and the Engineer and/or at other places as envisaged by the Contract, and change the format of any such files; and" 3) Add the following paragraphs at the end of the Sub-Clause: The license granted under this Sub-Clause shall survive the termination of the Contract for any reason. The royalty for the license is included in the Contract Price, and neither Party shall have any Claim in respect thereof.
4. The Contractor Sub-Clause 4.1 [Contractor's General Obligations]	Add the following sentence following to sub-paragraph 4.1 (a) of the Sub-Clause: "For the purposes of this Sub-Clause, where the Contractor's Documents are prepared using computer-based design or modelling tools, these documents shall be submitted to the Engineer, when requested, in an editable format corresponding to the native file format of the software used."
4. The Contractor Sub-Clause 4.9 [Quality Assurance]	Add the following sentence at the end of the first paragraph: "The quality assurance system shall include procedures for the management, control and verification of digital and design information, where required by the Specification or other Contract documents."
9. Tests on Completion Sub-Clause 9.1 [Contractor's Obligations]	Add the following paragraph at the end of the Sub-Clause: "For the purposes of this Sub-Clause, the documents to be provided by the Contractor and considered in connection with the Tests on Completion shall include, where required by the Specification or other Contract documents, information deliverables, digital data and records."
17. Risk and Responsibility Sub-Clause 17.5 [Intellectual and Industrial Property Rights]	After sub-paragraph (ii) , replace the concluding punctuation with "; or" and add the following new sub-paragraph (iii) : " (iii) the use of Contractor's Documents."

Source: The JICA Study Team

The intent of each supplementary clause proposed in Table 11-3 is explained below.

(1) Sub-Clause 1.3 [Communications]

This supplementary clause explicitly positions information transmission via the Common Data Environment (CDE) as formal “communication in writing” under Sub-Clause 1.3 of the General Conditions of Contract (GCC). While GCC 1.3 permits electronic transmission, it does not clearly define the date of receipt or the legal effect of communications transmitted via CDE. Accordingly, this clause clarifies that notices, approvals, and submissions transmitted through the Employer-designated CDE constitute valid contractual communications, thereby preventing disputes regarding the effectiveness of notices, reviews, and approvals.

(2) Sub-Clause 1.10 [Employer’s Use of Contractor’s Documents]

This supplementary clause further clarifies the scope and methods of use under the perpetual, transferable, non-exclusive, and royalty-free license stipulated in GCC 1.10. In particular, it explicitly permits “the copying, modification, translation, and derivative use”, “multi-location and multi-device use”, and “file format conversion of electronic deliverables” such as BIM models, digital design data, and software. By additionally stipulating that the license survives termination of the Contract, the clause secures long-term data usage rights for asset management and lifecycle use.

(3) Sub-Clause 4.1 [Contractor’s General Obligations]

While GCC 4.1 (a) requires submission of Contractor’s Documents, it does not clearly specify the obligation to submit BIM models or CAD data in editable native formats. This supplementary clause explicitly requires the Contractor, upon request by the Engineer, to submit digital deliverables in the native, editable file format of the software used. This ensures:

- Efficient review and approval by the Engineer;
- Future updating, modification, and maintenance by the Employer; and
- Avoidance of operational constraints caused by irreversible formats such as PDFs.

The clause therefore contractually guarantees the usability and reusability of digital deliverables.

(4) Sub-Clause 4.9 [Quality Assurance]

GCC 4.9 requires a quality assurance system, but its scope is primarily focused on construction quality and execution procedures, without clearly addressing the quality of digital information such as BIM models, attribute data, or CDE records. This supplementary clause enables the inclusion, where required, of digital information quality management, information consistency checks, and CDE workflow management and controls within the QA system, thereby contractually supporting the information quality verification processes required under ISO 19650.

(5) Sub-Clause 9.1 [Contractor’s Obligations]

In Tests on Completion (ToC), not only the physical completion of the Works but also the delivery of information deliverables—such as information models, data, and records—constitutes an essential basis for acceptance. However, GCC 9.1 is primarily premised on paper-based deliverables and does not clearly state that submission of digital information is a prerequisite for ToC. This supplementary clause explicitly allows information deliverables to be included in the scope of ToC, clarifying that delays in information handover may constitute delays in completion under the Contract.

(6) Sub-Clause 17.5 [Intellectual and Industrial Property Rights]

Following precedents such as Rail Baltica, this supplementary clause explicitly adds third-party intellectual property claims arising from the “use of Contractor’s Documents” to the scope of Contractor indemnity. Under the existing GCC 17.5, indemnity is limited to claims arising from (i) Goods and (ii) design responsibility, leaving risks associated with the use of BIM models and digital deliverables insufficiently addressed. By adding “the use of Contractor’s Documents” as item (iii), the clause clearly defines and allocates risks related to copyrights, patents, and other intellectual property arising from the use of models and data, in a contractually robust and dispute-resilient manner.

11.6.3 Positioning of Information Management Requirements within the Works Requirements

Table 11-4 presents information management requirements that should ideally be attached to the Works Requirements. These items represent key elements commonly referenced in ISO 19650-based information management and are organized by purpose-specific categories. They may be selectively applied according to the characteristics of each project.

Furthermore, technical prerequisites such as information standards, classification systems, and naming conventions must be defined and presented by the Employer together with the EIR as project-specific information requirements. Based on these prerequisites, the Contractor is required to operationalize the approach in the BEP, detailing information-production methods, planning and scheduling (MIDP/TIDP), role and responsibility allocation, and risk-management measures.

Table 11-4 Information Management Requirements to be Included in the Works Requirements

Category	Information Management Elements (Examples)	Overview
Employer's Information Requirements	Exchange Information Requirements (EIR)	Specifies the scope, granularity, quality criteria, and submission conditions for the information required by the Employer.
	Level of Information Need (LoIN)	Defines the amount, attributes, and accuracy of information required for drawings, models, data, and other deliverables.
	Security Requirements (ISO 19650-5)	Establishes protection levels for information assets, access control procedures, and project-specific security protocols.
Information Standards and Technical Standards	Information Standard	Defines unified project rules such as naming conventions, attribute requirements, classification systems, and coordinate reference systems.
	Information Production Methods & Procedures (IPM&P)	Specifies CDE workflows, review and approval procedures, information exchange processes, and file formats used for information production.
Planning and Scheduling	Master Information Delivery Plan (MIDP) template or requirements	Sets out the full list of project information deliverables, submission schedule, and allocation of responsibilities.
	Task Information Delivery Plan (TIDP) template or requirements	Organizes the submission schedule of each individual task team or author for their respective information deliverables.
	Mobilization Plan	Details the implementation plan for CDE setup, account creation, establishment of information management structures, and initial testing.
Roles, Responsibilities, and Risk Management	High-level Responsibility Matrix (e.g., RACI)	Defines the roles and responsibilities for producing, reviewing, and approving information.
	Risk Register (Information-related Risks)	Identifies and assesses risks associated with information delays, poor data quality, security breaches, and defines mitigation strategies.

