BIM GUIDE 5

BIM PROJECT GUIDE
A Guide to Enabling BIM in Projects

CIDB TECHNICAL PUBLICATION NO: 195

CIDB MALAYSIA

BIM GUIDE 5

BIM PROJECT GUIDE
A Guide to Enabling BIM in Projects

CIDB TECHNICAL PUBLICATION NO: 195

CIDB MALAYSIA

BIM Guide 5: BIM Project Guide

ISBN 978-967-0997-75-9

PREFACE

The **BIM Guide 5 - BIM Project Guide** is a document that is published by the Construction Industry Development Board (CIDB) to promote and support the use of BIM in Malaysian construction industry. Accordingly, the BIM Guide 5 - BIM Project Guide is a continuation from the series of BIM guide book, namely **BIM Guide 1- Awareness, BIM Guide 2- Readiness, BIM Guide 3- Adoption, and BIM Guide 4- BIM Execution Plan**. More importantly, this guide draws on the best BIM practices implemented by a number of countries and local organisations around the world.

The uptake and understanding of BIM within Malaysian construction industry is expected to increase since the release of the previous series of BIM guidebook. CIDB has worked together with public agencies alliance including Public Work Department (JKR), professional bodies, and private organisations in developing this guide that focuses on the consistent approach of BIM utilisation in a project.

The BIM Guide 5 - BIM Project Guide is developed substantially with BS EN ISO 19650 with the aim of outlining the processes of BIM implementation in a construction project. Overall, it is hoped that the BIM Guide 5 - BIM Project Guide is able to assist construction industry players in implementing BIM and help to unlock BIM benefits for a wider Malaysian construction industry. In this case, more insight and sharing from other organisations that can enhance BIM implementation in Malaysia are greatly appreciated. Therefore, interested parties may contact the Construction Research Institute of Malaysia (CREAM) or BIM secretariat, myBIM Centre.

Kindly forward your comments and suggestion to **it.pembinaan@cidb.gov.my** for further improvement on this guide.

ABOUT THIS GUIDE

The **BIM Guide 5 - BIM Project Guide aims to outline the processes of BIM implementation in construction project. This guide is intended to be used to:**

1. promote the use of BIM throughout the life-cycle;
2. creates a common BIM understanding for the construction industry;
3. define BIM deliverables in construction project;
4. clarifies the process for implementing BIM in construction project; and
5. define roles and responsibilities of project members.

This guide can be used as reference by project team to implement BIM on a project when practical. It contains knowledge and practical experience of implementing BIM in the construction project. The guide is organised in several section consists of:

1. **Section 1: Introduction;**
2. **Section 2: BIM basics in project;**
3. **Section 3: BIM workflow; and**
4. **Section 4: BIM modelling and documentation practice.**

This guide is developed substantially with BS EN ISO 19650 with the aim of outlining the processes of BIM implementation in a construction project. For the PASS 1192 standards, which formed the basis of the UK approach to BIM, are being superseded as the BS EN ISO19650 series of documents is developed. The evolution of these standards facilitates a consistent approach to information management at both national and international level. Table below shows some comparison between PASS 1192 and BS EN ISO 19650 to be as reference and enables user to have a clear understanding regarding the term and information process.

	PAS 1192	BS EN ISO 19650
Term	i. Supplier ii. Clients iii. Employer's Information Requirements (EIR) iv. Level of Information/Detail v. Project Implementation Plan (PIP) vi. Contract	i. Appointed Party ii. Appointing Party iii. Exchange Information Requirements (EIR) iv. Level of Information Need v. Delivery Team Mobilization Plan vi. Appointment
Contents of EIR	1. Information management 2. Commercial management 3. Competence assessment	1. Managerial aspects 2. Commercial aspects 3. Technical aspects
BIM Maturity	Stated as Level 0, Level 1, Level 2, Level 3	Stated as Stage 1, Stage 2, Stage 3

	PAS 1192	BS EN ISO 19650
Production of the pre-contract BIM execution plan (BEP) requirements	1. Project implementation plan (PIP) 2. Project goals for collaboration and information modelling 3. Major project milestones consistent with the project programme 4. Project information model (PIM) deliverable strategy (e.g. CIC Schedule)	1. Proposed names and professional resume of individuals from the delivery team 2. Delivery team's (DT) information delivery strategy 3. Proposed federation strategy to be implement by the delivery team 4. Delivery team's high-level responsibility matrix 5. Proposed additions or amendments to the project's information production methods and procedures 6. Proposed additions or amendments to the project's information standard 7. Proposed schedule of software (including versions), hardware and IT infrastructure
Production of the post contract BIM execution plan (BEP) requirements	1. Management (roles, responsibilities, milestones, deliverable strategy etc) 2. Planning and documentation (agreed matrix of responsibilities, revised PIP, TIDP, MIDP etc) 3. Standard method and procedure 4. IT Solutions	1. Confirm the names of the individual(s) who will undertake the information management function 2. Update the DT's information delivery strategy 3. Update the DT's high-level responsibility matrix 4. Confirm and document the DT's proposed information production methods and procedures 5. Agree with the appointing party any additions or amendments to the project's information standard 6. Confirm the schedule of software, hardware and IT infrastructure the DT use
Information Delivery/ Information Management	Assessment and Need ↓ Procurement ↓ Post-contract award ↓ Mobilization ↓ Production ↓ Asset Information Model (AIM)	Assessment and Need ↓ Invitation to Tender ↓ Tender Response ↓ Appointment ↓ Mobilization ↓ Collaborative production of information ↓ Information Model Delivery ↓ Project Close-Out

EDITORIAL TEAM

The development of **BIM Guide 5 - BIM Project Guide** was sponsored by the Construction Industry Development Board (CIDB) Malaysia, executed by the Construction Research Institute of Malaysia (CREAM) and supported by Public Work Department (JKR). We would like to thank the following members for their contribution and support.

Construction Industry Development Board (CIDB)

Datuk Ir Elias Ismail
Mr. Razuki Ibrahim
Mr. Jasni Ismail
Mr. Sharifuddin Umar
Mrs. Mazieana Che Amat

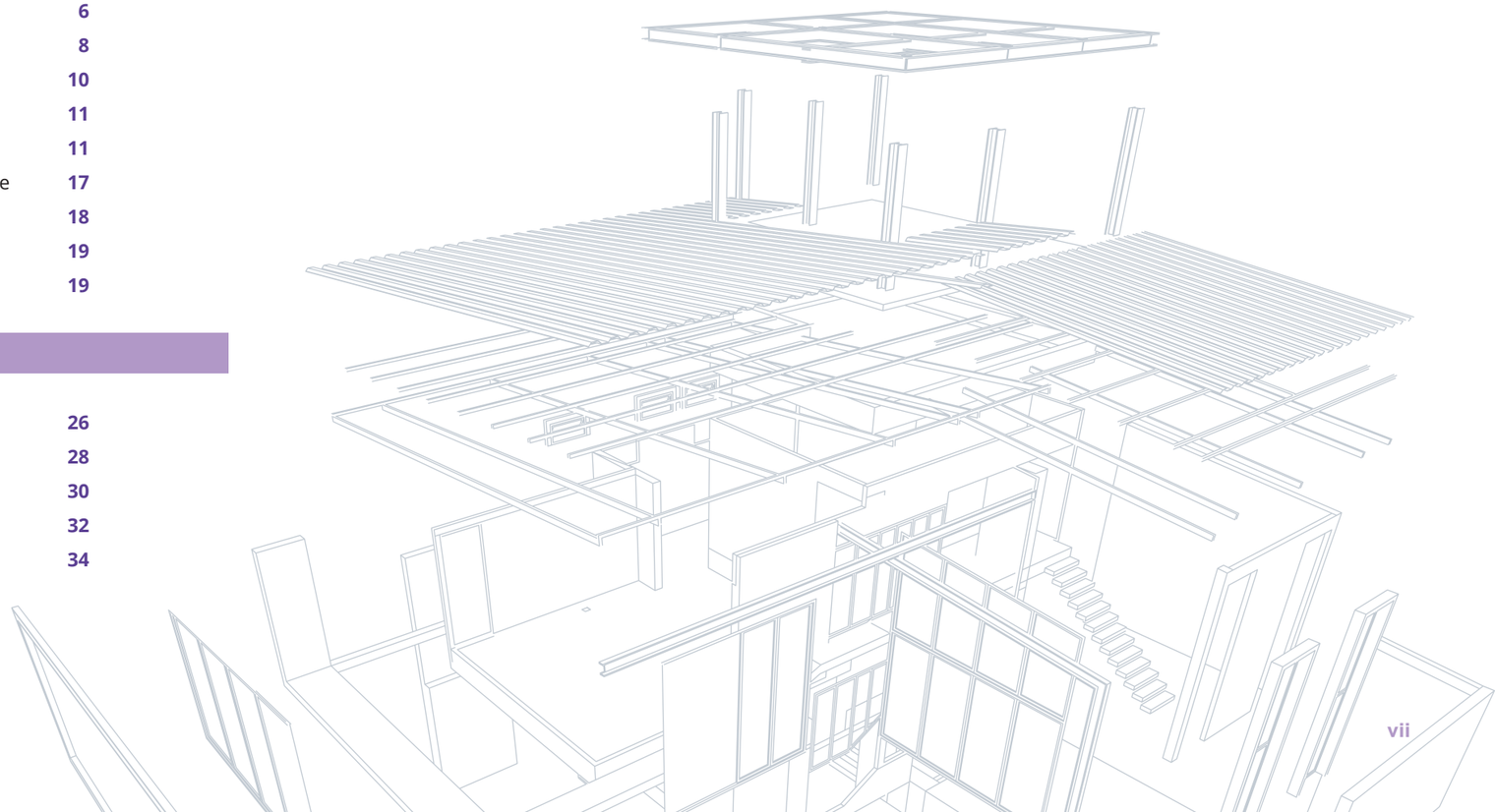
Construction Research Institute of Malaysia (CREAM)

Dato' Ir Rohaizi Mohd Jusoh
Ir Dr. Zuhairi Abd. Hamid, FASc
Mrs. Maria Zura Mohd Zain
Mr. Ahmad Farhan Roslan
Ms. Nurulhuda Mat Kilau
Mr. Mohammad Faedzwan Abdul Rahman

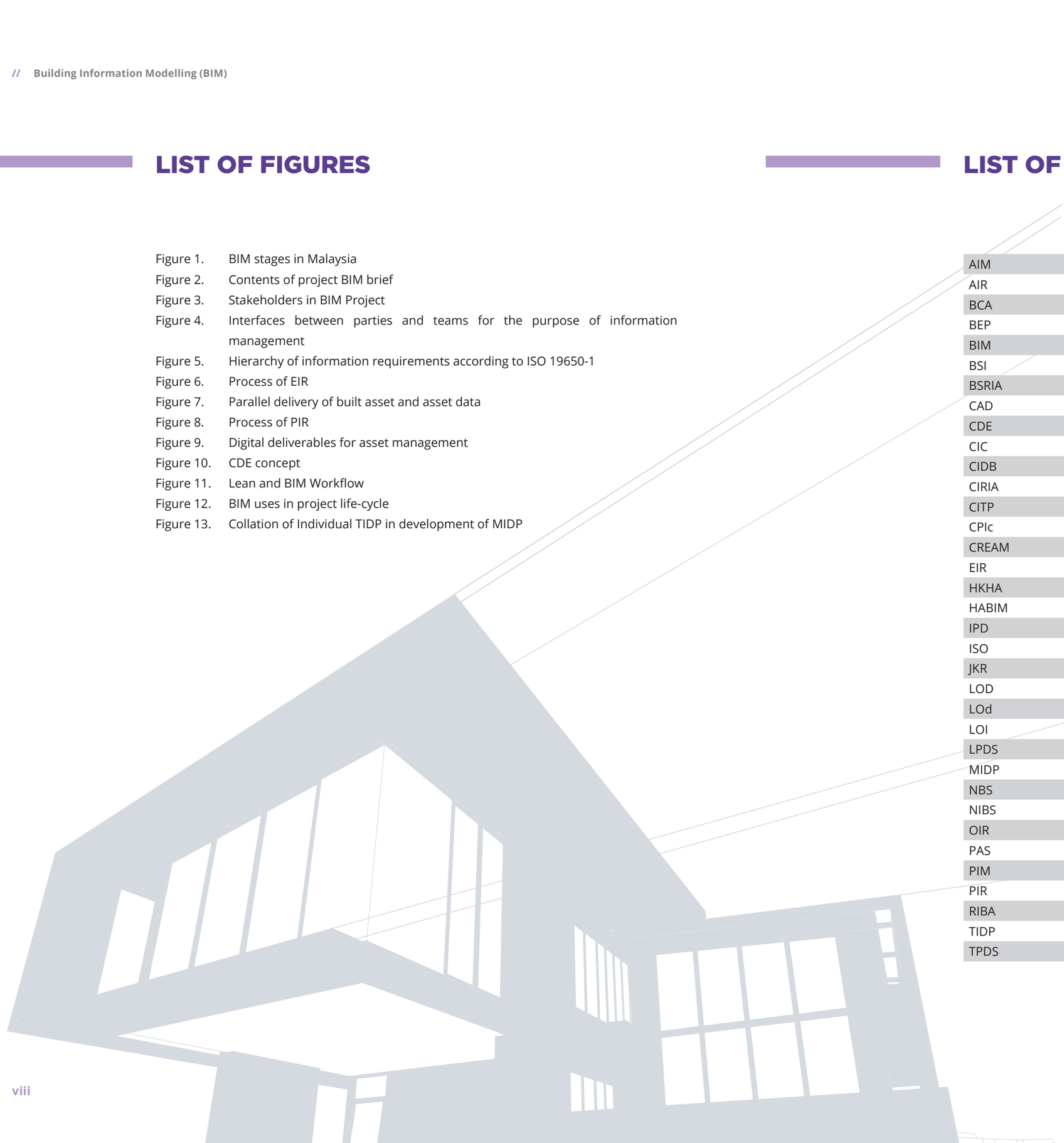
Public Work Department (JKR)

