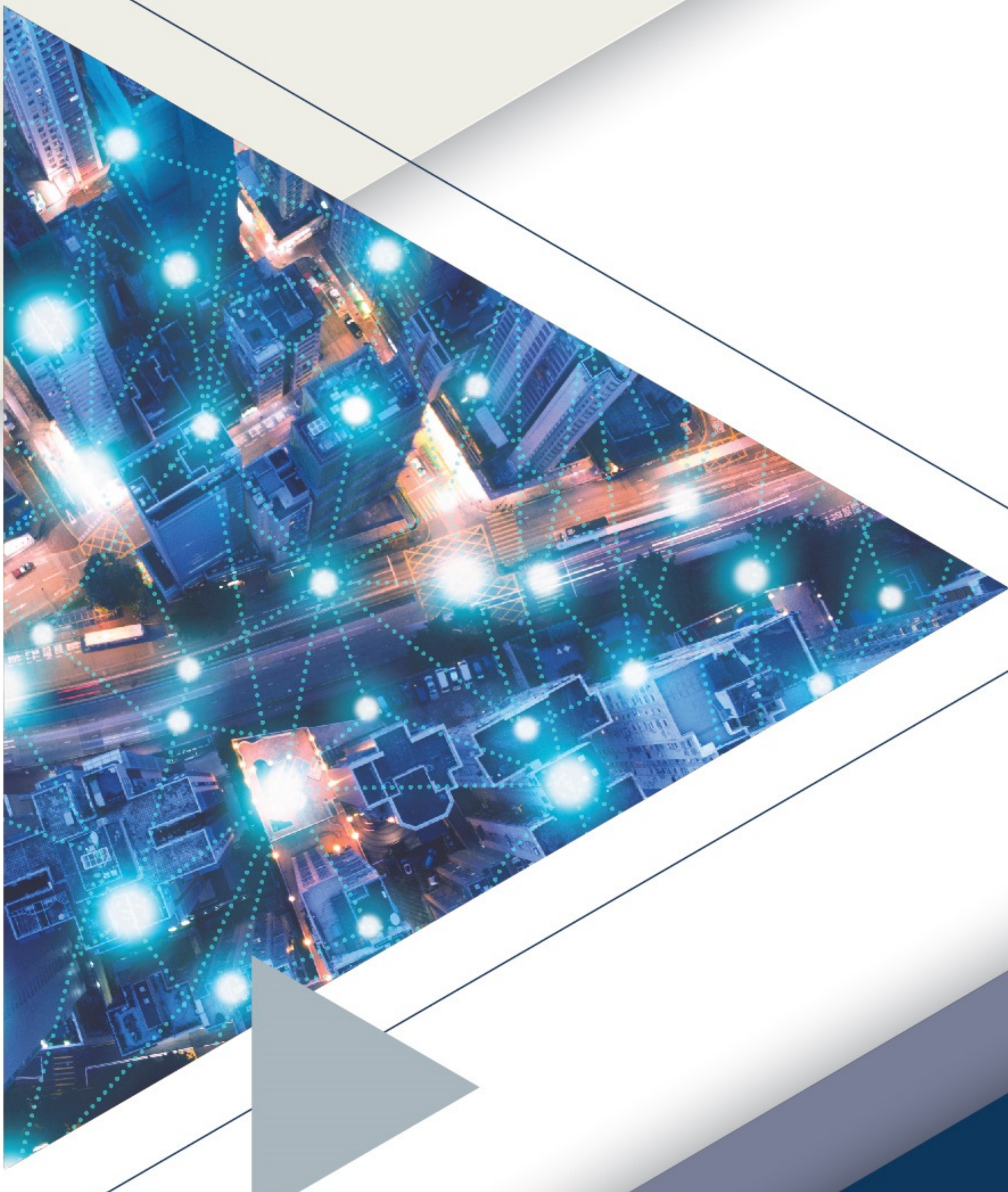
CONSTRUCTION
INDUSTRY COUNCIL
建造業議會

Reference Materials on BIM for Asset Management and Facility Management



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Enquiries

Enquiries about this Reference Materials may be made to the CIC Secretariat at:
38/F, COS Centre
56 Tsun Yip Street, Kwun Tong, Kowloon
Hong Kong

Tel: (852) 2100 9000
Fax: (852) 2100 9090
Email: bim@cic.hk
Website: www.cic.hk

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Preface

The Construction Industry Council (CIC) is committed to seeking continuous improvement in all aspects of the construction industry in Hong Kong. To achieve this aim, the CIC forms Committees, Task Forces and other forums to review specific areas of work with the intention of producing Alerts, Reference Materials, Guidelines and Codes of Conduct to assist participants in the industry to strive for excellence.

The CIC appreciates that some improvements and practices can be implemented immediately whilst others may take more time for implementation. It is for this reason that four separate categories of publication have been adopted, the purposes of which are as follows:

Alerts	The Alerts are reminders in the form of brief leaflets produced quickly to draw the immediate attention of relevant stakeholders to the need to follow some good practices or to implement some preventive measures in relation to the construction industry.
Reference Materials	The Reference Materials are standards or methodologies generally adopted and regarded by the industry as good practices. The CIC recommends the adoption of the Reference Materials by industry stakeholders where appropriate.
Guidelines	The Guidelines provide information and guidance on particular topics relevant to the construction industry. The CIC expects all industry stakeholders to adopt the recommendations set out in the Guidelines where applicable.
Codes of Conduct	The Codes of Conduct set out the principles that all relevant industry participants should follow. Under the Construction Industry Council (Cap. 587), the CIC is tasked to formulate codes of conduct and enforce such codes. The CIC may take necessary actions to ensure compliance with the codes.

If you have read this publication, we encourage you to share your feedback with us. Please take a moment to fill out the Feedback Form attached to this publication in order that we can further enhance it for the benefit of all concerned. With our joint efforts, we believe our construction industry will develop further and will continue to prosper for years to come.

1 Introduction

This publication serves as a document for practitioners in the construction industry aiming to explore the utilisation of Building Information Modelling (BIM) for Asset Management (AM) and Facility Management (FM). It provides insights, good practices, and recommendations on leveraging BIM to optimise asset performance, enhance facility management, and streamline operations throughout the entire lifecycle of a project. Additionally, the document briefly describes the transformation of existing corporate systems and workflows in AM and FM for facility owners, emphasising the exploration of market-available system solutions and the associated integration with the existing AM and FM systems to ensure a smooth workflow transition. In the context of BIM implementation for AM and FM, it is imperative to consider the processes in a broader corporate sense rather than solely at the project level. By adopting a corporate-level approach, facility owners can ensure a standardised and consistent implementation of BIM for AM and FM processes across all projects and facilities. This approach facilitates improved collaboration, better decision-making, and enhanced asset performance throughout the organisation.

1.1 Purpose and Scope

The primary objective of this publication is to bridge the gap between design and operation, enabling stakeholders to make informed decisions, improve collaboration, and the value of their assets.

The scope of this publication encompasses various aspects related to implementing BIM for AM and FM, including terminology and definitions specific to this domain, background information, objectives and benefits, workflows, integration strategies, IoT integration, data management, challenges, and resolutions. Each section provides discussion and recommendations to support professionals in their journey towards successful implementation of BIM for AM and FM.

1.2 Target Audience

The target audience for this publication includes practitioners in the construction industry involved in asset and facility management, including but not limited to project managers, architects, engineers, facility managers, and BIM personnel. It caters to individuals seeking to leverage BIM methodologies to enhance their AM and FM practices and improve project outcomes.

1.3 Structure of the Publication

To facilitate a comprehensive understanding of BIM for AM and FM, this publication is structured into several sections:

- Section 1: Introduction of this Publication (current section)
- Section 2: Objectives and Benefits of Using BIM for AM and FM: Discusses the goals and advantages of leveraging BIM in asset and facility management.
- Section 3: Workflow on BIM for AM and FM Processes: Presents a step-by-step workflow for implementing BIM in AM and FM, covering key activities and considerations.

- Section 4 Model Delivery Standards on AIM for Future Digital Twin Implementation and Data Format Handover after Project Completion: Outlines the model delivery standards that main contractors should adhere to for facilitating future digital twin implementation and data handover after project completion.
- Section 5: Workflow on Logistics of Information Exchange / Data Transfer and Mapping: Details the workflow for managing information exchange, data transfer, and mapping between various systems and stakeholders involved in AM and FM.
- Section 6: IoT Integration: Advice on Sensors, Data Collection, and Associated Wiring Works: Outlines the integration with sensors, data collection devices.
- Section 7: Advice on Developing Application Programming Interfaces (APIs) to Manage Data Collected from Physical Devices.
- Section 8: Upkeep of Model Geometry and Information in O&M Stage: Emphasises the upkeep of accurate model geometry and information for effective O&M practices.
- Section 9: Leveraging BIM to Create Digital Twin for AM and FM: Recommendations on integrating data repositories for future development and collaboration in Hong Kong.
- Section 10: Challenges, Resolutions, and Lessons Learnt: Explores common challenges in BIM implementation for AM and FM, offering resolutions and key takeaways.

By delving into each section, readers will gain an understanding of the principles, workflows, integration strategies, and challenges associated with implementing BIM for AM and FM processes in the construction industry.