Source: The JICA Study Team

11.6.4 Proposed Supplementary Clauses for the Bid Data Sheet and Bidding Forms

Table 11-5 presents the proposed clauses pertaining to BIM and information management to be included in the Bid Data Sheet and the Bidding Forms.

Table 11-5 Proposed Supplementary Clauses for the Bid Data Sheet and Bidding Forms

Sub-Clause (ITB / Form)	Proposed Supplementary Clauses
ITB 11.2 (Technical Bid – Required Documents)	Add the following items to ITB 11.2 (i) in the Bid Data Sheet: 1. Pre-contract BIM Execution Plan (pre-contract BEP) prepared in accordance with the ISO 19650 series, including: • Information Management Approach • Roles & Responsibilities (incl. proposed Information Manager) • Outline of the proposed use of the Common Data Environment • Summary response to the Employer's Exchange Information Requirements (EIR) 2. Information Management Capability Statement, including: • Experience in operating a Common Data Environment • Curriculum Vitae of the proposed BIM Manager • Past project records aligned with ISO 19650 or equivalent standards 3. (Optional) Evidence of the Bidder's ability to comply with the Information Protocol included in Section VIII.
Technical Proposal Form (Section IV – Forms)	Add the following required documents under the Technical Proposal list : • BIM Execution Plan (pre-contract BEP) Notes for Bidder: The Bidder shall submit pre-contract BEP including: • Outline BIM Method Statement • Draft Master Information Delivery Plan (MIDP) • Draft Task Information Delivery Plans (TIDP) • Outline CDE workflow and information exchange procedures (concept level) • Summary response to the Employer's EIR *Draft MIDP/TIDP are non-binding, indicative submissions intended to demonstrate understanding of the EIR and the ISO 19650 information delivery process. Notes for Employer: At the pre-bid meeting (if held) , the Employer will present the Information Requirements, including the EIR and outline of the CDE solution as defined in the Works Requirements.

Source: The JICA Study Team

11.7 Assessment of Information Management Capability at Tender Stage under ISO 19650

This section organizes the capability assessment (Assessment) framework defined in the ISO 19650 series and introduces assessment templates developed by various institutions. These findings serve as important reference examples for concretizing bid evaluation in the JICA Standard Bidding Documents discussed in the preceding section.

11.7.1 Positioning of Capability Assessment in ISO 19650

ISO 19650-2 explicitly defines the Employer's process for assessing the information management capability of tenderers. Clauses 5.2 and 5.3 require the Employer to conduct a capability assessment based on the Exchange Information Requirements (EIR).

The evaluation consists of the following two components:

- **Capability:**
Technical ability to create, manage, and deliver information, including knowledge and experience in BIM and information management, understanding of international and national standards, and the usage of systems/tools.
- **Capacity:**
Availability of adequate resources—including human resources (team size, role allocation, responsible persons), technological resources (software, hardware, CDE), and time resources (ability to meet schedule milestones).

The Employer uses the pre-appointment BEP submitted by tenderers as a primary reference document. Based on its contents, the Employer conducts the capability assessment and selects the contractor accordingly.

However, ISO 19650 only presents the overarching assessment framework and does not prescribe detailed evaluation methods. The specific assessment approach must be tailored to each project, taking into account factors such as project scale, complexity, criticality, organizational maturity in information management, procurement route (e.g., Design–Bid–Build vs. Design–Build), and contract structure (single contractor, joint venture, consortium, etc.).

ODA loan projects require a similar approach where assessments follow ISO 19650 principles while being adapted to the context and operational realities of each project.

The following section introduces representative templates for BIM/information management capability assessment—including the CPIx Protocol (CPIC) and the Capability and Capacity Assessment (CDBB)—which offer useful reference points for developing evaluation criteria within JICA’s SBD.

11.7.2 Reference Templates and Guidelines for Information Management Capability Assessment

11.7.2.1 CPIC: CPIx Protocol

The CPIx Protocol is a suite of practical templates issued by the Construction Project Information Committee (CPIC) to support project information management (See Table 11-6). It was developed in alignment with BS 1192 and PAS 1192-2 to support the UK government’s implementation of the “BIM Level 2” requirements.

Although the UK transitioned from the PAS 1192 series to the ISO 19650 series in 2019, the detailed assessment items included in the CPIx Protocol remain highly relevant as complementary tools that support practical ISO 19650-aligned assessments. They are still widely referenced as evaluation templates.

Table 11-6 CPIx Protocol Document Suite

文書名	Year of Publication
Pre-Contract BEP (ver.2.0)	February 2011
Post-Contract BEP (rev.1.0)	February 2011
BIM Assessment Form (ver.1.0)	February 2011
IT Assessment Form (ver.1.0)	April 2013
Resource Assessment Form (ver.1.0)	March 2013

Source: Prepared by the JICA Study Team based on CPIC official website

Within the CPIx Protocol, the three assessment forms (BIM/IT/Resource) are submitted as supplementary documents to the pre-appointment BEP. They provide objective evidence for the Employer's capability assessment. Their respective roles are as follows:

(1) BIM Assessment Form (Ver. 2.0)

This form evaluates the BIM competency of the delivery team members (design firms, consultants, contractors, specialist subcontractors, etc.) across multiple perspectives.

Structure
1. Standard Information Basic corporate information. 2. BIM Gateway Question Minimum BIM requirements that must be met to participate in the project. 3. Twelve (12) Areas of BIM Assessment of organizational understanding, experience, and capability across 12 BIM functional domains, including: - Design and construction 3D modelling - Life-cycle costing (LCC/LCA) - Facilities management (FM) - Quantity take-off and cost estimation - Visualization and business development - Safety planning - Clash detection - 4D scheduling - Production BIM - Procurement and purchasing - Supply chain management - Simulation (energy, fire safety, etc.) 4. BIM Project Experience Up to three completed projects demonstrating tangible BIM outcomes and benefits. 5. BIM Capacity Questions Assessment of internal BIM implementation status, organizational structure, resource allocation, collaboration arrangements, etc.