Mr. Muhammad Khairi bin Sulaiman
Ir Ahmad Ridzuan Abu Bakar
Ir Mohd Faiz Shapiai
Mrs. Nahziatul Shima Ismail
Sr Norafazarul Aini Nordin

CONTENTS



LIST OF FIGURES



LIST OF ABBREVIATION

AIM	Asset Information Model
AIR	Asset Information Requirement
BCA	Building and Construction Authority
BEP	BIM Execution Plan
BIM	Building Information Modelling
BSI	British Standards Institute
BSRIA	Building Services Research & Information Association
CAD	Computer-Aided Design
CDE	Common Data Environment
CIC	Construction Industry Council
CIDB	Construction Industry Development Board
CIRIA	Construction Industry Research and Information Association
CITP	Construction Industry Transformation Programme
CPIc	Construction Project Information Committee
CREAM	Construction Research Institute of Malaysia
EIR	Exchange Information Requirement
HKHA	Hong Kong Housing Authority
HABIM	Housing Authority BIM
IPD	Integrated Project Delivery
ISO	International Organization for Standardization
JKR	Public Work Department
LOD	Level of Development
LOd	Level of Detail
LOI	Level of Information
LPDS	Lean Project Delivery System
MIDP	Master Information Delivery Plan
NBS	National Building Specification
NIBS	National Institute of Building Sciences
OIR	Organisational Information Requirement
PAS	Publicly Available Specification
PIM	Project Information Model
PIR	Project Information Requirement
RIBA	Royal Institute of British Architects
TIDP	Task Information Delivery Plan
TPDS	Toyota Production Development System

Section 01

SECTION 1: INTRODUCTION

The introductory section provides an overview of BIM. In this section, the fundamental BIM knowledge is introduced as an integral part of BIM implementation.

1.1 What is BIM?

National BIM Steering Committee (2013) defines BIM as follows:

> **"Modelling technology and associated set of process to produce, communicate, analyse and use of digital information models throughout construction project life-cycle"**

Source: (CIDB Malaysia, 2016)

BIM evolves as the panacea of a virtual representation of construction throughout the life-cycle of a construction process. BIM is characterised as a data-rich, object-oriented, intelligent, and parametric digital representation of building facility. The characteristics of BIM have led to the development of independent models which can fulfil the needs of stakeholders in extracting and analysing all the information required in the supply chain. Overall, BIM is comprised of a model-based framework for multidisciplinary collaboration that encompasses of design, analysis, construction, operation, and data management.

1.2 BIM Stages

Construction Industry Transformation Programme (CITP) aims to transform the Malaysian construction industry through the implementation of Stage 2 BIM maturity by 2020.

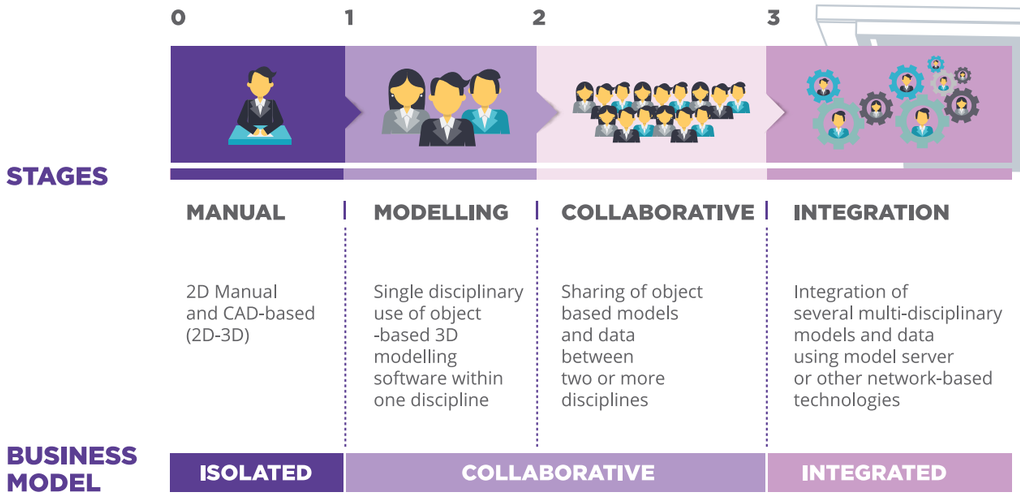


Figure 1. BIM stages in Malaysia

1.3 Benefits of BIM Implementation

BIM report 2016 shows that the top expected benefits of BIM implementation for construction organisation are as follows:

1	2	3
Improved project understanding;	Improved construction planning and monitoring;	Improved coordination between client-consultant-contractor;
4	**5**	**6**
Improved visualisation of the project;	Clash detections; and	Improved collaboration among project team members.

Section 02

SECTION 2: BIM BASICS IN PROJECT

In this section, the basic documents and key terms that are often related to BIM project will be explained in detail.

2.1 BIM Definitions

A glossary of BIM terminology is provided at the end of this document.

2.2 BIM Documents

BIM documents are fundamental for the implementation of BIM in a project because it provides the means that can define how a project will be executed, monitored, and controlled. Furthermore, it is able to assist the project team to understand the flow and management of data produced throughout the life-cycle of the construction process. Accordingly, the documents required for BIM implementation are explained in the following subsections.

2.2.1 Project BIM Brief

Project BIM Brief is developed by the client prior to engagement of the project team. Particularly, this project outlines the goals and benefits expected by the client that can be achieved from BIM. For instance, project BIM brief may be used to define the scope of works required from the consultants.

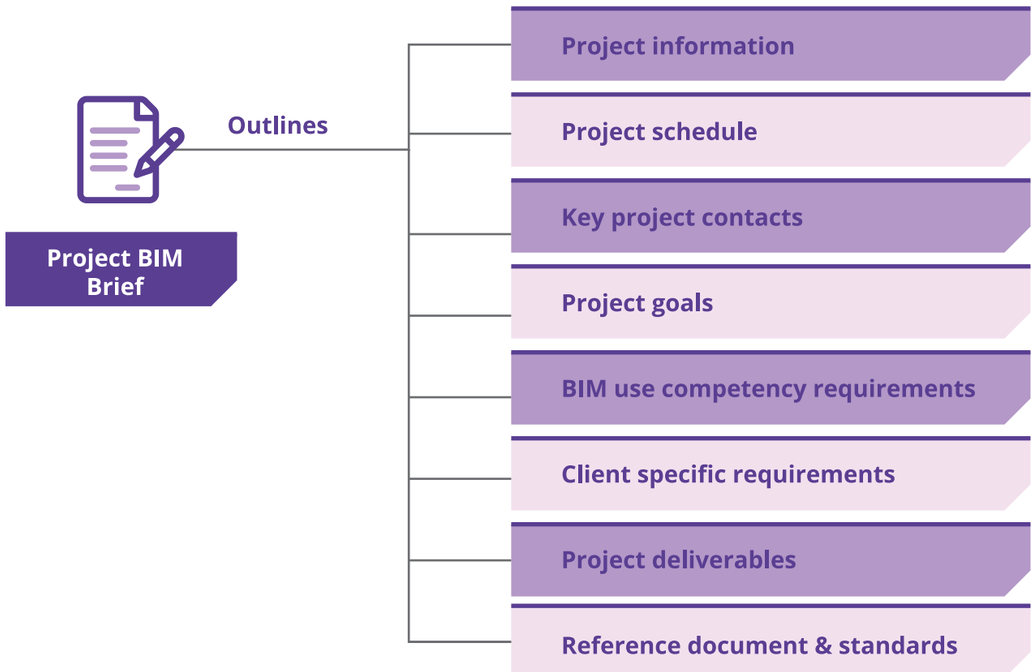


Figure 2. Contents of project BIM brief

2.2.2 BIM Capability Assessment

Regarding this matter, it is important to ensure that the project team has the capability to utilise BIM prior to commencing on the BIM project. In this case, the assessment on BIM capability among the prospective project team is deemed necessary because it is a part of the selection process. Accordingly, this guide suggests that BIM capability assessment must be conducted for the whole construction supply chain.

Reference

The BIM capability assessment tools for reference are listed below:

a) BIM Compass by Building Information Modelling Scottish Future Trust (https://bimportal.scottishfuturestrust.org.uk).
b) CPIx BIM Assessment Form by Construction Project Information Committee (CPIc) (https://www.cpic.org.uk/).

2.2.3 BIM Execution Plan (BEP)

In a general sense, the BEP should be developed according to the project requirements at the beginning of a project. The BEP outlines the project deliverables and provides the implementation details that can be employed by the project team throughout the project.

The BEP is responsible to assist the client and project team in documenting the agreed BIM deliverables and processes for the project. The document will then be submitted to the client with a detailed explanation on how the information modelling aspects of a project will be carried out including the followings:

a) project goals and value;
b) project team roles and responsibilities;
c) strategy for key deliverables and information to be used; and/or
d) methods and procedures.
e) information collaboration process/data exchange.

The BEP is developed both pre- and post-contract as a direct response to the Exchange Information Requirements (EIRs). In particular, the Pre-BEP will be used by the client to evaluate several aspects of the proposed approach which include project delivery, team capability, and capacity. Next, the appointed contractor is required to submit detail BEP once the contract has been awarded. Meanwhile, post-BEP sets the proper framework that allows the project to be delivered using BIM.

Reference

For details information on the BEP, please refer to:

a) CIDB BIM Guide Book 4: BIM Execution Plan (https://www.mybimcentre.com.my/download/bim-guide-4-bim-execution-plan/).
b) BIM project execution planning guide by The Pennsylvania State University (https://www.bim.psu.edu/).
c) Pre and Post – Contract BIM Execution Plan by CPIc (https://www.cpic.org.uk/cpix/cpix-bim-execution-plan/).

2.2.4 BIM Standards and Guidelines

BIM standards and guidelines are important guidance documents in implementing BIM. It describes processes that need to be developed and improve over time. These documents set out the requirements for standardised process in producing, managing and distribution of construction information using BIM. Development of open systems and standardised data is important in ensuring information can be utilized in the project life-cycle.

Below is a list of recommended BIM standards and guidelines from other countries together with the administration organisation or regulatory body.

A	British Standards Institute (BSI), United Kingdom	a) b)	BS EN ISO 19650-1&2: 2018 Organisation and digitization of information about buildings and civil engineering works, including building information modelling (BIM). Information management using building information modelling PD19650-0:2019 Transition guidance to BS EN ISO 19650
B	The Pennsylvania State University, United States	a) b) c) d)	BIM project execution planning guide BIM planning guide for facility owners The uses of BIM- Classifying and selecting BIM uses IR324-2 - Using Models in Construction: A Planning Guide
C	National Institute of Building Sciences (NIBS), United States	a)	The National BIM standard- United States (NBIMS-USTM V3)
D	The Building and Construction Authority (BCA), Singapore	a) b)	The Singapore BIM guide covers both BIM specification, BIM Modelling, and collaboration procedures. The Singapore BIM essential guide series provides references on good BIM practices in an illustrated, easy-to-read format, and are targeted at new BIM users in Singapore.
E	The Hong Kong Housing Authority (HKHA)	a) b)	Housing Authority BIM (HABIM) Standards and Guidelines Version 2.0 BIM Standards Manuals and User Guides

2.3 Stakeholders Roles in BIM Project

The stakeholders for the BIM project refer to individuals who are part of the project team which include client, consultants, contractors, or team members within an organisation. The following sections describe the roles and responsibilities with an emphasis on the project team participants as follows: (1) BIM for a client, (2) BIM for consultants, and (3) BIM for the contractor.