2 Objectives and Benefits of Using BIM for AM and FM

BIM offers numerous benefits that can revolutionise how assets and facilities are managed throughout their lifecycle. In this section, we will explore the key objectives and benefits of using BIM for AM and FM in the construction industry.

2.1 Objectives of Using BIM for AM and FM

1. Enhanced Decision-Making: BIM provides a comprehensive and data-rich environment that enables stakeholders to make informed decisions throughout the lifecycle of assets and facilities. It is important to direct users to align the Level of Information Need (LOIN) in BIM with the specific purposes for FM and AM, such as optimising space occupancy, energy saving, and predictive maintenance. By ensuring that the LOIN is derived based on the end-purpose, stakeholders can avoid the collection of unnecessary information and focus on capturing and managing data that directly contributes to achieving the desired FM and AM outcomes.

2. Improved Collaboration and Communication: BIM fosters collaboration among various stakeholders involved in AM and FM. With a shared digital platform, teams can collaborate more effectively, exchange information seamlessly, and resolve issues proactively.

3. Streamlined AM and FM Processes: BIM enables the integration of asset and facility information into a centralised digital model, providing a holistic view of the entire lifecycle.

4. Data-Driven Maintenance Strategies: BIM allows for the collection, analysis, and utilisation of vast amounts of data related to assets and facilities. It is important to direct users to derive the LOIN based on the requirements for implementing data-driven maintenance strategies, enabling predictive and preventive maintenance, reducing downtime, and optimising asset lifespan.

5. Efficient Space Management: BIM provides accurate and detailed spatial information that can be utilised for efficient space management.

6. Effective Asset Lifecycle Management: BIM supports the entire asset lifecycle, from design and construction to operation and decommissioning.

It is crucial to emphasise that the LOIN within the BIM models for AM and FM processes should be derived based on specific purposes, rather than aiming to encompass a collection of everything in exhaustive detail. By aligning the LOIN with the intended outcomes, stakeholders can ensure that the information captured within the BIM models directly contributes to achieving the desired objectives for asset and facility management. This targeted approach not only streamlines the data collection process but also facilitates more efficient decision-making, collaboration, and operational processes throughout the lifecycle of assets and facilities.

2.2 Benefits of Using BIM for AM and FM

1. Cost Savings: BIM enables organisations to achieve significant cost savings throughout the lifecycle of assets and facilities. By facilitating better decision-making, reducing rework, optimising maintenance, and improving resource allocation, BIM helps minimise operational costs, extend asset lifespan, and maximise the return on investment.
2. Improved Asset Performance: BIM provides a comprehensive view of asset information, including design specifications, maintenance schedules, and historical data. This enables organisations to optimise asset performance by identifying maintenance needs, predicting failures, and implementing proactive maintenance strategies, resulting in increased uptime, reduced downtime, and improved asset reliability.
3. Enhanced Sustainability: BIM supports sustainable asset and facility management practices. By integrating energy analysis tools, environmental data, and performance simulations, BIM enables stakeholders to make informed decisions that enhance energy efficiency, reduce environmental impact, and promote sustainable operations throughout the asset lifecycle.
4. Improved Occupant Experience: BIM enables organisations to enhance the occupant experience within facilities. By leveraging BIM data, stakeholders can optimise space utilisation, improve wayfinding, and implement personalised services, resulting in increased occupant satisfaction and productivity.
5. Efficient Maintenance Planning: BIM provides organisations with accurate and up-to-date information on assets and facilities. This information enables stakeholders to plan maintenance activities more efficiently, schedule inspections, manage spare parts, and track maintenance history, leading to improved maintenance efficiency and reduced operational disruptions.
6. Enhanced Facility Information Management: BIM serves as a centralised repository for all facility-related information, including operation and maintenance manuals, warranties, and as-built documentation. This centralised information ensures easy access, effective documentation control, and seamless information sharing, improving overall facility information management.
7. Improved Safety and Risk Management: BIM enables organisations to identify and mitigate safety risks associated with assets and facilities. By visualising safety-related information within the BIM model, stakeholders can analyse potential hazards, implement preventive measures, and optimise emergency preparedness, ensuring the safety of occupants and reducing liability risks.

By leveraging the objectives and benefits outlined above, organisations can harness the power of BIM to transform their AM and FM practices. The integration with BIM offers unprecedented opportunities for improved decision-making, collaboration, efficiency, and overall performance throughout the entire lifecycle of assets and facilities.

2.3 Guidelines for Evaluating the Benefits of BIM for AM and FM

The below content provides guidance for evaluating the potential benefits, costs and benefits of integrating BIM AM and FM processes.

1. Develop a structured framework for evaluating the costs associated with implementing BIM for AM and FM, including considerations such as initial investment in technology, training, data management, and potential workflow adjustments.
2. Conduct a thorough analysis of the potential benefits that could be realized through the adoption of BIM, encompassing areas such as improved decision-making, enhanced collaboration, streamlined processes, data-driven maintenance strategies, efficient space management, and effective asset lifecycle management.
3. Quantify the potential impact of BIM on operational costs, resource allocation, maintenance efficiency, risk reduction, and overall return on investment, considering both tangible and intangible benefits.
4. Assess the long-term value and impact of implementing BIM for AM and FM, taking into account the potential for improved asset performance, extended lifespan of facilities, enhanced operational efficiency, and the ability to adapt to future technological advancements.
5. Evaluate the potential for BIM to contribute to sustainable and resilient asset and facility management practices, aligning with long-term organisational goals and strategies for asset optimisation and performance.

3 Workflow on BIM for AM and FM Processes

Before delving into the workflow for BIM implementation AM and FM processes, it is essential to identify the key stakeholders involved in the implementation of BIM and their respective roles and responsibilities. The successful integration of BIM into AM and FM processes relies on the collaborative efforts of various stakeholders, each contributing their expertise and fulfilling specific responsibilities throughout the project lifecycle.

1. Project Owners / appointing party: Responsible for setting project requirements, defining objectives, and ensuring alignment with AM and FM processes. They play a crucial role in establishing the overall vision for BIM implementation and its integration with asset and facility management.
2. Facility Managers: Tasked with overseeing the operational aspects of the facility, including maintenance, space utilisation, and occupant satisfaction. Their input is vital in defining the asset information requirements and ensuring that the BIM models support efficient facility management practices.
3. Maintenance Teams: Play a pivotal role in defining the asset information requirements (AIRs) for effective maintenance and operational activities. They provide valuable insights into the data and information needed to support ongoing maintenance and facility operations.
4. Consultants and Contractors: Responsible for capturing accurate asset information during the design and construction phases, ensuring that the BIM models incorporate relevant data and align with project requirements.

In BIM for AM and FM, identifying and defining Asset Information Requirements (AIRs) is crucial. AIRs specify the information and data needed for effective asset management and facility maintenance, including asset details, maintenance schedules, operational manuals, and relevant documentation.

When maintenance parties' AIRs are unavailable, proactive collaboration with them is essential. Agree on standard practice for handing over asset information models and documentation to address their requirements adequately.

Key Considerations for formulating AIRs:

- Engage maintenance parties early in the project lifecycle to understand their specific asset information requirements.
- Define the LOIN based on maintenance parties's input to ensure the right level of detail for efficient utilisation.
- Collaborate to define and document the AIRs, including the types of information, formats, and delivery mechanisms that best support the maintenance parties' needs.
- Establish a clear process for the handover of asset information models and documentation, aligning with industry best practices and standards.
- Ensure that the BIM models and associated asset information are structured and organised to facilitate efficient utilisation by maintenance parties during the operational phase.

By proactively addressing the AIRs and collaborating with maintenance parties to define standard practices for information handover, the BIM for AM and FM processes can effectively support the long-term management and maintenance of assets and facilities, promoting operational efficiency and sustainability.

Prior to establishing project requirements and objectives, it is essential to proactively collaborate with maintenance parties to identify and define AIRs for effective asset management and facility maintenance.

To ensure a smooth transition from the construction BIM models to the AIM, below are the considerations:

- Early Collaboration and Planning:
  - Engage facility management teams early in the project to understand their specific information needs for AM and FM.
  - Conduct workshops or meetings to align the essential asset information required for effective facility management and operational purposes.
- Define Information Requirements:
  - Work with facility management teams to define the LOIN for the AIM, ensuring that it contains the right LOIN for efficient manipulation and usability.
  - Identify the specific asset data and attributes required for maintenance, operations, and future facility management activities.
  - Advice for Developing the Appropriate LOIN:
    - Fit-for-Purpose: Define the essential data parameters and attributes that align with the project's objectives and operational needs, focusing on capturing information that directly contributes to decision-making and performance optimization.
    - Avoid Over-Modeling: Refrain from including excessive detail or data elements that do not add value to the project outcomes. Strive for a balance between data richness and practicality to ensure that the AIM contains relevant and actionable information.
- Streamline Data Extraction and Refinement:
  - Develop clear processes and guidelines for transitioning from the construction BIM models to the AIM, outlining specific workflows and procedures for extracting and refining the necessary asset information.
  - Utilise automation tools and software to streamline the process of extracting and refining asset information, reducing manual effort and minimising the risk of errors.
- Data Validation and Verification:
  - Implement a validation process to ensure the accuracy and completeness of the asset information being transitioned to the AIM.
  - Verify the consistency and reliability of the asset data to avoid discrepancies and ensure its usability for facility management purposes.
- Iterative Refinement:
  - Establish a framework for iterative refinement of the AIM throughout the project lifecycle, allowing for regular reviews and updates based on evolving facility management needs.
  - Incorporate feedback from facility management teams to refine the AIM as needed, ensuring that it remains aligned with operational requirements.