(2) IT Assessment Form (Ver 1.0)

This form evaluates a firm's IT environment, information exchange capability, and data management systems.

Structure
Part 1: General Information and Company Policies on Information Exchange 1.1 General Information Basic company and project details, including project team roles (e.g., CAD/IT managers). 1.2 Project Information Production and Distribution Policies Policies regarding types of information produced, formats for electronic distribution, reuse conditions, software environments, etc.

1.3	Drawing and CAD Management
	Internal standards and management processes for drawings and CAD operations.
1.4	Document Numbering Systems
	Rules for document control and numbering.
1.5	Experience with Web-based Project Tools
	Experience using CDE platforms and project management systems.
1.6	Professional Indemnity Limitations
	Insurance coverage and liability limitations related to electronic information exchange.
1.7	Email Distribution Policies
	Internal policies regarding email communication and emergency procedures.
1.8	Policies on Internet Usage
	Restrictions and policies regarding use of internet resources.
Part 2: Technical Information on Software and Systems	
2.1	IT Infrastructure – Network, servers, and related hardware.
2.2	Operating Systems and Software Applications – Software currently in use.
2.3	Information Transport Capabilities – Data transfer tools and limitations.
2.4	Disaster Recovery Systems and Procedures – Backup and recovery arrangements.
2.5	Archiving Systems and Procedures – Data retention and archiving policies.
2.6	Security Systems – Security measures and compliance.

(3) Resource Assessment Form (Ver. 2.0)

This form evaluates human resource allocation and organizational arrangements for BIM execution.

Structure	
1.	General Information
1.1	General and Project Information Project name, company details, project role, project reference number.
1.2	Organization and Team Information Project team structure and decision-making hierarchy.
1.3	Resource Information Detailed resource profile by project stage, including discipline, training, qualifications, and years of experience.

11.7.2.2 CDBB: Capability and Capacity Assessment

The Centre for Digital Built Britain (CDBB) provides the Capability and Capacity Assessment (CCA) as guidance for evaluating the capability and capacity of suppliers undertaking information management tasks aligned with the ISO 19650 series. The document is positioned as a reference to support the selection of an appropriate Lead Appointed Party and its delivery team for ISO 19650-based projects. Rather than prescribing a fixed evaluation template, the CCA offers practical guidance on example questions and the types of evidence that tenderers may provide.

The CCA consists of a series of questions covering multiple domains such as information management capability, security compliance, and training arrangements. For each question, tenderers provide *Yes/No* responses accompanied by explanatory comments or supporting evidence (See Table 11-7). This ensures that the Employer is able to assess tenderer capability in a quantitative and comparable manner.

The CCA can be used either as a standalone assessment tool or integrated into an existing supplier evaluation process. Question sets may be added or removed depending on project scale and risk level. Evaluation criteria and weightings are project-specific—CDBB does not prescribe a standard scoring ratio.

Table 11-7 CCA Question List

Ref.	Question	Description of Information to Support of Response	Yes	No	Comments or Reference to Relevant Supporting Information
1	Does the team have experience working with a common data environment (CDE), as described in ISO 19650–1:2018 and ISO 19650–2:2018?	Provide evidence of the team(s) previous experience working with a common data environment (CDE). Include references to the platform(s) used and relevant functionality, where applicable.			
2	Does the team have the capability and commitment to operation in accordance with the principles and requirements outlined in the ISO 19650 series?	Provide evidence of the team(s) capability and commitment to implement and comply with these principles and requirements. This may consist of either evidence of past projects, organizational or internal standards that align with these principles, or a statement of commitment.			
3	Does the team have access to the ISO 19650 series?				
4	Does the team have the capability to produce and deliver information in accordance with (depending upon the appointment) an information standard and information production methods and procedures, as described in ISO 19650–2:2018?	Provide evidence of the team(s) previous experience in working with project standards, production methods, and procedures. This may include an example of the document, as well as a description of the team's involvement. OR Identify how you would propose to develop or deliver project standards, production methods, and procedures.			
5	Will any training be required to meet the documentation requirements (including exchange information requirements (EIR)) associated with your appointment on this project?	If 'yes', provide a description of the training to be undertaken and the anticipated timeframes. If applicable, this could be a reference to the mobilization plan. If 'no', provide resumes of the proposed team(s) and their relevant experience and/or training.			
6	Does the team have arrangements for training employees in building information modelling (BIM)-related skills, and do you assess their capabilities?	Provide evidence of the team(s) arrangements to ensure that the proposed team have the appropriate skills and understanding to implement and deliver projects in accordance with the ISO 19650 series principles.			

Ref.	Question	Description of Information to Support of Response	Yes	No	Comments or Reference to Relevant Supporting Information
7	Does the team have the capability and capacity to comply with a security management plan?	Provide evidence of the team(s) previous experience working with a security management plan including a description of your involvement. OR Identify the team(s) ability to adapt to deliver the security requirements, which may include existing security policies and their potential development, including IT hardware and processes.			
8	Does the team have access to the information technologies specified or envisaged within the information standards, information production methods and procedures?	Provide evidence of current information technologies and hardware utilized by the team(s). This may include any plans and timeframes for adopting the necessary information technologies.			
9	Does the team have experience in developing quality control procedures to verify compliance with information requirements?	Provide evidence of the team(s) previous experience in quality control verification.			
10	Does the team have experience in developing quality control procedures to verify compliance with specific standards, methods, and procedures?	Provide evidence of the team(s) previous experience in quality control verification.			

Source: [CDBB Capability and Capacity Assessment Guidance](#)

12 RECONSTRUCTION OF THE DRAFT HANDBOOK

12.1 Background and Rationale for the Update

The previous draft of the handbook introduced the basic concepts for Building Information Modelling/Management (BIM), but, it exhibited several limitations:

- The information management processes based on ISO 19650 series including the structuring of information requirements, the design of information flows, and alignment with contractual documents were not sufficiently reflected.
- BIM was primarily framed as a design support or 3D modeling tool, with limited emphasis on its strategic value for decision-making or its applicability to asset operation and maintenance.
- Concrete implementation guidance on technical elements such as Common Data Environment (CDE), Industry Foundation Classes (IFC), and Construction Operations Building Information Exchange (COBie), as well as staged implementation models, was insufficient.