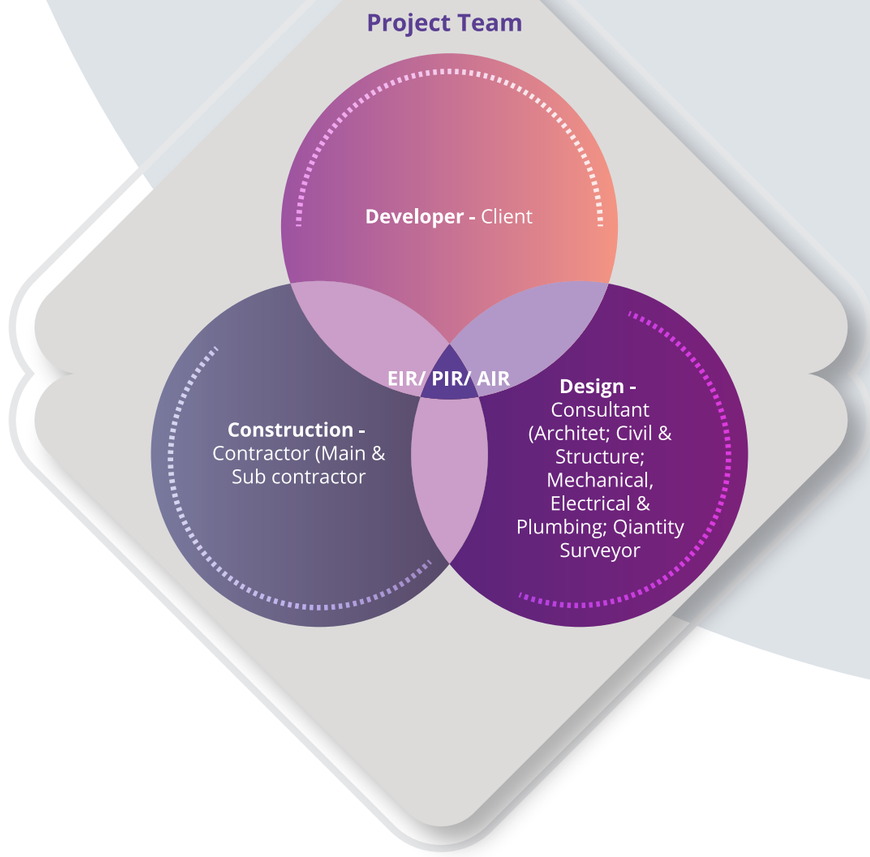


Figure 3. Stakeholders in BIM Project

2.3.1 Client Key Roles

Generally, clients who have a full understanding of the value of BIM will drive BIM adoption through the supply chain. In other words, client leadership in BIM implementation plays an important role in driving consistency and ensuring the focus of the project team in regards to the expected deliverables.

More importantly, the client needs to clarify the desired information from BIM throughout the asset life-cycle. In most cases, information requirement is associated with the project needs that are decided by the client prior to the beginning of asset management in a project. Accordingly, this refers to the need to appoint a capable person (e.g. project manager/ BIM manager) who is responsible for carrying out information delivery management for the asset. Section 3 provides a detailed explanation of the information delivery cycle of an asset.

The key roles of the client in the BIM project:

a) Identify aims, benefits, and expected deliverables of BIM for business and strategic decision,
b) Act as the main driver for the BIM project, and
c) Responsible for change management.

2.3.2 Consultant Key Roles

The responsibilities of consultants include the need to ensure the quality and integrity of the requirements desired by clients for the finished built asset. More importantly, consultants must understand that work collaboration among the team members of a project is the key success of BIM implementation. Therefore, a clear format statement of EIR should be developed to help the consultants to deliver information in a consistent and coordinated way.

The key roles of consultants in BIM project are as follows:

a) Identify the benefits of BIM to individual processes and workflows,
b) Willing to cooperate, collaborate, and share information,
c) Provide document and models for submission, and
d) Handover deliverables in accordance with clients' requirements.

2.3.3 Contractor Key Roles

In most projects, contractors may have direct involvement in a project depending on its type, particularly at the early phase of the project. In other words, they may have joint responsibility for the design development, rapid cost analysis, constructability, as well as traditional tasks of procurement and construction.

The key roles of contractors in BIM project are described below:

a) Manage information and issues from various stakeholders,
b) Deliver physical project as per the digital model, and
c) Utilise model information for construction and facility management.
d) Update BIM models as needed.

2.4 Contractual Considerations for BIM Projects

On another note, the regulatory, procurement, and legal contracting arrangement in the supply chain must be assessed and clarified for the purpose of facilitating the use of BIM and information exchange delivery across project life-cycle. Meanwhile, the EIR will be referred to as part of the contractual document for project delivery; hence, the EIR activities recommended in this guide may be performed under any procurement strategy and/or form of contract. Accordingly, listed below are some of the contractual considerations for BIM project:

a) Data sharing in the supply chain,
b) Model management and other roles and responsibilities,
c) Intellectual property rights and data management,
d) Data reliability, quality, integrity, and security,
e) Liabilities, and
f) Ownership of BIM process, risk management during model transfer, and model ownership.

Reference

Please refer to the followings for details information on the BIM legal:
a) BIM: Mapping out the legal issues by NBS (https://www.thenbs.com/knowledge/bim-mapping-out-the-legal-issues).
b) BIM legal documents by the Australian Institute of Architects (https://wp.architecture.com.au/bim/resources/legal-documents/).

2.5 Parties and Teams for Information Management

The ISO 19650-2 explains the interfaces between parties and teams in terms of information management which should not be considered as identification of contractual relationships. In this guide, the terms for both parties and teams are further explained in Figure 4.

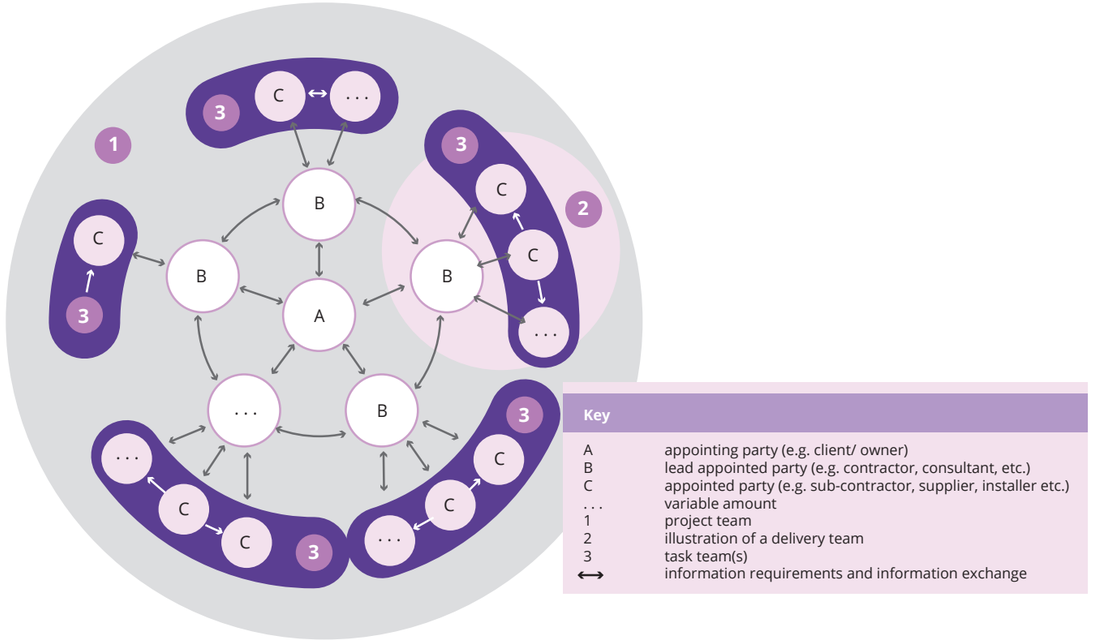


Figure 4. Interfaces between parties and teams for the purpose of information management

2.6 Types of Information Requirements and Information Models

In this section, a basic understanding of the information delivery cycle of an asset is clearly described. Generally, it is crucial to note that information requirements associated with a project should be provided to the client for business and strategic decision making about an asset during its operational phase. The concepts and terminology used are from ISO 19650-1.

Figure 5 presents an overview of the hierarchy of information according to ISO 19650-1. In this figure, "encapsulates" is defined as providing the input to, "contributes to" refers to provides input to, and "specifies" indicates the need to determine the content, structure, and methodology.

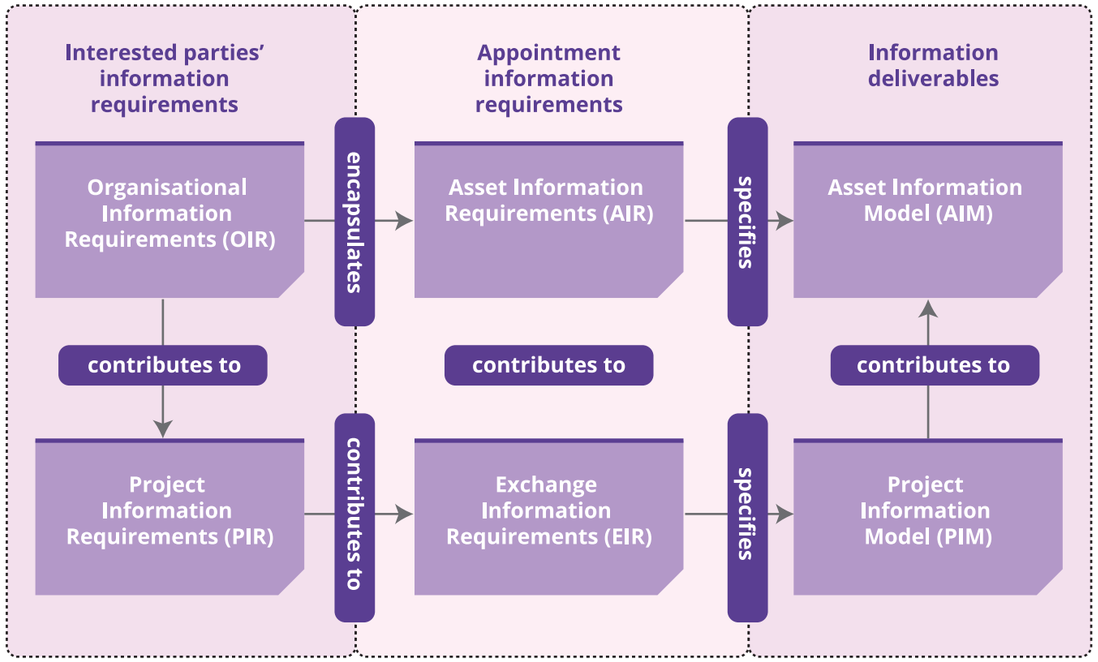


Figure 5. Hierarchy of information requirements according to ISO 19650-1

2.6.1 Organisational Information Requirements (OIR)

The OIR is established by an organisation to answer or inform the decision-making process in regard to high-level strategic objectives. More importantly, the OIR involves establishing and categorising the information requirements in order to meet the needs of asset management. However, it should be noted that the OIR is not considered as part of tender documentation even though it informs the Asset Information Requirements (AIR) and Project Information Requirements (PIR).

Tips

One of the important steps is to identify the following potential benefits of creating digital information model prior to embarking on the BIM project:

- time and money needed to create data and file store,
- time and money needed to identify the information required,
- time and money needed to collect data,
- individuals needed to conduct the work and provide governance, and
- software tools that are required to extract data from the asset information model and create reports.