- Training and Knowledge Transfer:
  - Provide training sessions for the facility management team on how to navigate and utilise the AIM for AM and FM purposes.
  - Ensure that the facility management team is proficient in using the AIM and understands its relevance to their day-to-day activities.
- Documentation and Handover:
  - Document the transition process and the rationale behind the inclusion of specific asset information in the AIM, providing clear documentation on how to access, navigate, and utilise the AIM for AM and FM purposes.
  - Include detailed documentation on data management protocols, including version control, data backup, and security measures for the AIM.

3.1 Planning for the manpower and resources

By strategically planning for the allocation of manpower and resources, appointing party/project owners can maximise the value derived from BIM implementation for AM and FM.

1. Assessment and Planning: Conduct a comprehensive assessment of the current AM and FM workflows to identify areas where BIM implementation can add value.
2. Skill Development and Training: Establish a dedicated BIM team with the necessary skills and expertise to manage and upkeep the BIM-related deliverables for AM and FM. Provide comprehensive training programs to equip staff with the required skills in BIM software, data management, and collaboration tools.
3. Outsourcing Considerations: Consider outsourcing certain BIM-related tasks to third-party service providers to supplement the in-house BIM team. This can provide access to specialised expertise and help manage costs effectively.
4. Alignment with Corporate Strategy: Ensure that the manpower and resource planning for BIM implementation aligns with the overall corporate strategy. This alignment is essential for seamless integration and sustained benefits across all facilities and projects.

3.2 Steps for Integration of BIM in AM and FM Processes

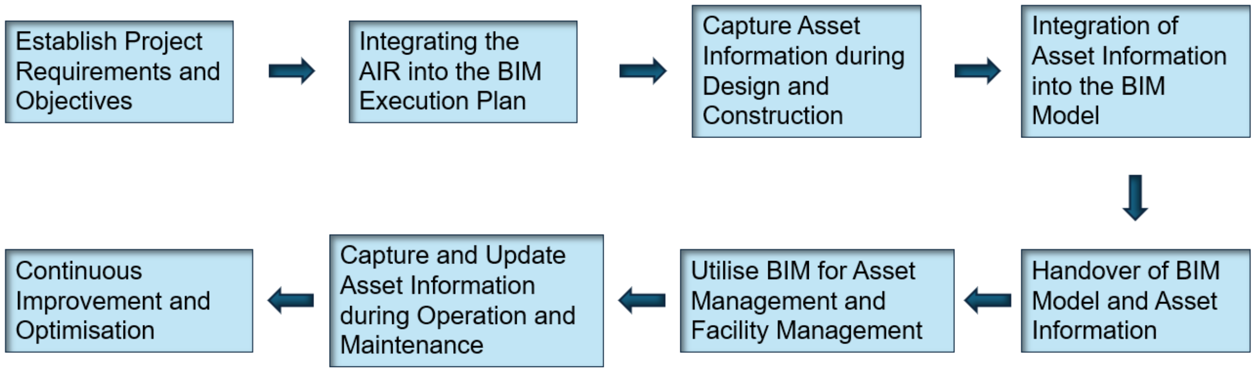
Steps:	Key stakeholders:	Description:
Step 1: Establish Project Requirements and Objectives	Project Owners including Facility Managers, Project Owners	The first step in implementing BIM for AM and FM is to establish project-specific requirements and objectives. This involves identifying the key goals, stakeholders, and desired outcomes for AM and FM processes. It is crucial to involve all relevant parties, including project owners, facility managers, and maintenance teams, to ensure alignment and set clear expectations. Before implementing BIM for AM and FM processes, it is important to assess existing IT systems and platforms to identify potential gaps and areas for

		improvement. Many organisations and companies have existing systems in place for asset and facility management, but these systems may not fully support the functionalities of BIM. The adoption of BIM technology may require revamping or creating new systems/platforms to incorporate its functionalities. This is because BIM offers a more comprehensive and integrated approach to asset and facility management, which may not be fully supported by existing systems. During the assessment process, it is important to consider the following: • The compatibility of existing systems with BIM technology and data formats. • The ability of existing systems to handle the increased amount of data and information generated by BIM. • The potential need for customisation or development of new systems to fully integrate BIM with existing AM and FM processes. • The potential impact on existing workflows and processes, and the need for training and support for users of the integrated system. Based on the assessment of existing systems, it is important to define the integration requirements and objectives for BIM and AM and FM processes. This involves identifying the key goals, stakeholders, and desired outcomes for the integration process. During this stage, key deliverables and metrics should be defined, such as the required LOIN for asset information, maintenance schedules, performance indicators, and data exchange formats. This step lays the foundation for the successful implementation of BIM for AM and FM.
Step 2: Integrating the AIR into the BIM Execution Plan	Consultants and contractors	Integrating the AIR into the BEP involves including the essential asset data and attributes needed for maintenance and facility management within the overall project BIM strategy. This integration ensures that the BEP outlines clear guidelines for capturing, managing, and utilizing asset information throughout the project. Define the specific asset data required, align with BIM standards, assign responsibilities, outline workflows for data integration, and emphasize regular reviews to keep the information relevant and effective for facility management. By incorporating the AIR into the BEP, project teams can streamline asset information management and support efficient utilisation within the BIM models for enhanced AM and FM practices. To further enhance the accuracy of the as-built BIM model, it is recommended to specify the types of advanced surveying technologies

		adopted and the required accuracy standards within the BEP. For instance, mandating laser scanning with defined accuracy parameters can ensure the precision of the as-built BIM model, validating the quality of the captured data. By explicitly outlining surveying technologies and accuracy requirements in the BEP, project stakeholders can establish a framework for conducting surveys that align with project quality standards, enhancing the reliability and usability of the BIM data for effective asset management and facility maintenance.
Step 3: Capture Asset Information during Design and Construction	Consultants and contractors	During the design and construction phases, capturing accurate and comprehensive asset information within the BIM models is crucial. This includes equipment, systems, materials, and spatial data. Designers and contractors share the responsibility of progressively capturing accurate and comprehensive asset information from the design stage to the construction phase. They must ensure seamless integration of asset information into the BIM model, aligned with project requirements. However, it's important to note that detailed asset information may not be available during the design stage since contractors are typically involved after this stage. Therefore, it may be appropriate to include only essential asset information in the design BIM model, with the understanding that additional asset information will be added progressively during the construction phase. Contractors are responsible for capturing asset information as stated in the BEP within the BIM models during the construction phase, such as manufacturer details, installation dates, warranty information, and maintenance requirements.
Step 4: Integration of Asset Information into the BIM Model	Consultants and contractors	Once the asset information is captured, it needs to be integrated into the BIM model. This integration involves linking the asset data with the corresponding objects within the BIM model, and establishing relationships and dependencies. During this stage, it is essential to adhere to a standardised naming convention and classification system to facilitate efficient data management and retrieval. The integrated asset information should be validated for accuracy and completeness to ensure its reliability for AM and FM processes.
Step 5: Handover of BIM models	Consultants and contractors	Upon project completion, the BIM models and associated asset information need to be handed over to the facility management team. This handover

and Asset Information		should include detailed documentation on how to access, navigate, and utilise the BIM models for AM and FM purposes. The handover process should also include training sessions for the facility management team to ensure their proficiency in utilising the BIM model. Additionally, the handover should incorporate the establishment of data management protocols, including version control, data backup, and security measures.
Step 6: Utilise BIM for Asset Management and Facility Management	Project Owners including Facility Managers, Project Owners	Once the BIM models and asset information are handed over, the facility management team can start utilising BIM for AM and FM processes. This involves leveraging the BIM models to support various activities, including maintenance planning, asset performance analysis, space management, and energy optimisation. The facility management team can extract relevant information from the BIM models to support decision-making, such as identifying assets requiring maintenance, tracking work orders, and managing spare parts. BIM can also be utilised to generate reports, visualise data, and facilitate communication among stakeholders involved in AM and FM.
Step 7: Capture and Update Asset Information during Operation and Maintenance	Project Owners including Facility Managers, Project Owners	During the operation and maintenance phase, it is crucial to capture and update asset information within the BIM models to reflect any changes or modifications. This includes recording maintenance activities, equipment replacements, and performance data. The facility management team should establish processes and protocols for regularly updating the BIM models with accurate and up-to-date asset information. This ensures that the BIM models remain a reliable source of information for AM and FM processes and supports continuous improvement and optimisation.
Step 8: Continuous Improvement and Optimisation	Project Owners including Facility Managers, Project Owners	The final step in the workflow is to foster a culture of continuous improvement and optimisation. This involves regularly reviewing and analysing asset and facility performance data captured within the BIM models to identify areas for improvement. By leveraging the insights gained from the BIM model, stakeholders can implement proactive maintenance strategies, optimise energy consumption, improve space utilisation, and enhance overall operational efficiency. This step involves collaboration among the

		facility management team, maintenance personnel, and other relevant stakeholders to drive continuous improvement and maximise the value of assets and facilities. Throughout the workflow, it is crucial to ensure effective communication and collaboration among all stakeholders involved in AM and FM processes. Regular meetings, information sharing, and feedback loops should be established to address any issues, resolve conflicts, and optimise the utilisation of BIM for AM and FM. By following this step-by-step workflow, organisations can harness the power of BIM to transform their AM and FM practices. The integration of BIM into asset and facility management processes offers unprecedented opportunities for improved decision-making, collaboration, efficiency, and overall performance throughout the entire lifecycle of assets and facilities.