To address these gaps, the handbook has been enhanced to better support the effectiveness of BIM implementation by ensuring compliance with international standards and providing practical guidance and templates that can be used directly in project delivery.

12.2 Direction of Reconstruction and Key Revisions

The current revision is aligned with the principles of the ISO 19650 series and establishes a systematic hierarchy of information requirements (OIR, AIR, PIR, EIR, SIR). It organizes the technical elements related to CDE and open standards, and presents a staged implementation model. For each project phase, key activities, deliverables, and responsibilities are clearly defined, enabling JICA staff and consultants to understand the expectation for assessment, production, and information management. The structure allows for adjustment and customization based on country-specific regulatory environments and project characteristics.

The main revision points are as follows:

- Reorganization of chapter structures with clear articulation of purpose, scope, and deliverables in alignment with the ISO 19650 series.
- Systematization of definitions, development procedures, and responsibility assignments for OIR, AIR, PIR, EIR, and SIR, and clarification of their relationship with each project phase.
- Clarification of functional requirements for the CDE (approval workflows, access control, clash management, audit logging), the roles and interrelationships of IFC, COBie, and classification systems, and guidance on their integration into contractual documents.
- Presentation of a staged implementation model aligned with ISO 19650 Stages 1 to 3, including considerations during the feasibility study phase and provisions for flexible adaptation to project plan changes.
- Inclusion of draft templates for information requirements (OIR, AIR, PIR, EIR, SIR) in Appendices 1 to 5, enabling direct use in practice.

13 IMPLEMENTATION AND SUPPORT FRAMEWORK FOR BIM INTRODUCTION USING THE RECONSTRUCTED HANDBOOK

This chapter outlines approaches for applying the reconstructed handbook to practical documentation and institutional arrangements. It includes draft Terms of Reference (TOR) for preparatory surveys, operational guidelines for Japan International Cooperation Agency (JICA) staff, and TORs for consultants engaged in official development assistance (ODA) loan projects.

13.1 Updating the Draft Terms of Reference for Preparatory Surveys

To enhance the effectiveness of Building Information Modelling/Management (BIM) introduction in ODA loan projects, the preparatory survey stage must ensure that the Employer and the implementing agency clearly confirm the objectives and policy for BIM introduction and reach an agreement on the information management framework.

In particular, how BIM-related provisions are positioned within the TOR has a direct impact on information quality during subsequent design, construction, and operation and maintenance phases.

13.1.1 Current Trends in TOR Descriptions and Policy for Updating

A review of the TORs for six randomly selected railway, road, and airport preparatory survey projects announced between 2022 and 2025 indicates that BIM/CIM-related descriptions primarily take the following forms:

- Utilization purposes limited to visualization functions, such as “preparation of perspective renderings” or “visual products for decision-making.”
- Optional or proposal-dependent statements, such as “to be proposed in the consultant’s submission” or “to consider introducing BIM.”
- Broad statements combining BIM with other digital technologies, such as “use of Information and Communications Technology (ICT) or digital technologies.”
- Ambiguous descriptions regarding depth and continuity of BIM application, such as “model detail around Level 200” or “consider potential application for maintenance.”

These descriptions indicate the possibility of introducing BIM, however, the positioning of BIM as a consistent information management framework is unclear and lacks essential elements for implementation—including information requirements, deliverables, roles and responsibilities, and contractual arrangements. Furthermore, vague criteria for adopting BIM and unclear support provisions create uncertainty in consensus-building with implementing agencies and in budget formulation.

To address these issues, the TOR for preparatory surveys should be reorganized based on the following principles:

- Clearly define the purpose and scope of BIM introduction, encompassing not only design support but also information management, decision-making support, and operation and maintenance.
- Present a phased implementation model (e.g., Stage 1-3) tailored to the BIM maturity of the implementing agency, and include activities such as supporting the development of OIR and AIR, Common Data Environment (CDE) planning, preparation of IFC/COBie and classification systems, and drafting Exchange Information Requirements (EIR) as TOR items.
- Link the development of information requirements with Plain Language Questions (PLQ)¹ and business process design to clarify the necessity and intended use of each type of information.

¹ A “plain language question” used to clarify information requirements within a project. It is designed to enable the Appointing Party to understand and verify the information needed at each project stage without requiring technical expertise. Its purpose is to confirm information completeness, support decision-making, and ensure consistency with contract documents. It is defined in frameworks such as PAS 1192. For details, refer to Section 5.4 of the draft handbook.

- Specify indicative resource requirements (person-months), technical environment, and capacity-building needs to support transparency in budgeting and contract negotiations.

13.1.2 Proposed Example of Revised Wording

Below is a proposed example of updated BIM-related text for inclusion in the TOR:

This assignment shall be undertaken on the premise of introducing Building Information Management (BIM), and the Consultant shall provide support on the following items:

- Assessment of implementation levels according to the BIM maturity of the implementing agency.
- Support for the development of the business case for BIM introduction, Organizational Information Requirements (OIR), Asset Information Requirements (AIR), and Project Information Requirements (PIR).
- Support for designing the Common Data Environment (CDE).
- Support for the preparation of a draft Exchange Information Requirements (EIR).
- Support for establishing information formats such as IFC, COBie, and construction information classification systems.
- Capacity-building and training for the implementing agency.

In determining the level of BIM introduction, reference shall be made to Stages 1-3 under ISO 19650, and deliverables and supporting content shall be organized accordingly.

13.2 Proposed Operational Guidelines for JICA Staff

To enhance the effectiveness of BIM introduction in ODA loan projects, it is essential that JICA staff—who serve as the Employer during the preparatory survey stage—understand the objectives and policy of BIM introduction from the initial phase of project formulation. Moreover, the staff should be equipped with a framework for appropriate decision-making, evaluation, and monitoring. From when the government of the recipient country becomes the Employer after the Loan Agreement (LA) is concluded to the design and construction stages, a clear established information management policy during the preparatory survey serves as the foundation for implementation in subsequent phases.

In this study, a proposed set of operational guidelines for JICA staff is developed based on the following perspectives.

13.2.1 Establishing Criteria for Decisions on BIM Introduction

At the preparatory survey stage, determining whether BIM should be introduced requires an integrated assessment of project objectives, scale, complexity, importance of maintenance, BIM maturity of the recipient country, and the readiness of relevant information requirements.