S *2.6.2 Exchange Information Requirements (EIR)*

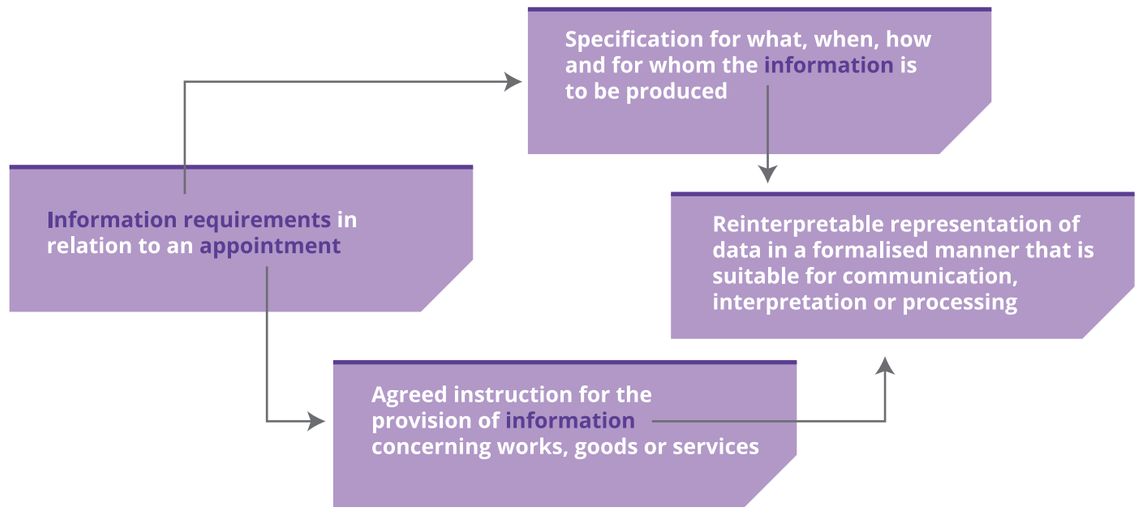


Figure 6. Process of EIR

Furthermore, EIR is normally aligned with project requirements which represent the completion of some or all project phases. Specifically, EIR consists of information regarding who, how, and when of their delivery, while the AIR and PIR describe what information is required. Apart from that, several different appointments may exist across a project. Hence, each appointment should be able to form a single coherent and coordinated set of information requirements which is sufficient to address all the PIR. Overall, the information needed to answer the PIR should be specified in EIR and incorporated into project-related appointments.

The EIR sets out managerial, commercial, and technical aspects of producing project information which should include the followings:

a) details of the roles and responsibilities of project team members,
b) information production processes and procedures,
c) data standards,
d) file formats, and
e) timetables for information exchanges.

The EIR should then be used for the development of the BIM Execution Plan (BEP).

2.6.3 Asset Information Requirements (AIR)

The AIR is described as a subset of the overall project brief that sets out multiple data to support organisation requirements within the OIR. Additionally, it must be understood that AIR defines the data and information required throughout the asset life-cycle. Figure 7 shows the processes of delivery of built asset and asset data.

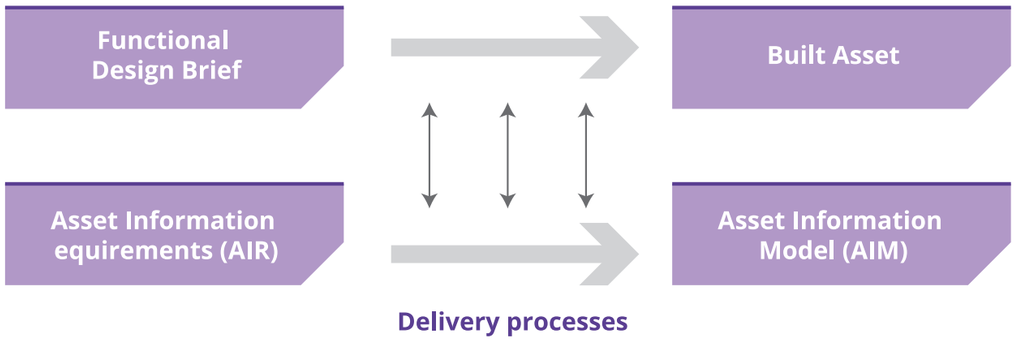


Figure 7. Parallel delivery of built asset and asset data

The provision of asset data as per specified requirements should form part of design and construction obligation within the associated contracts. Accordingly, it is important to ensure that the data required are clearly defined as well as objectively measured and tested against the defined standards.

2.6.4 Project Information Requirements (PIR)

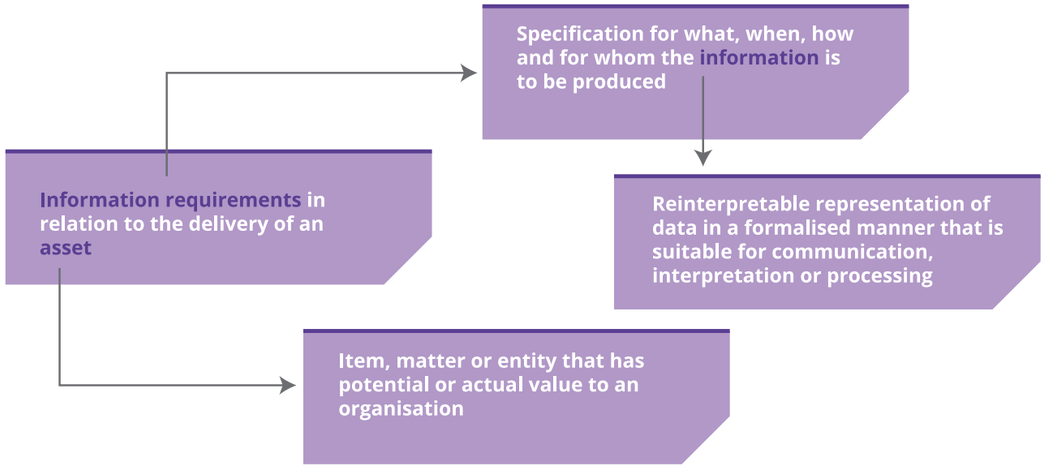


Figure 8. Process of PIR

All the information required by the client will be explained in PIR for the purpose of answering or informing high-level strategic objectives within the appointing party in a project. Meanwhile, a set of information requirements should be prepared for each of the key decision points of the appointing party during the project. In this case, a client with several experiences tends to have generic PIR that is adopted or customised according to each of their projects.

2.6.5 Asset Information Model (AIM)

The AIM refers to the deliverables provided by the delivery team that is able to achieve the requirements set by the client AIR. Furthermore, the AIM supports strategic and day-to-day asset management processes as well as provides data and information at the start of a refurbishment or extension of an existing asset. Figure 9 illustrates three digital deliverables for asset management which are referred to as AIM in ISO 19650-1.

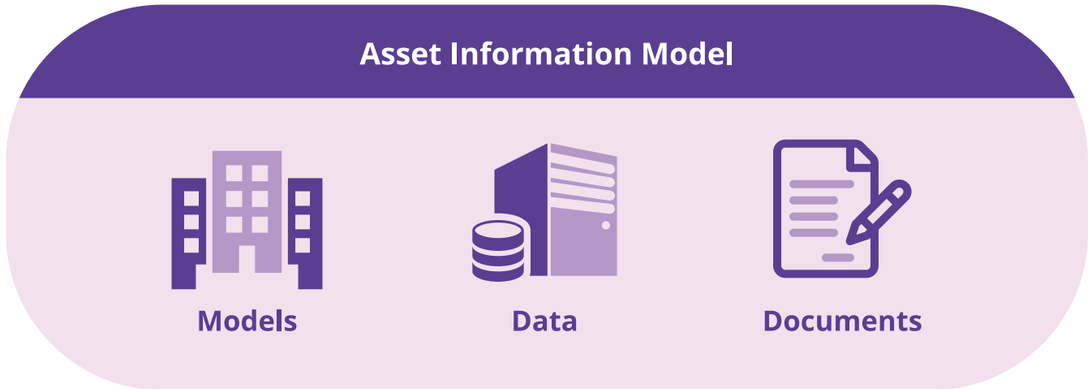


Figure 9. Digital deliverables for asset management

Tips

How to decide on AIR?

- Begin with the end in mind,
- Ask about the information required by the facility management team,
- Develop a well-structured data set that has been verified, validated, and reliable,
- Begin with any data that are usually scheduled in drawings or specifications,
- Adopt a 'fit and lean' approach to asset data,
- Be realistic and clear about the difference between real, foreseeable needs, and the 'nice to have',
- Understand the implications of requesting certain sets of data, and
- Consider the granularity of information needed.

2.6.6 Project Information Model (PIM)

On another note, it should be clearly understood that data created in the PIM often supports the delivery of the project which will be transferred to the AIM. The PIM begins with a design intent model that is progressively developed into an AIM which can be utilised during the operational phase. However, it is important to note that not everything added to the PIM during the project is relevant to the AIM. In other words, PIM should only be stored for auditing purposes and used as an archive for the project. Generally, PIM contains different types of information which include the methods of construction, scheduling and costing, details of systems as well as components and equipment that are installed during project construction.

2.6.7 *Common Data Environment (CDE)*

The CDE is described as a sharing platform that contains information about any given project. In particular, CDE is used to collect, manage, and disseminate all relevant approved project documents for multi-disciplinary teams in a managed process. Apart from that, it also functions as a digital hub that allows verified and coordinated information to be shared efficiently and accurately with every member of the project team.

On another note, the client should be able to define the platform for the CDE and determine who will procure, maintain, manage, and administer the CDE throughout the construction project cycle. Accordingly, the ISO 19650-1 defines the outline of CDE as a process that consists of four phases as illustrated in Figure 10.

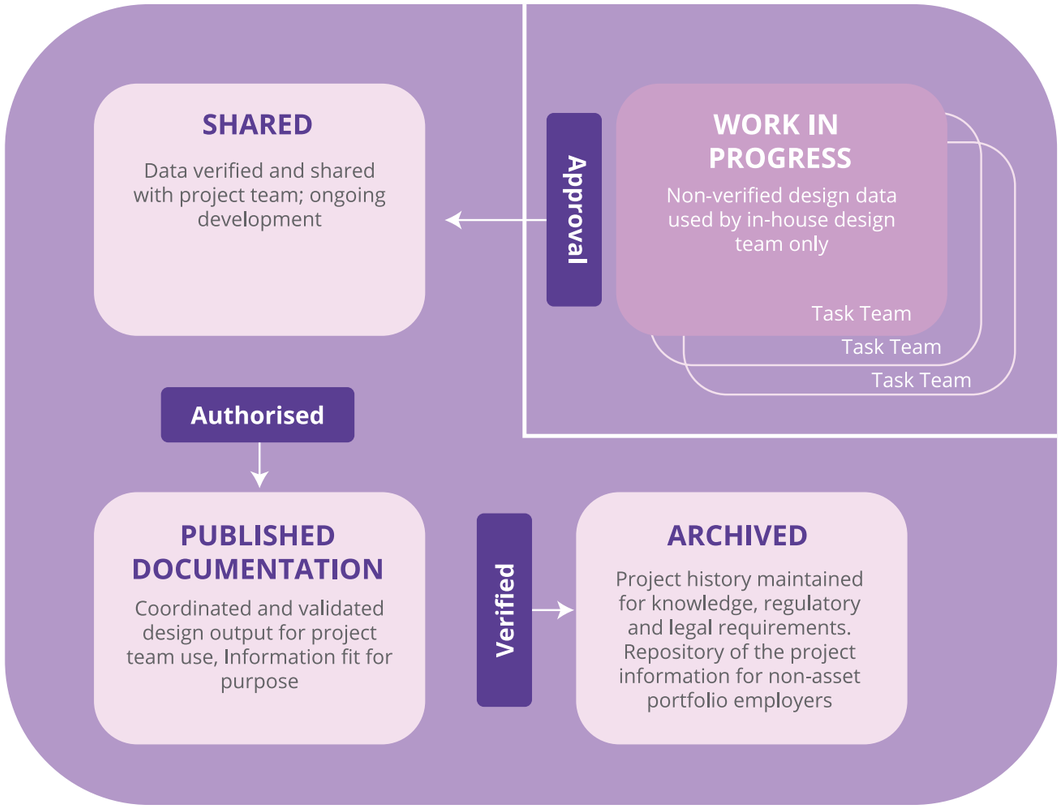


Figure 10. CDE concept

2.7 Process Optimisation: BIM, Integrated Project Delivery (IPD) and Lean Principle

Stakeholders involved in a BIM project should focus on creating an improved process for digitalisation. Regarding this matter, this guide recommends that the integration of BIM must occur with the Integrated Project Delivery (IPD) and lean principle for process optimisation purposes. The following sections provide a further understanding of the integration of IPD and lean principle in BIM practice.

2.7.1 *Integrated Project Delivery (IPD)*

The American Institute of Architects (AIA) defines IPD as a project delivery approach that integrates people, systems, business structures, and practices into a process. The purpose of the integration is to collaboratively harness the talents and insights of all participants with the aim of reducing waste and optimising efficiency throughout every phase of the design, fabrication, and construction.

The basis of IPD is to integrate clients, designers, contractors, suppliers, and manufacturers with the aim of developing an integrated model that captures the needs of all parties, particularly starting from the initial phases of a project. More importantly, IPD emerges as a delivery method that effectively facilitates the use of BIM in a construction project. Meanwhile, the application of BIM is important because it allows the IPD practices to be adopted in order to facilitate reliable information through the quality of the BIM data model that is equipped with a proper workflow.