Steps for integration of AM and FM Processes

3.3 Integration with Existing AM and FM Systems and Market-Available Solutions

The integration of BIM with existing AM and FM systems and workflows can pose challenges for facility owners. To ensure a smooth transition, it is essential to assess the current AM and FM workflows and identify opportunities for transformation through BIM implementation. Facility owners should explore market-available system solutions that can seamlessly integrate with their existing AM and FM systems. The following practical recommendations can help facility owners navigate the integration process:

- Conduct a thorough assessment of the current AM and FM workflows and identify areas for improvement through BIM implementation.

- Explore market-available system solutions that can integrate with existing AM and FM systems and workflows.
- Develop a clear integration plan that outlines the steps required to integrate BIM with existing AM and FM systems.
- Provide comprehensive training programs to equip staff with the necessary skills and mindset for embracing BIM practices.
- Establish regular communication channels and collaborative workflows to ensure alignment and engagement among all involved parties.

3.4 openBIM Integration for Enhanced Collaboration

openBIM standards play a crucial role in fostering enhanced collaboration and data exchange within AM and FM processes. By adhering to openBIM principles, stakeholders can achieve greater interoperability and transparency throughout the project lifecycle. The following points highlight the significance of openBIM integration:

- Interoperability: openBIM standards promote interoperability among various software platforms used in asset and facility management. This interoperability enables seamless data exchange and communication between different systems, enhancing overall project efficiency.
- Transparency: openBIM fosters transparency by ensuring that project data is accessible and understandable across all stakeholders. This transparency leads to improved decision-making processes and facilitates better coordination among team members.
- Collaboration: Through openBIM integration, stakeholders can collaborate more effectively by sharing accurate and up-to-date information in a standardized format. This collaborative approach enhances communication, reduces errors, and promotes a more integrated workflow.
- Innovation: Embracing openBIM principles encourages innovation within the industry by allowing for the development of new tools and technologies that support interoperability and data exchange. This innovation drives continuous improvement in asset and facility management practices.

Recommendations for openBIM Integration:

- Establish clear protocols for implementing openBIM standards within asset and facility management workflows.
- Provide training and resources to stakeholders to ensure they understand and adhere to openBIM principles.
- Utilise openBIM-compliant software solutions to facilitate seamless data exchange and collaboration.
- Regularly review and update openBIM processes to incorporate industry best practices and technological advancements.

By incorporating openBIM integration into BIM workflows for AM and FM, stakeholders can enhance collaboration, improve data exchange, and drive innovation within the industry. Embracing openBIM principles is essential for achieving optimal efficiency and effectiveness in managing assets and facilities throughout their lifecycle.

4 Model Delivery Standards on AIM for Future Digital Twin Implementation and Data Format Handover after Project Completion

In the era of digital transformation, the implementation and the handover of data in a suitable format for future digital twin implementation have become critical requirements in the construction industry. This section outlines the importance of model delivery standards on AIM and discusses the data formats that should be handed over by the main contractor after project completion to facilitate successful digital twin implementation.

Regarding the Information Exchange Workflow, it is essential to consider the incorporation of a Common Data Environment (CDE) or Common Data Collaboration Platform for BIM (BIM CDCP) into the BIM adoption, particularly from the perspective of information exchange and data collaboration, especially when integrating with GIS-enabled platforms. The use of CDE or BIM CDCP plays a crucial role in facilitating seamless information exchange, data collaboration, and integration with Geographic Information System (GIS) data for AM and FM with BIM adoption.

By addressing the use of CDE or BIM CDCP in the context of AM and FM with BIM adoption, this document provides comprehensive insights into the integration of collaborative data platforms for effective information exchange and data collaboration, aligning with the evolving needs of digital twin implementation and asset lifecycle management.

4.1 Importance of Model Delivery Standards on AIM

Model delivery standards on AIM define the requirements and guidelines for creating, organising, and delivering digital asset information within the AIM. These standards ensure consistency, interoperability, and usability of the AIM across the entire lifecycle of the asset.

Implementing model delivery standards on AIM offers several benefits:

1. Consistency: Model delivery standards establish consistent naming conventions, classification systems, and data structures, ensuring uniformity and coherence of the AIM. This consistency facilitates efficient data management, retrieval, and exchange, enabling stakeholders to locate and utilise asset information effectively.

2. Interoperability: Model delivery standards enable seamless integration and interoperability among different software applications used throughout the asset lifecycle. By adhering to open standards and industry protocols, the AIM can be easily shared and accessed by various stakeholders, ensuring the compatibility of data across different platforms.

3. Collaboration: Model delivery standards promote collaboration among project participants by providing a common framework and language for sharing asset information. These standards facilitate effective communication, coordination,

and information exchange between designers, contractors, facility managers, and maintenance teams, leading to improved project outcomes and streamlined operations.

4. Scalability: Model delivery standards on AIM ensure the scalability of the digital asset information. By defining the required LOIN, these standards allow the AIM to accommodate future updates, expansions, and modifications to the asset. This scalability supports the long-term usability and relevance of the AIM throughout the asset's lifecycle.

4.2 Data Formats for Digital Twin Implementation

To facilitate successful digital twin implementation, the main contractor should hand over the AIM data in suitable formats that enable seamless integration with digital twin platforms and applications. The following data formats are commonly used for digital twin implementation:

1. Industry Foundation Classes (IFC): IFC is an open file format widely used for exchanging BIM data. It supports the representation of 3D geometry, attributes, relationships, and classifications of building elements. Handing over the AIM data in IFC format ensures compatibility with various digital twin platforms and promotes interoperability.

2. COBie (Construction Operations Building Information Exchange): COBie is a data exchange standard that facilitates the capture and delivery of asset information throughout the asset lifecycle. It provides a structured format for organizing and delivering data related to equipment, systems, spaces, and maintenance requirements. COBie data can be used as a foundation for populating the digital twin with asset information.

3. buildingSmart Data Dictionary (bSDD): The buildingSmart Data Dictionary is a standardised classification system that provides a common language for organising and categorising asset information. Handing over the AIM data in accordance with the bSDD ensures consistency and compatibility with digital twin platforms that adhere to the same classification system.

4. Sensor Data Formats: In addition to geometric and attribute data, digital twins often require real-time sensor data for monitoring and analysis. Handing over sensor data in standardised formats such as JSON (JavaScript Object Notation) or CSV (Comma-Separated Values) allows for seamless integration with the digital twin platform and enables continuous monitoring and analysis of asset performance.

5. API (Application Programming Interface): In some cases, the main contractor may need to provide access to the AIM data through an API. An API allows external applications or platforms to retrieve and interact with the AIM data programmatically. Providing an API for accessing AIM data enables real-time integration with digital twin platforms and enables the development of custom applications and analytics.

It is essential for the main contractor to collaborate with the appointing party, digital twin platform providers, and relevant stakeholders to determine the specific data formats and requirements for digital twin implementation. This collaboration ensures that the AIM data is handed over in a format that aligns with the appointing party's digital twin strategy and enables seamless integration and utilisation of the AIM within the digital twin environment. The determination of data formats for digital twin implementation should ideally occur during the early stages of the project, specifically during the planning and scoping phase. Engaging with the appointing party, digital twin platform providers, and stakeholders at this stage allows for a comprehensive understanding of the digital twin requirements and ensures that the AIM data is structured and formatted accordingly.

4.3 Documentation and Metadata

In addition to delivering the AIM data in suitable formats, the main contractor should also provide comprehensive documentation and metadata that accompany the data handover. This documentation should consider the following items:

1. Data Structure and Hierarchy: A clear description of the data structure and hierarchy within the AIM, providing an overview of how the data is organised and related to each other.

2. Naming Conventions and Classification Systems: Documentation on the naming conventions and classification systems used within the AIM, ensuring that stakeholders understand the logic and standards employed for organising and categorising asset information.

3. Data Mapping and Relationships: The data mapping in the AIM should encompass a comprehensive representation of the installation and equipment data within the BIM model. This includes associating specific attributes and information with each installation and equipment component, such as manufacturer details, installation dates, warranty information, maintenance requirements, and spatial relationships within the facility.

   Examples for Illustration:

   - HVAC System and Room Relationship: The data mapping should illustrate how the attributes of HVAC systems, such as capacity and maintenance schedules, are linked to specific rooms or zones within the facility, enabling targeted maintenance and operational insights.

4. LOIN Guidelines: Guidelines specify the required LOIN for different asset components within the AIM, ensuring consistency and clarity regarding the LOIN expected in the model.

5. Data Validation and Quality Assurance: Documentation of the processes and procedures followed to validate the accuracy, completeness, and reliability of the AIM data, assuring that the handed-over data is of high quality.

6. Version Control: Documentation on version control protocols and procedures, ensuring that stakeholders can track and manage different versions of the AIM data effectively.

7. Access and Security: Information on access rights, permissions, and security measures implemented to protect the confidentiality and integrity of the AIM data.