Chapter 3 of the draft handbook emphasizes, within a four-step BIM introduction process, that Step 1 (“Developing the Business Case”)² should prioritize ensuring a common understanding among stakeholders, identifying challenges across the lifecycle, and clarifying the purpose of BIM introduction. These elements form the basis of the decision criteria within the proposed operational guidelines.

Specifically, transparency and consistency in decision-making should be ensured based on:

- Whether information needs within the recipient country’s O&M system are clearly defined;
- Whether project deliverables will serve as asset information in the future;
- Whether the implementing agency has the capacity to develop OIR/AIR or requires support; and
- Whether BIM introduction will enhance decision-making and consensus-building.

13.2.2 Clarifying Evaluation Items in the Proposal Review

The current JICA proposal evaluation scoring table does not include a separate evaluation item for BIM. However, proposals related to information requirements can be evaluated under existing categories. The key aspect is not only whether such proposals are included but also the soundness and appropriateness of

² Developing a business case involves evaluating based on quantitative evidence such as return on investment (ROI) and cost-effectiveness to demonstrate the rationale for investment decisions. It differs from a business plan.

their contents.

(1) Implementation Policy and Methodology

Evaluation should focus on information requirements proposed in the following areas:

- Approach, methodology, and evaluation methods for business case development, and how results are incorporated into the Feasibility Study (FS).
- OIR: Alignment with the recipient country's policy objectives and methods for identifying decision-support information.
- AIR: Consistency with asset classification systems (e.g., Uniclass, ISO 12006-2), proposed CDE operation policies, and applicability to O&M phases.
- PIR: Structuring information needed during design, construction, and O&M in alignment with OIR and AIR.
- EIR: ISO 19650-compliant guidance for information exchange and definitions of mandatory items for contractual and deliverable verification.
- Methods for collecting and analyzing information requirements: Use of PLQ, linkage to business process design, etc.
- Clarity of information use: Such as asset management, contract formulation, and deliverable verification.

(2) Work Plan

Evaluation should consider the specificity and feasibility of tasks required for developing information requirements:

- Plans for workshops (e.g., consultations with implementing agencies on OIR/AIR formulation);
- Structure and formats of deliverables (e.g., OIR/AIR/PIR drafts, asset information classification tables); and
- Feasibility of schedules and collaboration arrangements with implementing agencies.

(3) Experience in Similar Assignments

This item evaluates experience in international infrastructure projects involving development of information requirements:

- Experience with O&M support, classification system design, and information standardization³ in infrastructure projects.
- Experience using international standards such as IFC, COBie, classification systems, and CDEs.
- Experience in JICA projects or FIDIC-based contracts involving development of information requirements.

(4) Experience and Capability of Proposed Personnel

Proposal reviews mainly evaluate the experience of the Team Leader and Deputy Team Leader. While these roles do not necessarily require direct BIM expertise, the team must include personnel with the following capabilities:

- Expertise in designing and implementing information requirements (e.g., OIR/AIR/PIR development, template design, PLQ preparation).
- Experience designing or applying information structures based on international standards (Uniclass,

³ Information Standard: Project-specific standards based on ISO 19650 that unify the format, structure, naming conventions, and classification systems of information.

ISO 12006-2, IFC, COBie).

- Experience in stakeholder consultation and providing training for implementing agencies.
- Relevant qualifications (e.g., ISO 19650-related information management certification, IT strategy qualifications, ISO 55000-based asset management qualifications such as JAAM-Certified Asset Manager).

The abovementioned expertise may be assigned either to the Team Leader/Deputy Team Leader or to dedicated information management specialists. Identifying personnel with these capacities strengthens the credibility and feasibility of BIM implementation support.

13.2.3 Verification of Deliverables and Establishing a Continuous Support Framework

Information requirements (OIR, AIR, etc.) and design deliverables (such as IFC models and visualization materials) developed during the preparatory survey are intended for use by the implementing agency during the design and construction stages. However, since it usually takes one to two years before the Loan Agreement is concluded, project plans and BIM-related requirements may be updated in the interim.

When implementing agencies have adequate capacity, they should update information requirements as appropriate and refine the specifications for outsourcing design and construction consultancy services. Where capacity is insufficient, JICA may need to provide monitoring and technical support through mechanisms equivalent to the former SAF to ensure project feasibility.

13.2.4 Approach to Consultation and Consensus-Building with Implementing Agencies

Consultations on BIM introduction inherently involve complex technical aspects, budget, institutional arrangements, and training. The proposed operational guidelines outline a structured process to facilitate smooth consensus-building, including:

- Shared understanding of the business case early in the project.
- Support for developing information requirements.
- Presentation of a phased implementation model.
- Proposal of training and capacity-building plans.

Elements presented in Chapters 3 and 4 of the draft handbook are also applicable to these consultations with implementing agencies. Incorporating these elements into the operational guidelines helps the establishment of a practical support framework.

13.3 Proposed TOR for Consultants Engaged in ODA Loan Projects

To enhance the effectiveness of BIM introduction in ODA loan projects, it is essential to clearly position information-management-related tasks within the scope of services of consultants contracted for the design, procurement, and construction stages. Specifically, BIM-related tasks extend across the design phase (implementation of information requirements), procurement support (drafting contract documents and technical specifications), and construction phase (supervision duties corresponding to the Engineer under FIDIC Conditions of Contract).

(1) Design Phase

1) Support for Updating Information Requirements

While OIR and SIR developed during the preparatory survey are generally maintained, AIR, PIR, and EIR require updating as design details are refined and maintenance policies evolve. The consultant shall support the review and updating of these information requirements and facilitate consensus-building with the implementing agency.

2) Preparation of the BIM Execution Plan (BEP) based on the EIR

In accordance with the EIR issued by the implementing agency, the consultant shall prepare the BEP, including the Master Information Delivery Plan (MIDP), Task Information Delivery Plans (TIDP), definition of deliverables, roles and responsibilities, CDE operation principles, and acceptance criteria. Since BIM execution during the design phase falls under the consultant's responsibilities, therefore, the consultant must ensure the quality of deliverables and consistency of contracts.

3) Design and Operational Support for the CDE

The consultant shall support the planning and operation of the CDE for sharing, approving, and verifying design deliverables. The CDE must satisfy key functional requirements such as access control, approval workflows, clash checking, and audit logging.

4) Establishment of Information Formats

The consultant shall support the development of information formats such as IFC and COBie and clarify deliverable formats, acceptance criteria, and their relationship with payment conditions within contract documents.