Reference

Please refer to the followings for more information on the IPD:

a) Integrated Project Delivery: An Action Guide for Leaders by Charles Pankow Foundation (https://leanipd.com/integrated-project-delivery-an-action-guide-for-leaders/).

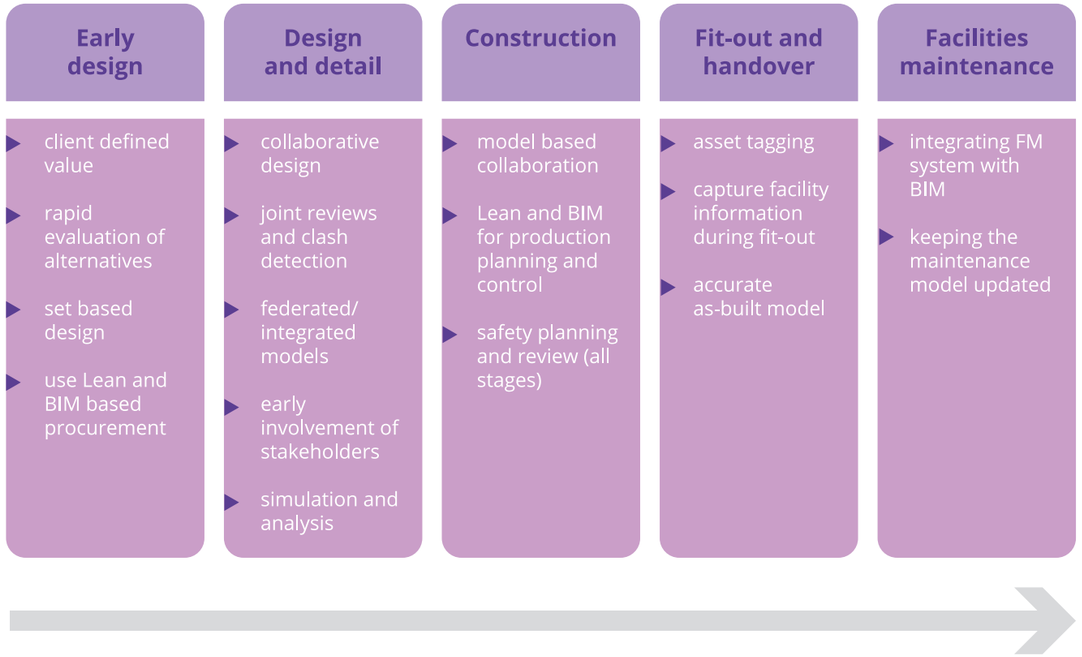
b) Integrated Project Delivery: A guide by The American Institute of Architects (http://info.aia.org/siteobjects/files/ipd_guide_2007.pdf).

2.7.2 *Lean Principle*

According to IPDA (2018), lean thinking involves defining the customer value, mapping the value chain, establishing pull, creating flow, and finding the right problems to solve. Accordingly, construction processes are currently developed based on the lean concept due to the success of lean manufacturing.

The Lean Project Delivery System (LPDS) comprises of several phases which include project definition, lean design, lean supply, lean assembly, and use or completion. More importantly, this method has been adapted into the construction industry and integrated with computer modelling based on the Toyota Production Development System (TPDS) (Harris & McCaffer, 2013). Furthermore, it is crucial to understand that the lean concept is built on a foundation of team integration and open sharing of information. Therefore, this clearly indicates that BIM provides a collaborative environment that facilitates the integrated design as well as the construction process as the underlying of this foundation.

On another note, BIM-based workflow information system assists the project team in the implementation of lean practices which include integrated information management or product orientation in the supply chain (Sacks & Barak, 2013; Papadonikolaki, 2015). Figure 11 presents the lean and BIM workflow for the entire project life-cycle.

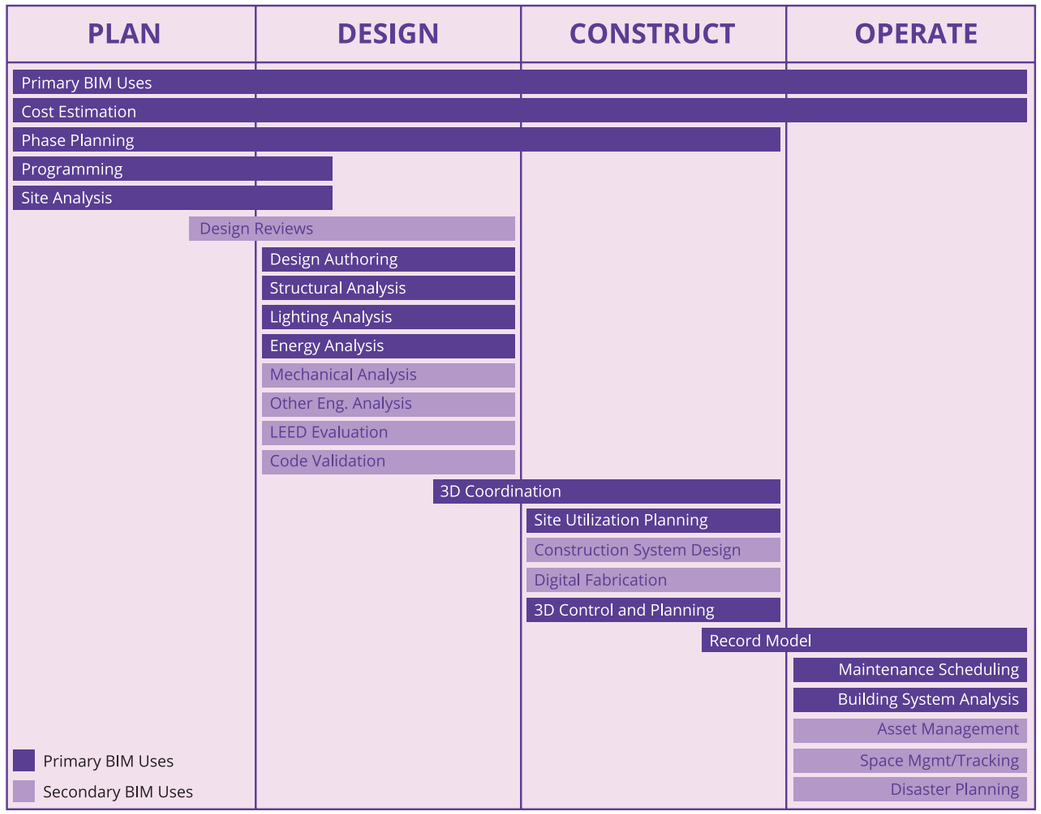


Source: CIRIA, 2013

Figure 11. Lean and BIM Workflow

2.8 BIM Uses

Essentially, the BIM uses refer to how BIM can be utilised in a project. Specifically, a BIM use is defined as "a method of applying BIM during a facility's life-cycle to achieve one or more specific objectives". In this guide, BIM uses have been referred to as the "Penn State BIM Execution Planning Guide". Therefore, a BEP is required to clearly state BIM uses according to the project objectives. Figure 12 illustrates BIM uses in the project life-cycle.



Source: Penn State BIM Execution Planning Guide

Figure 12. BIM uses in project life-cycle

2.9 Master Information Delivery Plan (MIDP)

The MIDP forms a part of the BIM execution plan that is required by the EIR. In addition, it should be understood that MIDP is a primary plan that manages the delivery of information during the project life-cycle. More importantly, it is prepared by the BIM manager in collaboration with the task team managers in order to assist the delivery of project information during the project.

2.10 Task Information Delivery Plan (TIDP)

The TIDP includes the details of when the project information must be prepared, an individual who is responsible for producing the information as well as what protocols and procedures for the phase that should be followed.