By providing comprehensive documentation, the main contractor facilitates the understanding, management, and utilisation of the AIM data by the appointing party and other stakeholders involved in digital twin implementation and ongoing asset management.

In conclusion, model delivery standards on AIM and the handover of data in suitable formats for future digital twin implementation are crucial considerations in modern construction projects. By adhering to established model delivery standards and providing the AIM data in compatible formats, the main contractor can ensure interoperability, collaboration, scalability, and successful integration with digital twin platforms. Additionally, comprehensive documentation and metadata accompanying the data handover enhance the usability and accessibility of the AIM data, supporting effective asset management and decision-making throughout the asset lifecycle.

5 Workflow on Logistics of Information Exchange/Data Transfer and Mapping

The efficient exchange and transfer of information are vital for successful project execution. This section focuses on the workflow surrounding the logistics of information exchange and data transfer, as well as the importance of accurate data mapping. It outlines the key steps and considerations involved in managing this process effectively to ensure seamless collaboration and data integration between project stakeholders.

5.1 Information Exchange Workflow

The logistics of information exchange involve the coordinated flow of data between various project participants, including appointing parties, appointed parties, designers, contractors, suppliers, and other stakeholders. A well-defined workflow for information exchange helps streamline communication, minimise errors, and ensure that the right information reaches the right people at the right time. The following steps outline a typical workflow for information exchange:

1. Identify Information Requirements: The first step is to identify the specific information requirements of each project stakeholder. This includes determining what information needs to be exchanged, who needs to receive it, and when it should be delivered. Clear communication channels and protocols should be established to facilitate information sharing.

2. Capture and Create Information: The next step involves capturing and creating the required information. This may include generating design drawings, specifications, schedules, procurement documents, and other relevant data. It is important to ensure that the information is accurate, complete, and up to date before sharing it with other stakeholders.

3. Packaging and Formatting: Once the information is created, it needs to be packaged and formatted appropriately for exchange. This may involve converting files into Standardised formats, such as PDF, DWG, or IFC (Industry Foundation Classes), to ensure compatibility and ease of use for the recipients. Packaging the information in a structured and organised manner enhances its accessibility and usability.

4. Information Distribution: The packaged information is then distributed to the intended recipients using the agreed-upon communication channels. This can involve digital methods such as email, cloud-based file-sharing platforms, or project management software. It is crucial to communicate the purpose, context, and any specific instructions related to the shared information to avoid confusion or misinterpretation.

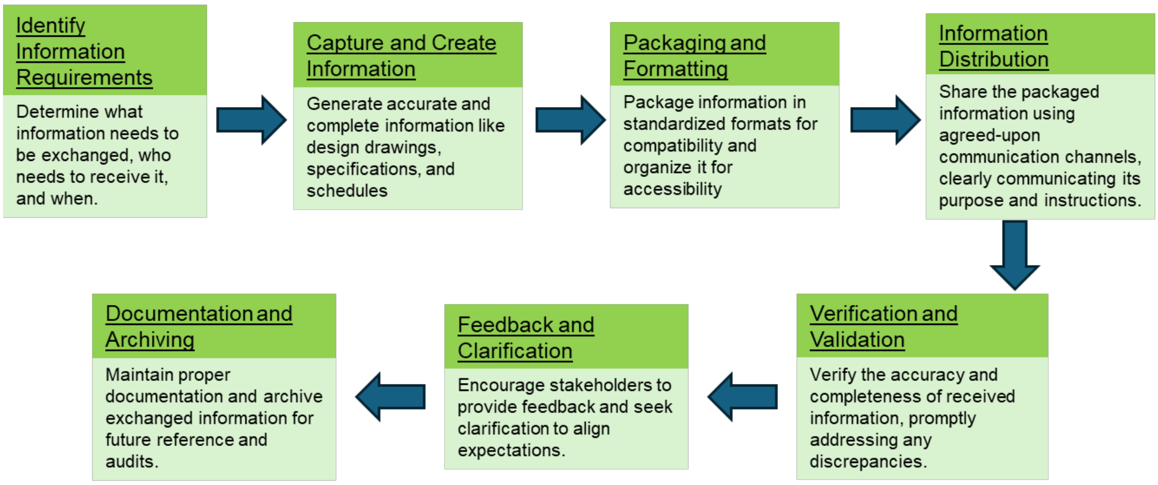
5. Verification and Validation: Upon receiving the information, stakeholders should verify its accuracy and completeness. This may involve reviewing the content against predefined standards, comparing it with existing data, or conducting quality checks. Any discrepancies or errors should be promptly addressed to ensure data integrity and reliability.

6. Feedback and Clarification: Stakeholders may provide feedback or seek clarification on the shared information. This feedback loop allows for the resolution of any discrepancies, clarification of requirements, and alignment of expectations. Timely communication and collaboration among project participants are essential during this phase to ensure a shared understanding of the exchanged information.

7. Documentation and Archiving: It is important to maintain proper documentation and archiving of all exchanged information. This includes maintaining a record of the exchanged files, correspondence, and any modifications or updates made during the information exchange process. Archiving ensures that historical information is readily available for future reference, audits, or potential claims. The workflow of the Common Data Environment (CDE) under ISO 19650 plays a crucial role in the documentation and archiving of exchanged information. For details please refer to the latest CIC BIM Standards General.

By following a well-defined workflow for information exchange, project stakeholders can enhance communication, minimise errors, and improve overall project coordination. Efficient information exchange lays the foundation for successful collaboration and helps ensure that project teams can make well-informed decisions based on accurate and up-to-date information.

In conclusion, the logistics of information exchange and data transfer are critical components of modern construction projects. By following a well-defined workflow and leveraging appropriate technologies and standards, project stakeholders can ensure efficient communication, collaboration, and data integration. Accurate data mapping facilitates seamless interoperability and supports informed decision-making. Successful implementation of information exchange and data transfer workflows enhances project outcomes, streamlines processes, and ultimately contributes to the overall success of the project.



Typical workflow for information exchange

6 IoT Integration: Advice on Sensors, Data Collection, and Associated Wiring Works

The integration of Internet of Things (IoT) technologies in the construction industry has revolutionised the way data is collected, analysed, and utilised. While this section primarily addresses IoT integration during the construction phase, it is essential to recognise that the application of IoT technology extends beyond construction and continues to provide valuable data and insights during the asset management and facility maintenance stages.

In the operational and maintenance phases, IoT technology continues to play a critical role in optimising asset performance and facilitating proactive maintenance. The data collected by IoT sensors and devices supports predictive maintenance strategies, enabling facility managers to identify potential issues before they escalate into costly failures. Additionally, IoT data contributes to performance analysis, energy optimisation, and space management, driving efficient and sustainable facility operations.

IoT data seamlessly integrates with BIM models and FM systems, providing a holistic view of asset performance and operational conditions. This integration enables facility managers to make data-driven decisions, optimise space utilisation, and ensure the comfort and safety of building occupants. Furthermore, IoT data supports the development of digital twins, virtual representations of physical assets that enable continuous monitoring and simulation of asset behaviour.

6.1 IoT Integration in Construction

IoT integration involves the seamless integration of sensors, devices, and data collection mechanisms into the construction environment. These IoT-enabled devices, commonly referred to as "smart devices", can capture and transmit data related to various parameters such as temperature, humidity, vibration, occupancy, energy consumption, and more. This data is then processed and analysed to gain valuable insights that can drive informed decision-making and optimise project performance.

The following advice will help in effectively integrating IoT technologies into construction projects:

1. Identify Data Requirements: Start by identifying the specific data requirements for your project. Determine the parameters you want to monitor, the frequency of data collection, and the level of granularity needed. This will help you select the appropriate sensors and devices for your IoT infrastructure.

2. Selecting Sensors and Devices: Choose sensors and devices that are specifically designed for construction environments and can withstand the harsh conditions typically encountered on construction sites. Consider factors such as durability, reliability, accuracy, and compatibility with your existing systems. There is a wide range of sensors available, including temperature sensors, humidity sensors, motion sensors, pressure sensors, and more. Select the sensors that are most relevant to your project objectives.

3. Wireless vs. Wired Solutions: Decide whether you want to deploy wireless or wired IoT solutions. Wireless solutions offer flexibility and ease of installation, as they eliminate the need for extensive wiring work. However, they may have limitations in terms of range, battery life, and potential interference. Wired solutions, on the other hand, provide a more stable and reliable connection but require careful planning for routing cables and may incur additional installation costs.
4. Bandwidth Considerations: Effective IoT integration in construction projects requires careful assessment of available network capacity, data transmission speeds, and the impact of data volume on network performance. By optimising data transmission protocols, implementing data compression techniques, and aligning IoT devices with network capabilities, construction teams can maximise data utilisation while minimising network congestion. Proactive bandwidth considerations enable real-time data insights without compromising network performance or data integrity.
5. Data Collection Devices: In addition to sensors, consider the data collection devices that will gather and transmit the data from the sensors. These devices can range from simple data loggers to advanced gateway devices that aggregate and transmit data to a central server or cloud-based platform. Evaluate the compatibility, connectivity options, and scalability of these devices to ensure they meet your project requirements.
6. Connectivity and Communication: Select the appropriate communication protocols and technologies for your IoT deployment. Common options include Wi-Fi, Bluetooth, Zigbee, LoRaWAN, and cellular networks. Consider factors such as range, data transmission speed, power consumption, and security when choosing the communication technology.
7. Power Supply: Determine the power requirements for your IoT devices. Some sensors and devices may be battery-powered, while others may require a constant power supply. Plan for power sources and backup options to ensure uninterrupted data collection and transmission. Consider energy-efficient solutions and explore the possibility of harnessing renewable energy sources, such as solar power, for powering your IoT infrastructure.
8. Wiring Works: If you opt for wired IoT solutions, plan the wiring works carefully. Consider the layout of the construction site, the locations of sensors and devices, and the routing of cables. Ensure that the wiring works comply with safety regulations and industry standards. It is advisable to involve qualified electrical contractors who specialize in construction wiring to ensure proper installation and minimise potential risks.
9. Data Management and Integration: Establish a robust data management system to handle the influx of data from IoT devices. This may involve integrating IoT data with existing project management systems, BIM models, or data analytics tools. Ensure compatibility and interoperability between different systems to enable seamless data integration and analysis.