(2) Procurement Support Phase

1) Support for Drafting FIDIC Contract Documents

Based on the design deliverables, the consultant shall prepare construction contract documents compliant with the applicable FIDIC Conditions of Contract (e.g., Red Book). These documents shall clearly define contractual conditions, deliverables, payment terms, and acceptance criteria.

2) Preparation of Technical Specifications Including BIM Requirements

Using design deliverables as the basis, the consultant shall prepare technical specifications incorporating BIM-related requirements, including EIR for contractors. This enables contractual clarity regarding information management requirements during the construction stage.

3) Contractual Integration of Design Deliverables

The consultant shall clarify how design deliverables will be used in the construction contract, including deliverable traceability, acceptance conditions, and links to payment milestones.

(3) Construction Phase

1) Role of the Engineer under FIDIC Conditions of Contract

Under a FIDIC form of contract, the consultant acts as the Engineer and is responsible for supervising the construction contract, including review, approval, and acceptance of BIM deliverables and oversight of information management activities.

2) Examples of BIM-Related Supervision Tasks

- Review, approval, and acceptance of BEP and related documents
- Use of 4D models in reviewing construction programmes
- Verification of model updates in accordance with variation instructions
- Attribute data checks during inspections and testing
- Confirmation of IFC/COBie deliverables and support the issuance of payment certificates
- Approval, recording, and ensuring traceability of deliverables within the CDE

Support for Designing, Procuring, and Operating the Implementing Agency's CDE

The consultant shall assist the implementing agency in designing, procuring (vendor selection), and operating the CDE required for the construction phase. This ensures seamless information exchange with contractors, proper verification of deliverables, and smooth handover of information for maintenance.

13.3.2 Use of the Handbook by Consultants

Consultants engaged in BIM activities during the design, procurement, and construction phases should consult the handbook to ensure alignment with the information management framework and to maintain the quality of deliverables.

14 ASSESSMENT OF CURRENT CONDITIONS AND FEEDBACK FOR IMPLEMENTING THE DRAFT HANDBOOK

This chapter summarizes the institutional, contractual, operational, and technical conditions identified through consultations with relevant organizations and in-country interviews, along with specific feedback obtained for the purpose of applying the draft handbook and the information-requirements templates (OIR, AIR, PIR, EIR, etc.) developed in this study to ODA loan projects. The objectives of this chapter are summarized as follows:

- Assessment of alignment with local systems and practices;
- Identification of gaps and challenges for implementation; and
- Extraction of insights for the next phase of BIM implementation planning.

14.1 Overview of Target Projects

Table 14-1 presents an overview of the three target projects, the organizations consulted through interviews and meetings, and the application domains and key discussion points related to the draft handbook.

Table 14-1 List of Target Projects

Country/ City	Project Name	Phase	Organizations Consulted	Application Domain/Key Issues
India / Delhi	Delhi Metro (Existing Lines and Phase 4)	Operation and Maintenance (including sections under construction)	DMRC (Operator) JV DDC for detailed design (Systra, etc.)	- ISO 19650 implementation policy - BIM/CDE operations - AIM redevelopment - Integration with existing FM systems
Mongolia/ Ulaanbaatar	Chinggis Khaan International Airport Expansion Project	Pre-planning and pre-design (policy coordination)	Ministry of Construction and Urban Development Construction Development Center (CDC) NUBIA (Airport Operator)	- Policies and standards related to BIM (ISO 19650/National Annex) - Implementation and training capacity
India/ Bengaluru	Bengaluru Metro Phase 3	Design and tender-documentation preparation	BMRCCL (Operator) Planning Department Design Consultant	- Formulation of OIR, AIR, and business case for EIR - Trial application of the handbook templates

Source: The JICA Study Team

14.2 Methodology for the Current-state Assessment

To examine the feasibility of implementing the draft handbook and the various information-requirements templates in ODA loan projects, a current-state assessment was conducted for the target projects.

14.2.1 Survey Methods

The assessment combined the following five approaches:

- **In-country Interviews:**
Detailed discussions were conducted with operators (including O&M departments), supervisory authorities and government agencies, and design organizations to understand their BIM adoption status, information-management structures, and challenges encountered on-site.
- **Review of Institutional Frameworks and Contracts:**
Assessed the presence of BIM roadmaps and guidelines, and examined how information-management requirements are incorporated and applied within the contract documents of each project.

- **Presentations and Workshops:**
The relevance of ISO 19650, international case studies (airport and railway projects), the draft handbook, information-requirements templates (OIR/AIR/PIR/EIR), and examples of CDE configurations were shared to build understanding among stakeholders and identify implementation challenges.
- **Site Visits:**
Sites visited include Operations Control Centers (OCCs), depots, airport equipment rooms, and other facilities to directly observe O&M practices and the operational status of related systems.
- **Assessment of Actual Operational Practices:**
Implementation of operational practices were examined such as the CDE and FM systems (SAP, MAXIMO, IBMS, etc.), the use of Excel-based asset records, naming conventions, asset tagging, and other operational aspects of information management.

14.2.2 Evaluation Criteria

Analysis of the survey results was conducted using the following three perspectives:

- **Development of Institutional Frameworks and Standards:**
Evaluated the status of policies and guidelines related to BIM, including the adoption of international standards (ISO 19650), as well as the degree to which information-management requirements are reflected in contract documents.
- **Actual Operations of BIM/CDE:**
Assessed the maturity of digital practices in the field, including the implementation and operation of CDE and BIM systems, workflow and access-rights management, and the effectiveness of information handover among design, construction, and O&M.
- **Human Resources, Budget, and Technical Infrastructure:**
Evaluated the organization's capacity and the adequacy of its infrastructure necessary for sustainable operation, including its BIM promotion framework, deployment of specialized personnel, education and training plans, integration with existing FM systems, and budget and investment plans for CDE implementation and operation.

14.3 Findings and Feedback from the Field Assessment

This section summarizes the actual conditions identified for each project and the main feedback obtained from relevant organizations through the current-state assessment. The maturity levels of institutional frameworks, operational practices, and organizational foundations, as well as project-specific and cross-cutting challenges, are clarified and analyzed.