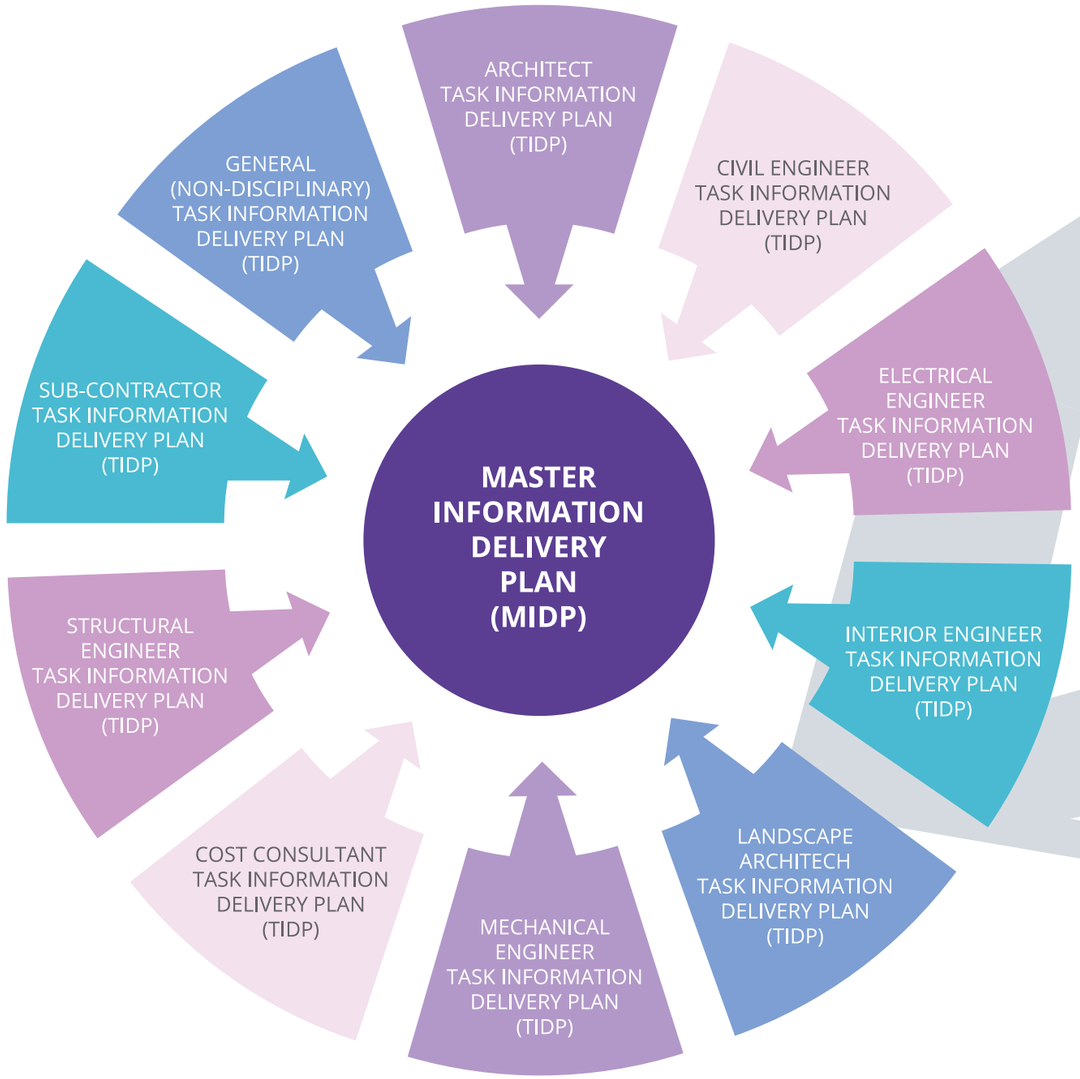


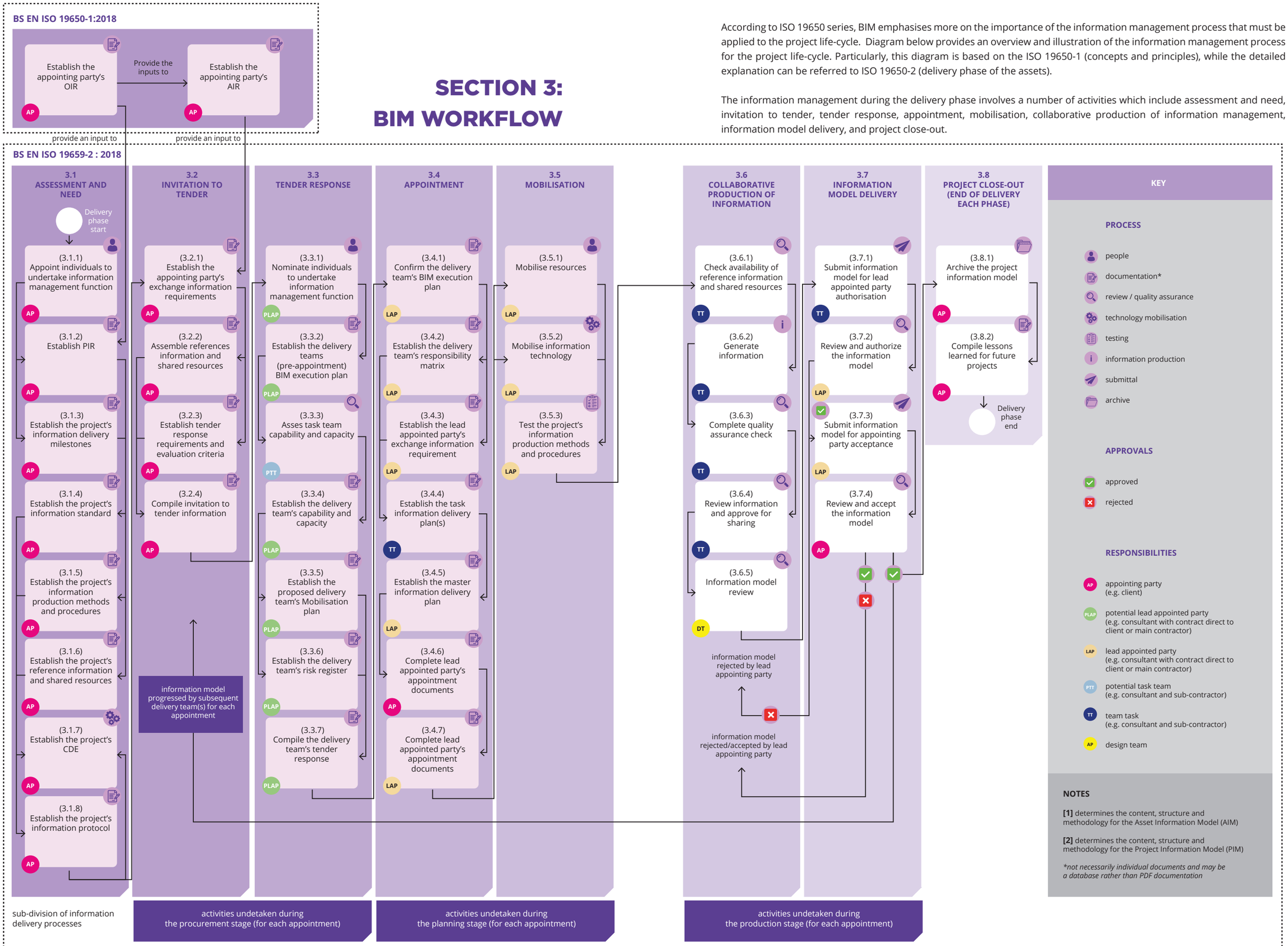
Figure 13. Collation of Individual TIDP in development of MIDP

Section 03

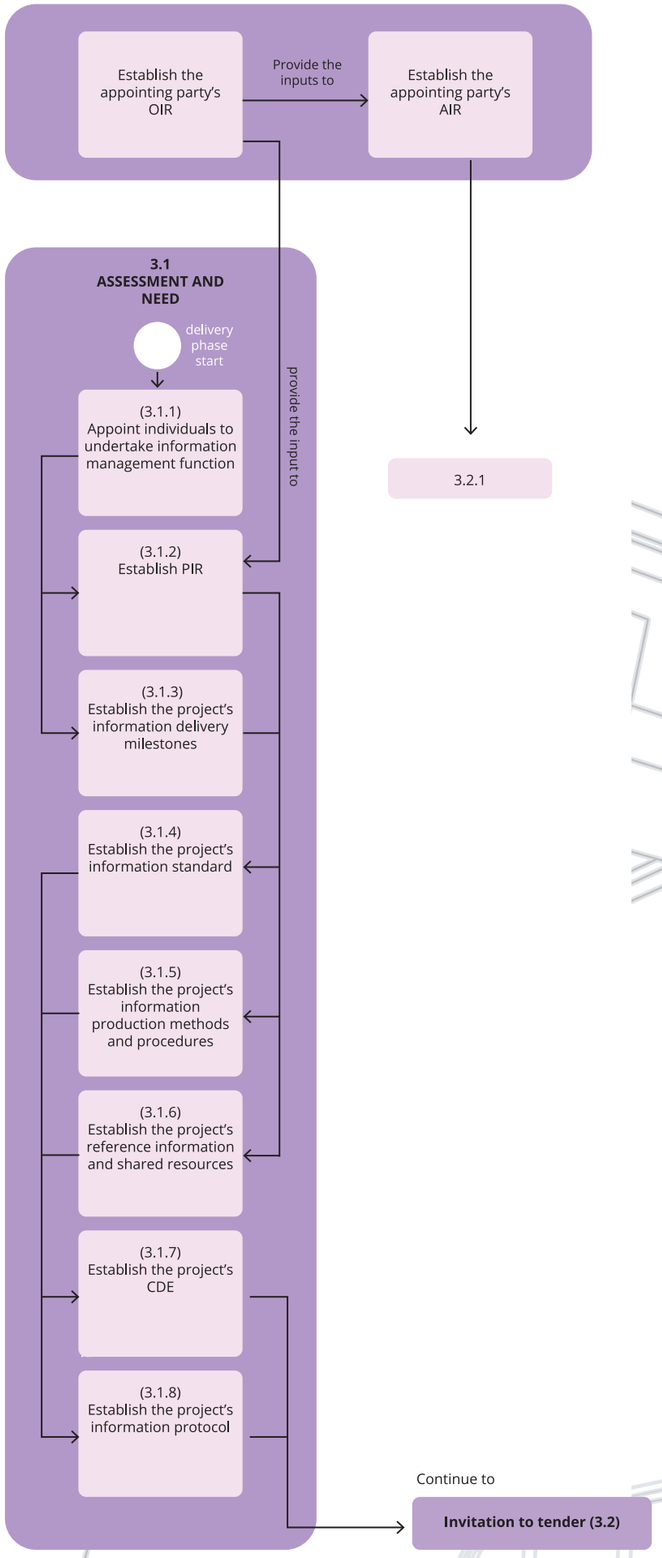
SECTION 3: BIM WORKFLOW

According to ISO 19650 series, BIM emphasises more on the importance of the information management process that must be applied to the project life-cycle. Diagram below provides an overview and illustration of the information management process for the project life-cycle. Particularly, this diagram is based on the ISO 19650-1 (concepts and principles), while the detailed explanation can be referred to ISO 19650-2 (delivery phase of the assets).

The information management during the delivery phase involves a number of activities which include assessment and need, invitation to tender, tender response, appointment, mobilisation, collaborative production of information management, information model delivery, and project close-out.



3.1 Assessment and Need



3.1.1 Appoint Individuals to Undertake Information Management Function

The appointing party should regard the effective management of information throughout the project as well as reflect the long-term asset information management strategy. However, the appointing party can appoint a prospective lead appointed party or a third party to be responsible for information management function.

3.1.2 Establish the Project's Information Requirements (PIR)

The appointing party must establish the information requirements of the projects as stated in the AIR. Next, the AIR will address the questions which need to be answered by the appointing party at each of the key decision points throughout the project life-cycle.

3.1.3 Establish the Project's Information Delivery Milestones

The appointing party should establish the information delivery milestones of the project in accordance to the plan of work.

Reference

Listed below are several references for developing a plan of work:

a) Royal Institute of British Architects (RIBA) 2013 Plan of Works (RIBA);
b) Construction Industry Council BIM Protocol (CIC BIM);
c) Construction Industry Council (CIC); and
d) Soft Landing Building Services Research & Information Association (BSRIA).

3.1.4 Establish the Project's Information Standard

The appointing party should establish specific information standards required by the organisation that are within the information standard of the project.

3.1.5 Establish the Project's Information Production Methods and Procedures

The appointing party should establish specific information production methods and procedures required by the organisation that must be within the information production methods and procedures of the project.

3.1.6 Establish the Project's Reference Information and Shared Resources

The appointing party should establish the reference information and shared resources that are intended to be contributed to the prospective lead appointed parties during the tender process or appointment. However, this should be carried out using open data standards whenever possible in order to avoid duplication of effort and interoperability issues.

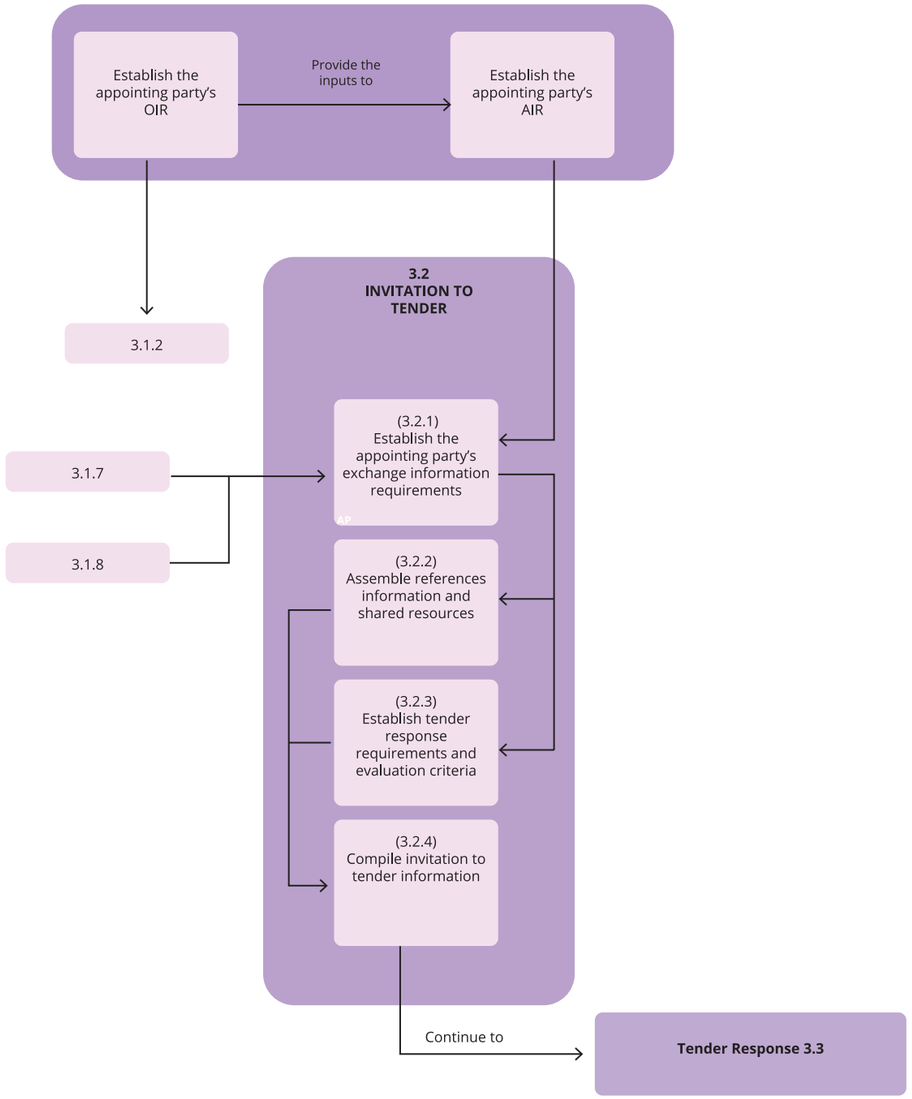
3.1.7 Establish the Project's Common Data Environment (CDE)

The appointing party should establish (implement, configure, and support) the CDE of the project in order to serve the overall requirements of the project as well as support the collaborative production of information.

3.1.8 Establish the Project's Information Protocol

The appointing party should establish the information protocol of the project including any associated license agreements that will subsequently and appropriately be incorporated into all appointments.

3.2 Invitation to Tender



3.2.1 Establish the Appointing Party's Exchange Information Requirements (EIRs)

The appointing party shall should establish their EIRs to that will be delivered by the prospective lead appointed party during the appointment. The appointing party shall. In this case, the appointing party should carry out the followings:

a) Establish the information requirements of the appointing party that will be served during the appointment and then considered on their OIR, AIR, and PIM.
b) Establish the Level of Information (LOI) that is required to meet each information requirement.
c) Establish the acceptance criteria for information requirements which encompass the project information standard, project information production methods as well as reference information or shared resources provided by the appointing party.
d) Establish the supporting information that is needed by the prospective lead appointed party in order to understand or evaluate each information requirement.
e) Establish important dates relative to the information delivery milestones of the project as well as the key decision points of the appointing party.

3.2.2 Assemble References Information and Shared Resources

The appointing party should assemble the reference information or shared resources that will be provided to the prospective lead appointed party during the tender process or appointment. Hence, the followings must be considered by the appointing party:

a) The reference information or shared resources identified during the project initiation,
b) The information generated during previous phases of the project,
c) The suitability of information to be used by the prospective lead appointed party.