10. Data Storage and Retention: Determine the appropriate data storage solutions to accommodate the volume and variety of IoT-generated data. Considerations should include the scalability, security, and accessibility of the storage infrastructure, as well as the retention period required to meet regulatory and operational needs. Additionally, guidance on data archiving, backup procedures, and data lifecycle management can be provided to ensure the long-term integrity and accessibility of historical IoT data.

11. Priority Settings for Time-Sensitive Signals/Alarms: Determine establishing priority settings for time-sensitive signals and alarms generated by IoT sensors. This includes defining protocols for identifying critical events, establishing escalation procedures, and integrating prioritisation mechanisms within the IoT infrastructure to ensure that urgent signals are promptly addressed and acted upon.

12. Data Security and Privacy: Implement appropriate security measures to protect the IoT infrastructure and the collected data. This includes securing communication channels, encrypting sensitive data, implementing access controls, and complying with data protection regulations. Regularly update firmware and software to address security vulnerabilities and follow best practices for IoT security.

13. Scalability and Future Expansion: Consider the scalability and future expansion of your IoT infrastructure. Anticipate potential changes or additions to the sensors and devices required for your project. Plan for the integration of new technologies and devices as the project progresses, ensuring that your IoT infrastructure can accommodate future needs.

14. Dynamic Data Exchange: To maximise the benefits of IoT integration with BIM models, it is crucial to establish dynamic data exchange mechanisms that enable bidirectional communication between sensors and the BIM models. Implementing protocols for real-time data synchronisation, automated alerts, and data visualisation within the BIM models enhances the project's monitoring capabilities and supports proactive maintenance practices. By advising on the importance of dynamic data exchange, this section underscores the value of leveraging IoT technologies to enrich the BIM models with real-time insights and optimize construction and facility management processes.

Considerations for selecting the IoT sensors

By following these guidelines, construction professionals can effectively integrate IoT technologies into their projects. IoT integration enables real-time data collection, analysis, and decision-making, leading to improved project outcomes, enhanced productivity, and optimised resource utilisation.

In conclusion, the integration of IoT in construction offers tremendous opportunities for data-driven decision-making and optimisation of project performance. By carefully selecting appropriate sensors, data collection devices, and considering the associated wiring works, construction professionals can harness the power of IoT to gain valuable insights, improve productivity, and drive successful project outcomes. Embracing IoT technologies in construction not only opens up new horizons for innovation, collaboration, and efficiency in the industry but also contributes to the entire lifecycle of assets and facilities. By providing valuable data and insights from the construction phase to ongoing management and maintenance, IoT technology enables stakeholders to drive informed decision-making, optimise resource utilisation, and enhance the performance and sustainability of assets and facilities throughout their lifecycle.

7 Advice on Developing Application Programming Interfaces (APIs) to Manage Data Collected from Physical Devices

Managing this data effectively and making it accessible for analysis and integration with other systems requires the development of robust Application Programming Interfaces (APIs). This section provides advice on developing APIs to manage the data collected from physical devices.

7.1 Understanding Application Programming Interfaces (APIs)

An Application Programming Interface (API) serves as the bridge between different software applications, allowing them to communicate and interact with each other. In the context of managing data from physical devices, an API acts as an intermediary layer that enables the transfer of data between the devices and the systems that process and analyse it.

APIs play a vital role in IoT applications by providing a standardised method for accessing and manipulating data collected from physical devices. They define the rules, protocols, and data formats that allow applications to interface with the collected data. By developing well-designed and well-documented APIs, organisations can simplify the integration of IoT data into their existing software systems and enable developers to create innovative applications built on top of the collected data.

7.2 Advice for Developing APIs to Manage IoT Data

When developing APIs to manage data collected from physical devices, the following advice can help ensure their effectiveness and usability:

1. Define Clear Objectives: Clearly define the objectives of the API. Determine the specific functionalities it should provide, such as data retrieval, data manipulation, device configuration, or real-time monitoring. Understanding the goals of the API will guide the development process and enable you to prioritize the essential features.

2. Design for Simplicity and Consistency: Strive for simplicity and consistency in API design. Use clear and intuitive naming conventions for endpoints, methods, and parameters. Follow industry best practices and established standards, such as REST (Representational State Transfer) or GraphQL, to ensure consistency and ease of use.

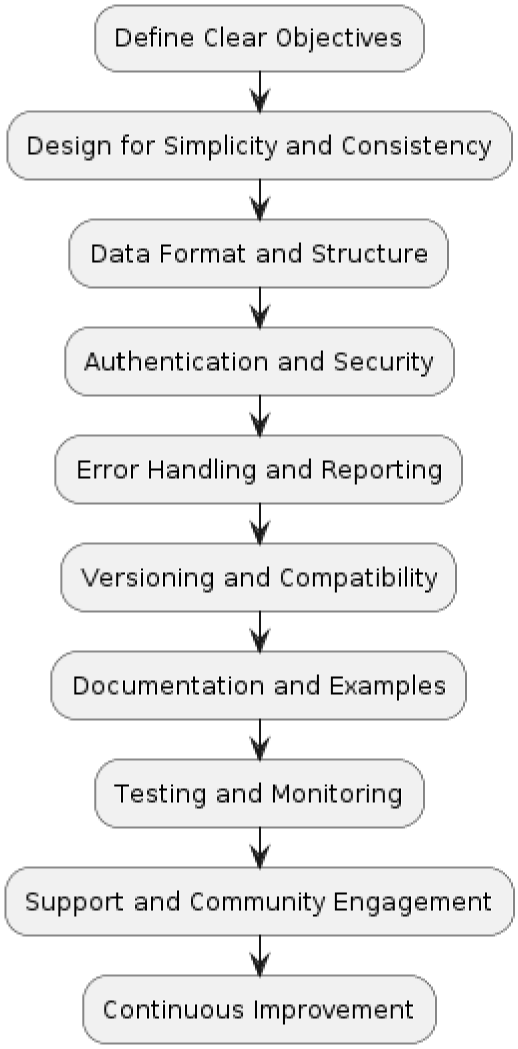
3. Data Format and Structure: Decide on the data format and structure for the API responses. Common formats include JSON (JavaScript Object Notation) and XML (eXtensible Markup Language). Ensure that the data structure is well-defined, organised, and self-descriptive, making it easier for developers to understand and work with the collected data.

4. Authentication and Security: Implement appropriate authentication and security measures to protect the API and the data it manages. Utilise secure protocols such as HTTPS (HTTP Secure) to encrypt data transmission. Consider

implementing authentication mechanisms like API keys, OAuth, or token-based authentication to control access to the API and ensure data privacy.

5. Error Handling and Reporting: Design the API to handle errors gracefully. Define error codes, messages, and appropriate HTTP status codes to provide meaningful feedback to developers when errors occur. Include detailed error descriptions and troubleshooting guidelines in the API documentation to assist developers in resolving issues quickly.
6. Versioning and Compatibility: Plan for API versioning and compatibility. As your IoT infrastructure evolves and new features are added, updates to the API may become necessary. Implement versioning mechanisms to ensure backward compatibility and provide developers with a smooth transition path when migrating to newer versions of the API.
7. Documentation and Examples: Create comprehensive and user-friendly documentation for the API. Include clear instructions on how to authenticate, use different endpoints, and interpret the data returned by the API. Provide code examples and sample requests to help developers understand how to interact with the API effectively.
8. Testing and Monitoring: Thoroughly test the API to ensure its functionality, reliability, and performance. Conduct unit tests, integration tests, and load tests to validate the API's behaviour under different scenarios. Implement robust logging and monitoring mechanisms to track API usage, identify performance bottlenecks, and proactively address issues.
9. Support and Community Engagement: Provide developer support channels to address queries, issues, and suggestions related to the API. Foster a developer community by establishing forums, chat groups, or dedicated support portals where developers can collaborate, share experiences, and contribute to the improvement of the API.
10. Continuous Improvement: APIs should be treated as living entities that evolve. Gather feedback from developers and end-users to identify areas for improvement and prioritize new features. Regularly update and enhance the API based on user feedback, emerging technologies, and evolving industry standards.

By following these guidelines, organisations can develop robust APIs that effectively manage data collected from physical devices. Well-designed APIs simplify the integration of IoT data into existing systems and enable developers to build innovative applications that leverage the collected data for valuable insights and enhanced decision-making.