14.3.1 Summary by Project

(1) Delhi Metro Rail Corporation

The Delhi Metro Rail Corporation has a relatively long history of BIM/CDE utilization, and a well-established information management framework using BIM 360 has been implemented during the design and construction phases. BIM tasks—such as modelling, clash detection, quantity take-off, and visualization—are mandated throughout design and construction. Tangible benefits have been observed, including reduced lead time, error reduction, and enhanced integration of multidisciplinary designs. In contrast, BIM application in the O&M phase, considerations for COBie-based asset tagging and AIM development are underway, with future integration of the FM system identified as a key challenge.

Field personnel highlighted specific issues such as mechanisms for information handover between design/construction and O&M, assuring the quality of as-built models, and clarifying the scope and operational boundaries of COBie. Expectations were also expressed regarding the potential of BIM to accelerate decision-making and reduce workload in the field.

(2) Chinggis Khaan International Airport

In Mongolia, the Ministry of Construction and Urban Development is advancing standardization and policy development based on ISO 19650. Progress has been made in institutional aspects, such as the development of their National Annex and planning staff-training programs led by the Construction Development Center (CDC). Meanwhile, operational maturity remains low, with heavy reliance on Excel-based equipment records, absence of naming conventions, and limited deployment of FM systems.

The airport operator (NUBIA) identified the lack of BIM-skilled personnel, training needs within the O&M department, and the upfront investment required for CDE introduction as major challenges. Additionally, expectations were raised for BIM to support cost management, budgeting efficiency, strengthening of maintenance operations, and future formulation of mid- to long-term policy roadmaps.

(3) Bengaluru Metro

Bengaluru Metro is currently at the design and tender-documentation stage, requiring development of OIR, AIR, and a business case towards EIR formulation. At this stage, information-requirements templates aligned with ISO 19650 have been presented, and a working draft has been prepared. Further development of institutional and operational arrangements is expected through joint review and refinement with relevant agencies.

Field personnel have requested guidance on how to incorporate BIM-related clauses into contract documents, as well as advice on formulating OIR, AIR, and business-case documents.

14.3.2 Cross-Cutting Challenges

The assessment identified several common challenges across projects:

(1) Delays in Establishing Institutional Frameworks and Standards

Although progress is being made in developing policies and guidelines related to ISO 19650 and BIM, there proves to be an insufficient translation into practical operational procedures and contractual requirements. In particular, ensuring effective application of National Annex provisions at the project-execution level remains a challenge.

(2) Immature Information-management Practices

While some projects have introduced CDE and FM systems, issues remain in information integration across design, construction, O&M, and workflow design. Common challenges include ensuring the quality of as-built models and establishing mechanisms for reliable information handover to O&M departments.

(3) Insufficient Organizational, Human Resource, and Technical Foundations

Many organizations lack foundational elements necessary for sustainable BIM operations, including structured BIM governance systems, allocation of specialized personnel, training programs, integration with existing FM systems, and budget/investment planning for CDE implementation. Therefore, urgent priorities highlighted the need for training of O&M staff and improving digital literacy among field personnel.

14.4 Key Considerations for Implementation and Policy Directions for BIM Introduction

This section provides a structured summary of implementation issues associated with introducing BIM and CDE in ODA loan projects based on the current-state assessment and stakeholder feedback presented in the previous sections. It also outlines a phased policy direction for applying the draft handbook and information-requirements templates in practice, and illustrates possible implementation pathways using representative projects.

The aim of this section is not to prescribe a single, uniform end-state, but rather to clarify an implementation process that can be adapted to various maturity levels of individual countries and projects.

14.4.1 Key Implementation Issues in ODA Loan Projects

The assessment confirmed that the introduction of BIM and CDE in ODA loan projects is consistently associated with three major categories of issues:

- **Institutional Frameworks and Standardization:**
While ISO 19650 and BIM-related policies/guidelines are being established in many countries, frameworks for implementing them as consistent operational rules within individual ODA loan projects are not necessarily established yet. Standardized approaches are insufficient for defining the role of establishing, updating, and managing information requirements (e.g., OIR, AIR, EIR) and for explicitly stating information management responsibilities as contractual terms. Consequently, varying levels of compliance occur on a project-by-project basis.
- **Information-management Structures:**
While the introduction of CDE and FM systems is progressing; their utilization often remains confined to the design and construction phases. Many cases fail to function sufficiently as information collaboration systems designed with the maintenance phase in mind. Implementation challenges include the digital infrastructure being limited to mere information storage. This occurs because operational processes remain ambiguous regarding the confirmation process for as-built information, responsibility boundaries during handover, workflow design, and access rights management.
- **Organizational Capacity, Human Resources, and Technical Foundations**
Insufficient organizational structures for BIM promotion, specialized personnel, education/training programs, and the necessary budget/investment plans for CDE implementation and operation are common constraints across many projects. Particularly, the lack of BIM understanding and involvement within O&M departments represents a major barrier to AIM utilization. This suggests that maturity in organizational and operational aspects, rather than technical capabilities, is the primary constraint on implementation.

14.4.2 Phased Policy Directions for Implementation

Reflecting the issues identified above, this study concludes that a phased implementation approach is the most realistic path for introducing BIM and CDE in ODA loan projects. The policy directions are grouped into three stages, as outlined below.

(Note: “Activation of BIM governance structures and human-resource development programs” is considered essential in all stages and is therefore included in each policy set.)

(1) Short-term Actions

- Support for developing information requirements and preparing working drafts;
- Development of proposed contract clauses on information management aligned with ISO 19650; and
- Activation of BIM governance structures and human-resource development programs.

(2) Mid-term Policy Directions

- Expanded deployment of CDE and FM systems;
- Establishment of mechanisms for information integration across design, construction, and O&M; and
- Activation of BIM governance structures and human-resource development programs.

(3) Long-term Policy Directions

- Full implementation of AIM and its integration into routine O&M operations;
- Support for development of standards such as National Annexes;
- Standardization of contractual and operational rules;
- Establishment of continuous benefits-management and improvement cycles; and

- Activation of BIM governance structures and human-resource development programs.

14.4.3 Project-specific Roadmaps

Examples of phased implementation pathways for the assessed projects are summarized below.

(1) Delhi Metro

- Short-term: Pilot application of ISO 19650 in operational sections, including rehabilitation and construction areas.
- Medium-term: Design of an expanded O&M-focused CDE and assessment of integration with FM systems.
- Long-term: Full AIM implementation and enhancement of preventive-maintenance and renewal-planning processes.