3.2.3 Establish Tender Response Requirements and Evaluation Criteria

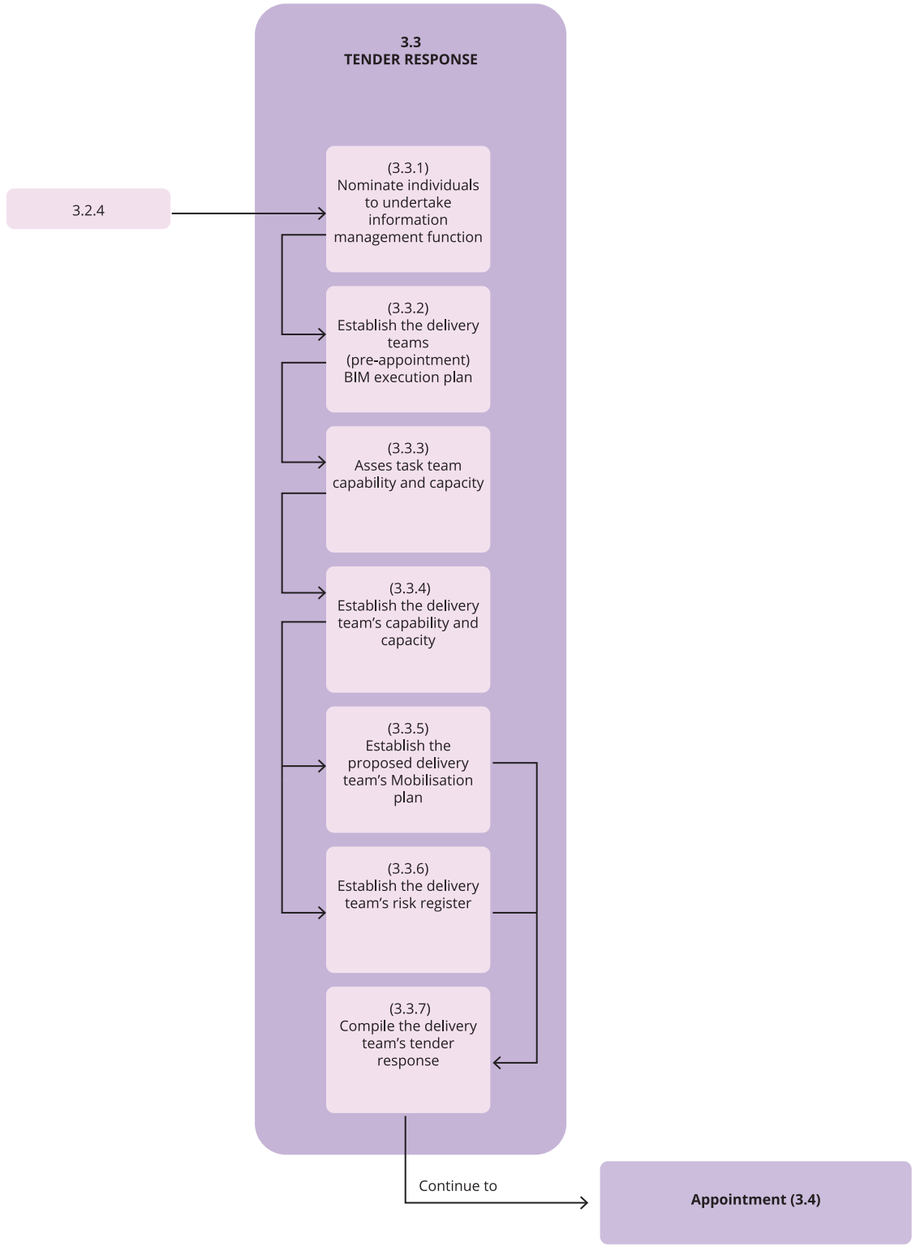
The appointing party should establish the requirements that must be fulfilled by the tendering organisations within their tender response. Accordingly, the appointing party must consider the following aspects:

a) Contents of the pre-BEP of the delivery team,
b) Competency of the prospective individual who undertakes the delivery of information management function on behalf of the delivery team,
c) Assessment of the prospective lead appointed party in regard to the capability and capacity of the delivery team,
d) Proposed mobilisation plan of the delivery team,
e) Information delivery risk assessment of the delivery team.

3.2.4 Compile Invitation to Tender Information

The appointing party should compile the information that must be included within the invitation to tender package.

3.3 Tender Response



3.3.1 Nominate Individuals to Undertake Information Management Function

The prospective lead appointed party must ensure effective management of information throughout the appointment. Accordingly, this can be achieved by nominating individuals from within the organisation to undertake the information management function on behalf of the lead appointed party. However, a scope of services need to be established by the lead appointed party in order to appoint a prospective appointed party or a third party to undertake information management function.

3.3.2 Establish the Delivery Teams (pre-appointment) BIM Execution Plan (BEP)

The prospective lead appointed party should establish the BEP of the delivery team (pre-appointment) that will be included within the tender response of the prospective lead appointed party. Apart from that, the prospective lead appointed party is expected to develop a proper BEP which includes the roles and responsibilities of the delivery team, information delivery strategy, federation strategy, project information production methods as well as proposed schedule of software, hardware, and IT infrastructure.

3.3.3 Assess Task Team Capability and Capacity

Regarding this matter, it is important to conduct an assessment on the capability and capacity of the task team to deliver information in accordance to the EIR of the appointing party as well as the proposed (pre-appointment) BEP of the delivery team.

3.3.4 Establish the Delivery Team's Capability and Capacity

The prospective lead appointed party should establish the capability and capacity of the delivery team by aggregating the assessment undertaken by each task team. Subsequently, this will produce a summary of the capability of the delivery team in managing and producing information as well as its capacity for timely delivery of the information.

3.3.5 Establish the Proposed Delivery Team's Mobilisation Plan

The prospective lead appointed party must establish the proposed mobilisation plan of the delivery team which will be initiated and implemented during mobilisation.

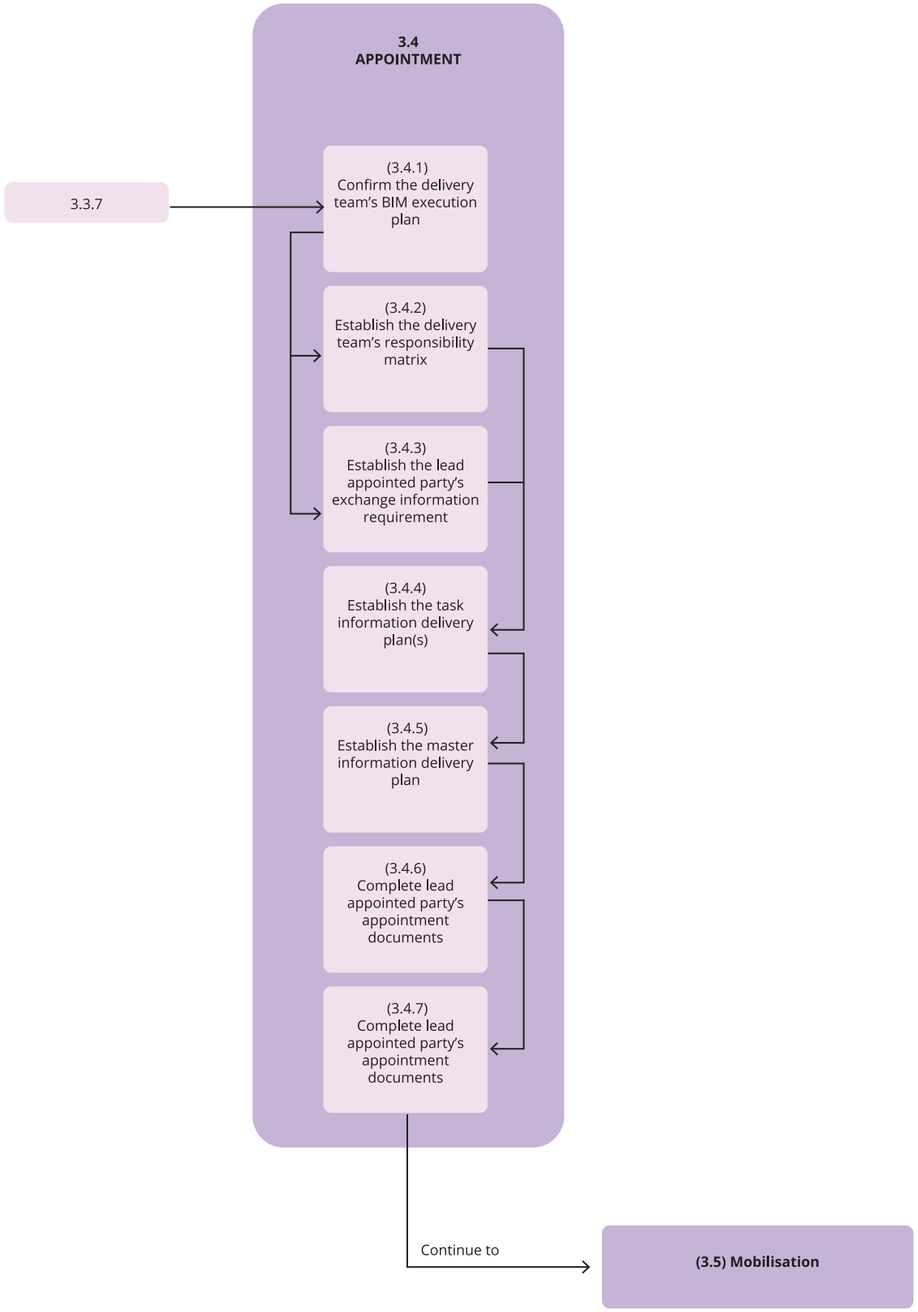
3.3.6 Establish the Delivery Team's Risk Register

The prospective lead appointed party should establish the risk register of the delivery team which contains the risks associated with the timely delivery of information that is in accordance to the EIR of the appointing party as well as how the delivery team intends to manage these risks.

3.3.7 Compile the Delivery Team's Tender Response

The prospective lead appointed party should compile (where available) the following items that must be included in the tender response: (pre-appointment) BEP, capability and capacity assessment, mobilisation plan, and information delivery risk assessment.

3.4 Appointment



3.4.1 Confirm the Delivery Team's BIM Execution Plan (BEP)

The lead appointed party shall confirm the BEP of the delivery team which must be in agreement with each appointed party.

3.4.2 Establish the Delivery Team's Responsibility Matrix

The lead appointed party must further refine the high-level responsibility matrix to establish the detailed responsibility matrix.

3.4.3 Establish the Lead Appointed Party's Exchange Information Requirement (EIR)

The lead appointed party should establish their EIR for each appointed party. Hence, it is recommended for the lead appointed party to establish a clear schedule of information requirements as a formal appointment when engaging the internal teams.

3.4.4 Establish the Task Information Delivery Plan(s) (TIDP)

Each task team shall establish a TIDP that must be maintained throughout its appointment.

3.4.5 Establish the Master Information Delivery Plan (MIDP)

The lead appointed party must aggregate the TIDP from each task team in order to establish the MIDP of the delivery team.

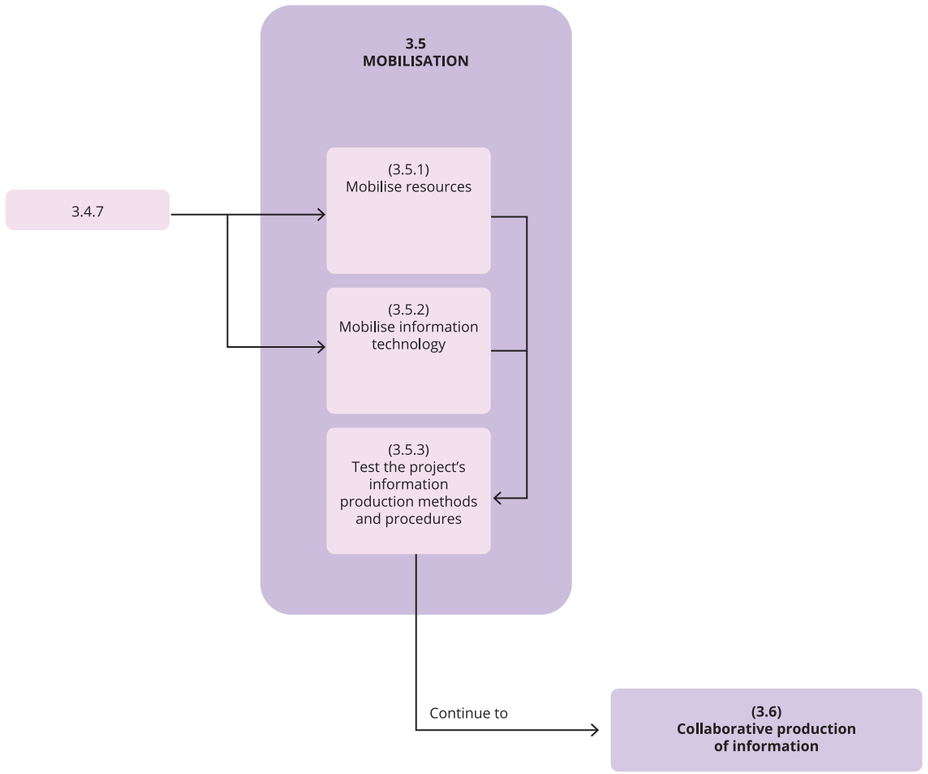
3.4.6 Complete Lead Appointed Party's Appointment Documents

The appointing party must take into account the important aspects that will be included within the complete appointment documents for the lead appointed party which should then be managed via change control throughout the duration of the appointment.