Advice for Developing APIs to Manage IoT Data

7.3 Benefits of Well-Designed APIs for Managing IoT Data

Developing well-designed APIs to manage data collected from physical devices brings several benefits to organisations:

1. Seamless Integration: APIs provide a standardised and efficient way to integrate IoT data into existing software systems, making it easier to leverage the collected data for analysis, visualisation, and decision-making.
2. Scalability and Flexibility: Well-designed APIs enable organisations to scale their IoT infrastructures by adding new devices, sensors, and data sources without disrupting existing systems. APIs facilitate the seamless integration of new devices and accommodate future expansion.
3. Interoperability: APIs foster interoperability by allowing different applications and systems to communicate and exchange data. This enables organisations to connect IoT data with other systems, such as project management tools, analytics platforms, or customer relationship management (CRM) systems.
4. Innovation and Collaboration: APIs empower developers to create innovative applications and solutions that leverage the collected IoT data. By providing access to Standardised data and functionalities, APIs encourage collaboration among developers, leading to the development of new services and products.
5. Data Accessibility: Well-designed APIs make IoT data easily accessible to authorized users and applications. This accessibility promotes data-driven decision-making, as stakeholders can access and analyse real-time data to gain valuable insights and optimise operations.
6. Time and Cost Savings: APIs simplify the development process by providing pre-defined endpoints, data structures, and functionalities. This reduces the time and effort required to integrate IoT data, resulting in cost savings and faster time-to-market for IoT-driven applications.
7. Enhanced User Experience: APIs that are intuitive, well-documented, and easy to use improve the overall user experience. Developers can quickly understand and utilise the API, leading to faster adoption and increased productivity.
8. Data Security and Control: APIs enable organisations to enforce security measures, such as authentication, authorization, and encryption, to protect the IoT data and ensure data privacy. APIs provide granular control over data access, allowing organisations to define access levels and permissions for different user roles.

8 Upkeep of Model Geometry and Information in O&M Stage

In the field of engineering and construction, the Operations and Maintenance (O&M) stage is a critical phase that focuses on the ongoing upkeep and management of assets and infrastructure. During this stage, it is essential to maintain accurate and up-to-date model geometry and information to ensure the effective operation, maintenance, and future development of the project. This section provides detailed advice on the upkeep of model geometry and information during the O&M stage.

8.1 Importance of Model Geometry and Information in O&M

Model geometry and information serve as the digital representation of the physical assets and infrastructure, providing a comprehensive and detailed view of the project. In the context of O&M, the accurate depiction of building geometry and equipment locations holds significant importance for the maintenance team, enabling them to effectively carry out their responsibilities and optimise operational efficiency.

1. Spatial Familiarisation: Accurate model geometry allows the maintenance team to familiarise themselves with the spatial layout of the building, including the arrangement of structural elements, equipment placements, and utility connections. This familiarity is essential for efficient navigation within the facility and quick identification of maintenance areas.

2. Equipment Locating and Identification: Detailed model geometry facilitates the precise locating and identification of equipment and components within the building. Maintenance personnel can utilise the model to pinpoint the exact positions of assets, access technical specifications, and understand the interrelationships between different systems, streamlining maintenance activities.

3. Maintenance Planning and Execution: Detailed model geometry and information support maintenance planning and execution activities. Maintenance schedules can be developed based on the condition and requirements of individual assets, ensuring that preventive maintenance tasks are performed at the appropriate intervals and minimising the risk of unexpected failures.

4. Performance Monitoring and Analysis: Model geometry and information provide the foundation for performance monitoring and analysis during the O&M stage. By comparing real-time data from sensors and monitoring systems with the expected performance defined in the model, deviations and anomalies can be identified, allowing for timely corrective actions and optimisation of asset performance.

5. Safety and Compliance: Accurate model geometry and information help ensure safety and regulatory compliance. By incorporating safety-related data, such as escape routes, fire suppression systems, or hazardous materials storage locations, into the model, emergency response planning and compliance with safety regulations can be effectively managed.

6. Future Development and Expansion: Model geometry and information serve as a valuable resource for future development and expansion plans. By maintaining

accurate and up-to-date models, organisations can assess the feasibility of modifications or additions to existing infrastructure, streamline the planning process, and avoid potential clashes or conflicts with the existing assets.

8.2 Advice for Upkeeping Model Geometry and Information

To effectively upkeep model geometry and information during the O&M stage, the following advice should be considered:

1. Establish Data Governance: Implement a robust data governance framework to ensure the accuracy, integrity, and consistency of model geometry and information. Define clear roles and responsibilities for data management, establish data quality standards, and implement processes for data validation, verification, and updates.

2. Capture As-Built Data: During the construction phase, capture accurate as-built data to reflect the actual conditions and configurations of the assets. Utilise advanced surveying technologies, such as laser scanning or photogrammetry, to capture the precise geometry of the constructed elements and integrate this information into the as-built BIM model. It is particularly valuable in situations where the as-built data is incomplete or inaccurate. In such cases, advanced technology can provide a more comprehensive and detailed view of the asset, enabling the creation of more accurate and useful BIM models for O&M purposes.

3. Implement Change Management Processes: Develop change management processes to handle modifications, repairs, or replacements of assets during the O&M stage. Ensure that any changes to the physical assets are accurately reflected in the model geometry and information. Implement workflows and documentation requirements to capture and validate the changes before updating the model.

4. Utilise a Centralised Data Repository: Establish a centralised data repository to store and manage the model geometry and information. This repository should provide controlled access to authorized personnel and support version control to track changes over time. Implement appropriate security measures to protect the confidentiality and integrity of the data.

5. Regular Data Updates and Validation: Regularly update and validate the model geometry and information to reflect any changes or additions to the assets. Implement a periodic review process to verify the accuracy and completeness of the data. Conduct site inspections, compare field measurements with the model, and resolve any discrepancies to maintain the accuracy of the information. In certain environments, such as isolation wards or other sensitive areas where regular site inspections may not be feasible, it is crucial to establish alternative processes for updating the BIM models after replacement works, renovation activities, or any modifications to the assets. This may involve leveraging digital documentation, as-built records, and collaboration with the responsible personnel to ensure that any modifications or replacements are accurately reflected in the BIM models.

6. Integrate with O&M Systems: Integrate the model geometry and information with O&M systems and software platforms. This integration enables seamless data exchange between the model and various maintenance management systems, asset databases, or enterprise resource planning (ERP) systems. Ensure the compatibility of data formats and establish data exchange protocols to enable efficient information flow.

7. Implement Data Visualisation and Analysis Tools: Utilise data visualisation and analysis tools to effectively leverage model geometry and information. These tools offer interactive 3D visualisation, asset tagging, query capabilities, and advanced analytics to support asset management, performance monitoring, and decision-making during the O&M stage. By providing dynamic and immersive asset views, interactive 3D visualisation allows stakeholders to gain a deeper understanding of asset configuration, condition, and performance. This visualisation can be used to identify potential issues, evaluate different scenarios, and make informed decisions based on real-time data. For instance, interactive 3D visualisation can simulate the impact of various maintenance scenarios on asset performance, enabling stakeholders to assess strategy effectiveness and choose the optimal approach. Furthermore, interactive 3D visualisation facilitates real-time monitoring of asset performance, providing valuable insights into asset condition and enabling proactive maintenance and optimisation.

8. Collaborate with Stakeholders: Foster collaboration among different stakeholders involved in the O&M stage. Engage maintenance personnel, facility managers, asset owners, and other relevant parties to provide input, validate the model data, and share their domain-specific knowledge. Encourage feedback and suggestions to continually improve the accuracy and usability of the model geometry and information.

9. Training and Documentation: Provide comprehensive training and documentation to users who interact with the model geometry and information. Ensure that personnel responsible for O&M activities are trained on how to navigate and utilise the model effectively. Develop user manuals, guidelines, and training materials to facilitate the understanding and use of the model. Regularly update the documentation as needed to reflect any changes or enhancements to the model.

10. Regular Audits and Quality Control: Conduct regular audits and quality control checks on the model geometry and information. Implement a systematic process to review the data for accuracy, completeness, and consistency. Identify and resolve any issues or discrepancies promptly to maintain the reliability and usability of the model.

11. Continuous Improvement: Continuously seek opportunities for improvement in the upkeep of model geometry and information. Solicit feedback from users and stakeholders, assess the effectiveness of existing processes and tools, and explore emerging technologies and best practices in the field. Implement iterative improvements to enhance the efficiency and value of the model throughout the O&M stage.

12. Data Archiving and Retention: Establish a data archiving and retention policy to preserve the model geometry and information beyond the O&M stage. Define the duration for which the data should be retained and establish protocols for data backup, storage, and retrieval. Ensure compliance with applicable legal and regulatory requirements regarding data retention.

13. Regular Communication and Reporting: Maintain regular communication and reporting mechanisms to keep stakeholders informed about the status and updates of the model geometry and information. Provide timely reports on maintenance activities, asset performance, and any changes or enhancements made to the model. Foster transparency and collaboration to ensure effective decision-making and coordination among stakeholders.

14. Consider Future Integrations: Anticipate future integrations and interoperability requirements when designing and maintaining the model geometry and information. Account for potential upgrades, expansions, or integration with emerging technologies, such as BIM, Internet of Things (IoT), or Artificial Intelligence (AI). Plan ahead to ensure the scalability and adaptability of the model to future needs.