(2) Chinggis Khaan International Airport Expansion Project

- Short-term: Support for developing the business case and information requirements and planning of a pilot CDE environment.
- Medium-term: Support for preparing ISO 19650 aligned project standards (interim guidelines).
- Long-term: Full AIM implementation and expansion across the airport portfolio level.

(3) Bengaluru Metro

- Short-term: Finalization of working drafts for the business case and information requirements.
- Medium-term: Development of supplementary contractual clauses and activation of CDE operations.
- Long-term: Handover to AIM and commencement of O&M phase information management operations.

15 OVERALL CONCLUSIONS OF THE STUDY

15.1 Key Achievements

This study systematically organized an information management framework to advance BIM/CIM utilization in ODA loan projects by using international standards, such as the ISO 19650 series, as the core reference. A draft handbook along with information requirements templates were developed to support practical application. The key achievements are summarized as follows:

(1) Ensuring Alignment with International Standards and Bridging for Practical Implementation

The study translated international best practices, centered on the ISO 19650 series, into actionable guidance for ODA loan projects. This includes identifying technical challenges for ISO 19650 implementation, presenting an overall BIM introduction framework, lifecycle-based asset management, structuring of information requirements, Common Data Environment (CDE) design, and methods for integrating such elements into contract documents.

(2) Development of Structured Information Requirements Templates and Practical Tools

Template proposals for Organizational Information Requirements (OIR), Asset Information Requirements (AIR), Project Information Requirements (PIR), Exchange Information Requirements (EIR), and Security Information Requirements (SIR) were developed to clarify and standardize information needed across each project phase. Linkages with Plain Language Questions (PLQ) and business process design were presented in concrete terms.

(3) Presentation of the BIM Introduction Process and Roadmap

The study defined a four-step BIM introduction process: from business case development to execution planning, organizational reform, and monitoring and evaluation. Along with this is clarification on a phased implementation model, practical examples, and evaluation flow during the Feasibility Study (FS) stage.

(4) Implementation Guidance for Contracting and Procurement, and Analysis of International Case Studies

A policy for integrating BIM-related information management requirements into JICA Standard Bidding Documents was formulated, along with analysis of implementation examples from international projects. Specific guidance was also presented on intellectual property rights, CDE operations, and contractual organization of deliverables.

(5) Collection and Integration of Feedback for Local Implementation

Through interviews and workshops in countries such as India and Mongolia, the study identified challenges and current conditions related to institutions, operations, human resources, and technical foundations, then incorporated feedback from implementing agencies.

15.2 Key Achievements

The study and field interviews revealed several common challenges, as outlined below:

(1) Delays in Institutional Development and Standardization

There remains insufficient application of ISO 19650 and related BIM policies/guidelines to project execution and contract documents. Supplementary instruments—such as National Annexes, sector-specific guidelines, or project-specific manuals—are needed to align with local legal frameworks and contract practices.

(2) Underdeveloped Information Management Systems and CDE Operations

Information linkage and workflow integration between design, construction, and operation and maintenance (O&M) phases remain limited. Furthermore, CDE or facility management (FM) system

adoption and operations are still emerging, and arrangements for ensuring as-built model quality and information handover to O&M departments are not yet in place.

(3) Insufficient Organizational, Human Resource, and Technical Foundations

There are inadequate BIM promotion structures, assignment of specialized personnel, training programs, integration with existing FM systems, and budgets for CDE operation. Therefore, strengthening BIM literacy and training for O&M departments is an urgent need.

(4) Gaps in Contracting and Procurement Arrangements

Information management requirements are not yet fully integrated into international contracts such as FIDIC. Interim project-level arrangements are required while monitoring developments in FIDIC and related international guidelines.

(5) Concerns Regarding Practical Implementation and Cost Implications

Concerns remain regarding operational workload, initial investment costs, ensuring practical feasibility in the field, and establishing mechanisms for continuous improvement and feedback.

15.3 Outlook and Recommendations

Based on the above achievements and challenges, the following directions and recommendations are proposed:

(1) A New ODA Support Model Combining International Standards and Japan's Strengths

In recent years, progress has been seen in international standardization of information management, including BIM. Particularly in Europe and the United Kingdom, the ISO 19650 series is gaining global adoption. The same global framework is increasingly required in ODA loan projects.

At the same time, Japan possesses unique strengths that complement international standards and provide sustainable value: robust organizational maintenance systems, site-based O&M training, and a culture of long-term quality assurance and continuous improvement. These capabilities are met internationally with high regards.

Future ODA projects should integrate Japanese strengths with international standards such as ISO 19650. Support should encompass not only BIM adoption in the design and construction phases but also information utilization in O&M, human resource development, and organizational capacity strengthening, ensuring that infrastructure “continues to function after construction.” This approach will help solve problems that are frequently observed in developing countries, such as inadequate maintenance and facility downtime, and ensure lifecycle-wide reliability through centralized and integrated information management.

By combining Japan's site-based O&M culture and training programs with ISO-compliant information management processes and CDE operations, a comprehensive “BIM–O&M model” can be deployed internationally. This will promote the establishment of a quality assurance and a culture of continuous improvement in infrastructure operations in developing countries. This approach goes beyond simple transfer of international standards and represents the creation of a sustainable infrastructure operations model that integrates digital systems, human resources, and organizational capability—demonstrating new value in ODA.

(2) Integrated Development of Information Requirements, Standards, and Contractual Frameworks

OIR, AIR, PIR, and EIR must be developed alongside business processes, CDE design, and contract documents (special conditions, technical specifications, etc.) to ensure consistency, transparency, and traceability of information across the project lifecycle.

(3) Promotion of Human Resource Development and Organizational Transformation

Strengthen the development of BIM champions and on-site leaders, provide continuous training (including

for O&M personnel), and establish cross-departmental BIM communities.

(4) Phased Introduction and Continuous Improvement

Gradually raise maturity from initial implementation, disseminate lessons learned from pilot projects and proofs of concept (PoCs) across organizations, and institutionalize key performance indicator (KPI)-based evaluation and Plan-Do-Check-Act (PDCA) improvement cycles.

(5) Utilization of Digital Infrastructure and Emerging Technologies

Actively adopt CDE and FM systems, mobile/cloud tools, augmented reality (AR) or virtual reality (VR) technologies, digital twin models, and AI to enhance data utilization in the O&M phase.

(6) International Collaboration and Use of External Support

Promote quality assurance and knowledge accumulation through collaboration with international organizations, sharing of standards and training materials, and integration of third-party evaluations.