15. Engage External Expertise: Consider engaging external experts, such as consultants or technology providers, to support the upkeep of model geometry and information during the O&M stage. These experts can provide specialized knowledge, tools, and resources to optimise data management processes, enhance data quality, and implement best practices in asset management.

In conclusion, the upkeep of model geometry and information during the O&M stage is crucial for effective asset management, maintenance planning, safety, and future development. By following the advice provided in this section, organisations can ensure the accuracy, integrity, and usability of the model throughout its lifecycle, enabling efficient and informed decision-making for the successful operation and maintenance of assets and infrastructure.

9 Leveraging BIM to Create Digital Twin for AM and FM

BIM has become an increasingly valuable tool for AM and FM in recent years. BIM contains a comprehensive, data-rich 3D digital model of a building and its assets, capturing both the physical and functional characteristics of the built environment. This BIM model, containing detailed information about the building's features, can then serve as the foundation for digital twin - a virtual replica that mirrors the actual physical asset. The BIM models can be used throughout the construction project lifecycle, from design and construction to operations and maintenance, providing a centralised source of information to support asset and facility management workflows, such as predictive maintenance, energy management, and space utilisation. To facilitate the long-term upkeep, sharing, and reuse of BIM data, there is of paramount need for centralised repositories to store and share this valuable information across the construction project lifecycle.

9.1 Importance of Government Data Repository or Government SDI Integration

Effective data management and archiving are critical for the sustainable development of any city. By establishing a government data repository, Hong Kong can reap several benefits:

1. Data Preservation: A government data repository or SDI ensures the preservation and long-term storage of valuable data and information collected by various government departments and agencies. It safeguards historical records, research findings, spatial data, and other relevant information, preventing loss or degradation due to technological obsolescence or physical deterioration.

2. Future Planning and Development: Archiving data and information in a centralised repository or SDI allows for easy access and retrieval when planning and developing future projects. It provides a comprehensive and up-to-date resource for decision-makers, researchers, and urban planners to analyse past trends, assess the impact of previous projects, and make informed decisions for future development.

3. Efficient Data Sharing: Integration of a government data repository or SDI promotes efficient data sharing among different government departments and agencies. It eliminates data silos, reduces redundancy, and enhances collaboration by providing a single point of access to spatial data and related information. This streamlines processes improves data integrity, and fosters evidence-based decision-making.

4. Interoperability and Standardisation: A government data repository or CSDI establishes standards and protocols for data collection, storage, and sharing. It promotes interoperability between different systems and datasets, ensuring that data from various sources can be easily integrated and analysed. Standardisation enhances data quality, consistency, and compatibility, enabling effective data utilisation across different applications and platforms.

5. Public Access and Transparency: Integrating a government data repository or CSDI can enhance public access to spatial data and information. By making data openly available to the public, citizens, researchers, and businesses can utilise the information for research, innovation, and the development of new applications. This promotes transparency, accountability, and civic engagement in the planning and development process.

The Hong Kong Government has developed the Government BIM Data Repository (GBDR) and the Common Spatial Data Infrastructure (CSDI) to manage and store valuable BIM data of capital works projects and geospatial data collected by government departments as well as public and private organizations. The GBDR and CSDI are critical components of the government's data management and archiving strategy, and they play a vital role in facilitating sustainable Smart City development.

Construction professionals are encouraged to explore the wealth of public datasets available through the CSDI to support decision-making, enhance the efficiency of work and streamline the workflow and processes for asset and facility management. The CSDI provides access to diverse geospatial data, including information on [information mentioned not accurately presented data provided by CSDI, suggested to include other examples related to construction industry e.g. 3D Visualisation Map, Digital Topographic Map, Road Network, slope…. etc. By leveraging this data, construction stakeholders can contribute to the development of innovative solutions aimed at improving public amenities, optimising urban infrastructure, and enhancing community well-being.

To further enhance the value and usefulness of these existing government repositories, it is recommended to integrate them with BIM methodologies for AM and FM processes. Such integration would enable professionals in the construction industry to leverage the existing data available in the government repositories to optimise their AM and FM practices, leading to more sustainable Smart City development.

The guidance provided in this section emphasises the importance of stakeholder engagement, data governance, standardisation, scalability, data security, user-friendliness, capacity building, and collaboration. By following these recommendations, Hong Kong can establish a robust and future-proof data infrastructure that supports evidence-based decision-making, fosters innovation, and contributes to the sustainable development of the city. The effective contribution of BIM with AM and FM data from the industry back to the government through the GBDR will not only promote data transparency and accessibility, but will also enhance the overall quality of the BIM data and unlock the potential for BIM data reuse to support city-wide analysis. This integration will enable professionals in the construction industry to leverage the wealth of data stored in the GBDR and CSDI, leading to improved collaboration, streamlined processes, and informed decision-making in asset management and facility maintenance.

10 Challenges / Difficulties / Resolutions / Lessons Learnt

The implementation and management of any system often come with their fair share of challenges and difficulties. In this section, we explore common challenges faced during system implementation, maintenance, and upgrading, along with strategies for resolution and lessons learned from these experiences.

10.1 Challenges and Difficulties

a) Challenges in Data Integration:

- Example: In a real-world scenario, a facility management team faced challenges in integrating BIM data with their existing Computerised Maintenance Management System (CMMS). By developing custom data mapping templates and utilizing industry-standard formats such as COBie, the team successfully streamlined the integration process and improved data consistency.
- Practical Recommendation: When encountering challenges related to data integration across multiple systems and platforms, consider establishing clear data mapping protocols and standardised data exchange formats to ensure seamless interoperability.

b) Difficulties in Stakeholder Collaboration:

- Example: During a complex project, the coordination between the design team, construction contractors, and facility managers posed challenges in maintaining consistent asset information. By implementing regular interdisciplinary coordination meetings and utilising shared BIM models, the project team effectively addressed the difficulties and improved information exchange.
- Practical Recommendation: To address difficulties in stakeholder collaboration, establish regular communication channels and collaborative workflows to ensure alignment and engagement among all involved parties.

c) Resolutions for Data Quality Assurance:

- Example: A case study involving the implementation of BIM for asset management revealed challenges in ensuring the accuracy of asset data. By establishing automated data validation routines and conducting periodic data audits, the organisation successfully resolved data quality issues and enhanced the reliability of asset information.
- Practical Recommendation: Implement robust data quality assurance processes, including regular data validation checks and audits, to maintain the accuracy and reliability of asset information throughout the asset lifecycle.

d) Change Management:

- Example: In a facility management organisation transitioning to BIM-based workflows, the lessons learned emphasised the importance of providing comprehensive training programs and change management support to equip staff with the necessary skills and mindset for embracing BIM practices.

- Practical Recommendation: Prioritize change management strategies and user training to facilitate the adoption of BIM technologies and processes within asset management and facility management teams.

e) Integration Challenges and Solutions for Existing AM and FM Systems

- The integration of BIM with existing AM and FM systems can pose challenges for facility owners. Common challenges include data integration issues, difficulties in stakeholder collaboration, and data quality assurance. To overcome these challenges, facility owners can consider the following practical recommendations:
  - Establish clear data mapping protocols and standardised data exchange formats to ensure seamless interoperability.
  - Implement regular interdisciplinary coordination meetings and utilise shared BIM models to improve information exchange.
  - Develop robust data quality assurance processes, including regular data validation checks and audits, to maintain the accuracy and reliability of asset information.
  - Prioritise change management strategies and user training to facilitate the adoption of BIM technologies and processes within asset management and facility management teams.
  - Explore market-available system solutions that can seamlessly integrate with existing AM and FM systems and workflows.
  - Establish regular communication channels and collaborative workflows to ensure alignment and engagement among all involved parties.

f) User Engagement for Formulating Asset Data Requirements and System Feature Design

- Example: It is essential but may be difficult to actively involve end-users and stakeholders in the process of defining asset data requirements and designing system features to ensure the system's effectiveness and usability.

- Practical Recommendation: Best practices for user engagement, such as conducting workshops, focus groups, and user testing, should be emphasised to gather insights into the specific needs and preferences of end-users. By involving stakeholders from various departments and roles, organisations can ensure that the BIM system aligns with operational requirements and addresses the challenges faced in AM and FM.

By incorporating practical recommendations and real-world examples, this guide provides valuable insights into addressing challenges, implementing effective resolutions, and leveraging lessons learned to enhance BIM implementation in asset management and facility management.

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Member	**Representing Organisation / Remarks**
Prof. Jack CHENG Chin-pang	Chairperson of Committee on BIM
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Mr. Kwok Tak-wai	The Hong Kong Federation of Electrical and Mechanical Contractors Limited
Ir Ole WONG Ming-yan	Existing Com-BIM Member/ The Association of Consulting Engineers of Hong Kong
Cr Michael WONG Wai-lun	Existing Com-BIM Member/ Thong Kong Construction Association
Mr. Froky WONG Yuen-hung	The Hong Kong Institute of Building Information Modelling
Sr YIP Yin-yung	Existing Com-BIM Member/ The Real Estate Developers Association of Hong Kong
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Convenor and Secretary

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Mr. George Wong

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CIC Secretariat – BIM
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Fax No.: (852) 2100 9090