3.4.7 Complete Appointed Party's Appointment Documents

The lead appointed party must consider the important aspects that will be included within the appointment documents for each appointed party which will then be managed via change control throughout the duration of the appointment.

3.5 Mobilisation



3.5.1 Mobilise Resources

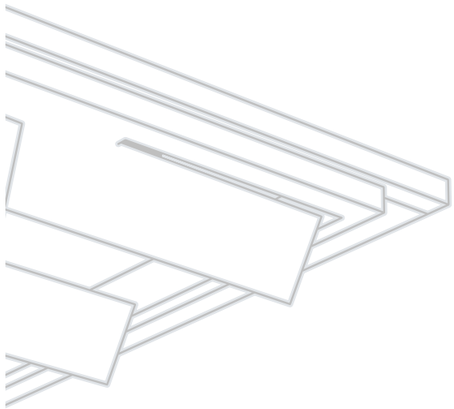
The lead appointed party should mobilise the resources (e.g. resource availability of each task team as well as develop and deliver education on topics and training to delivery team members) as defined based on the mobilisation plan of the delivery team.

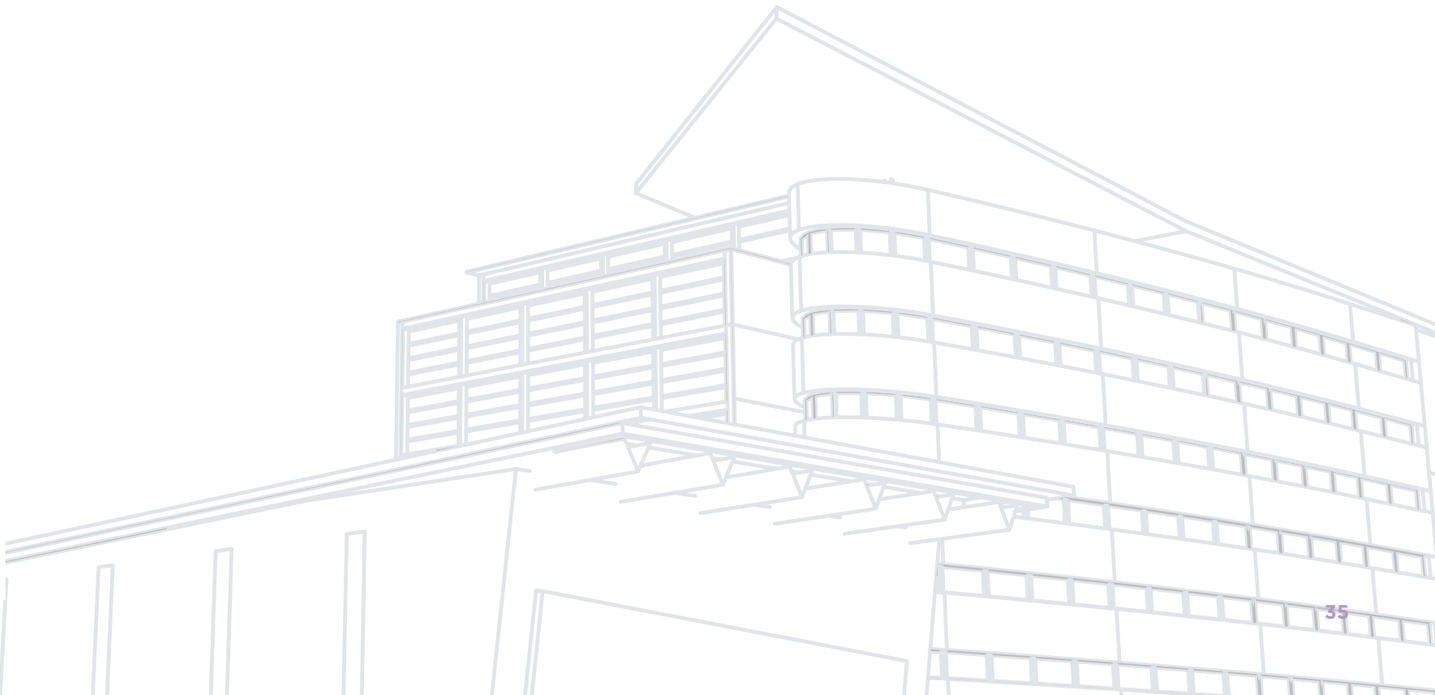
3.5.2 Mobilise Information Technology

The lead appointed party is expected to mobilise the information technology (e.g. software, hardware, and IT infrastructure; CDE of the project, CDE of the delivery team and connectivity to the project, information exchanges between task teams, and information delivery to appointing party) as defined by the mobilisation plan developed by the delivery team.

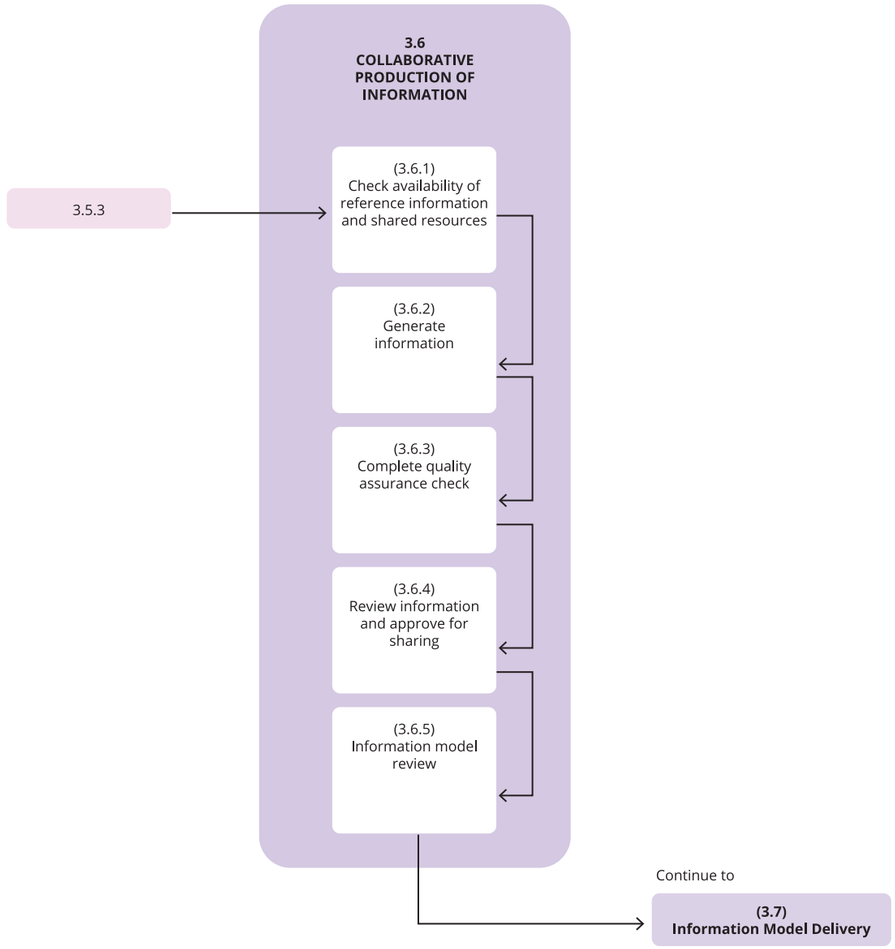
3.5.3 Test the Project's Information Production Methods and Procedures

The lead appointed party should test the information production methods and procedures of the project (e.g. document the information production methods and procedures of the project. information container breakdown structure, shared resources to be used by the delivery team, communicate the information production methods and procedures of the project to all tasks teams) as defined based on the mobilisation plan of the delivery team.





3.6 Collaborative Production of Information



3.6.1 Check Availability of Reference Information and Shared Resources

In the attempt to generate information, each task team must ensure their access to the relevant reference information and shared resources within the CDE of the project. Accordingly, the task team should inform the lead appointed party and subsequently assess the potential impact of the inaccessible relevant data on the TIDP.

3.6.2 Generate Information

Each task team must be able to generate information in accordance to their respective TIDP. Specifically, the task team should generate information, coordinate and cross-reference all information shared within the CDE of the project as well as spatially coordinate geometrical models with other geometrical models.

3.6.3 Complete Quality Assurance Check

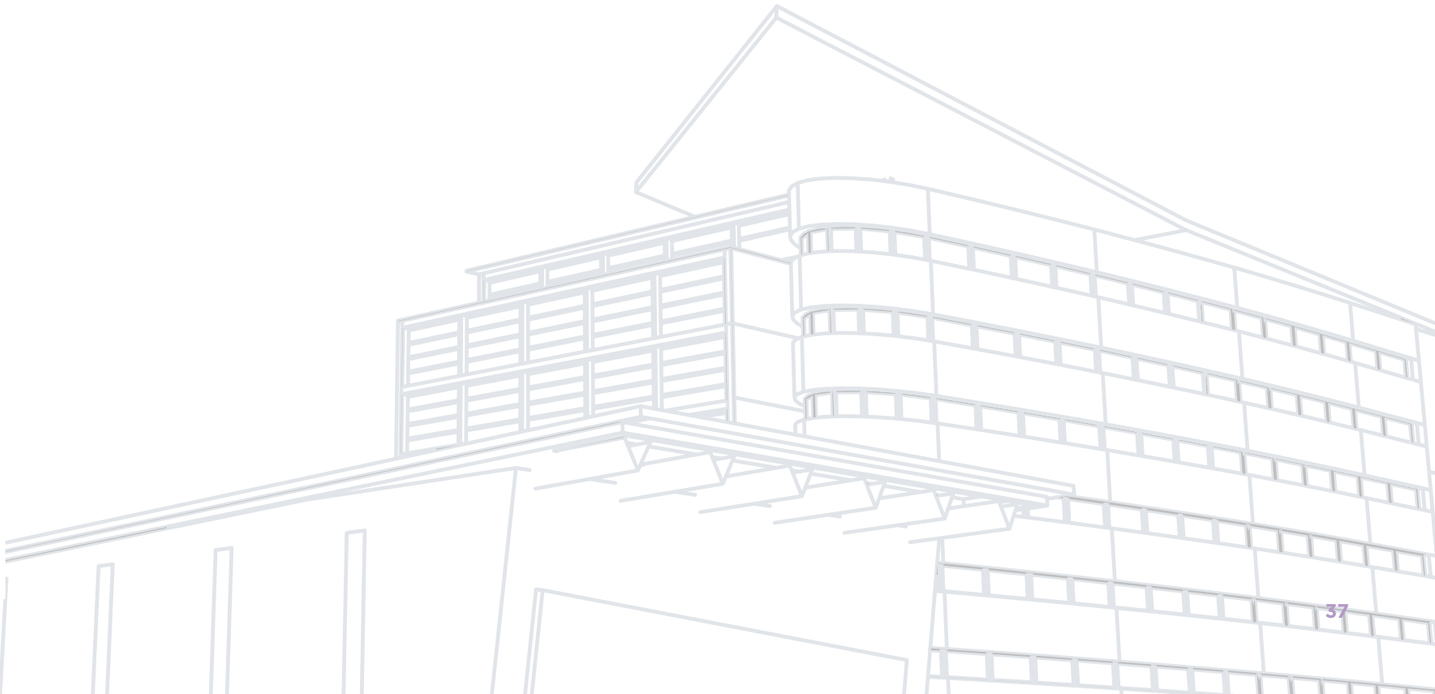
Each task team is expected to complete a quality assurance check for each information container in accordance to the project information production methods and procedures. In this case, the task team should check the information container based on the information standard of the project. Section 4.7 provides further explanation on the recommendation of quality assurance and quality control for information production.

3.6.4 Review Information and Approve for Sharing

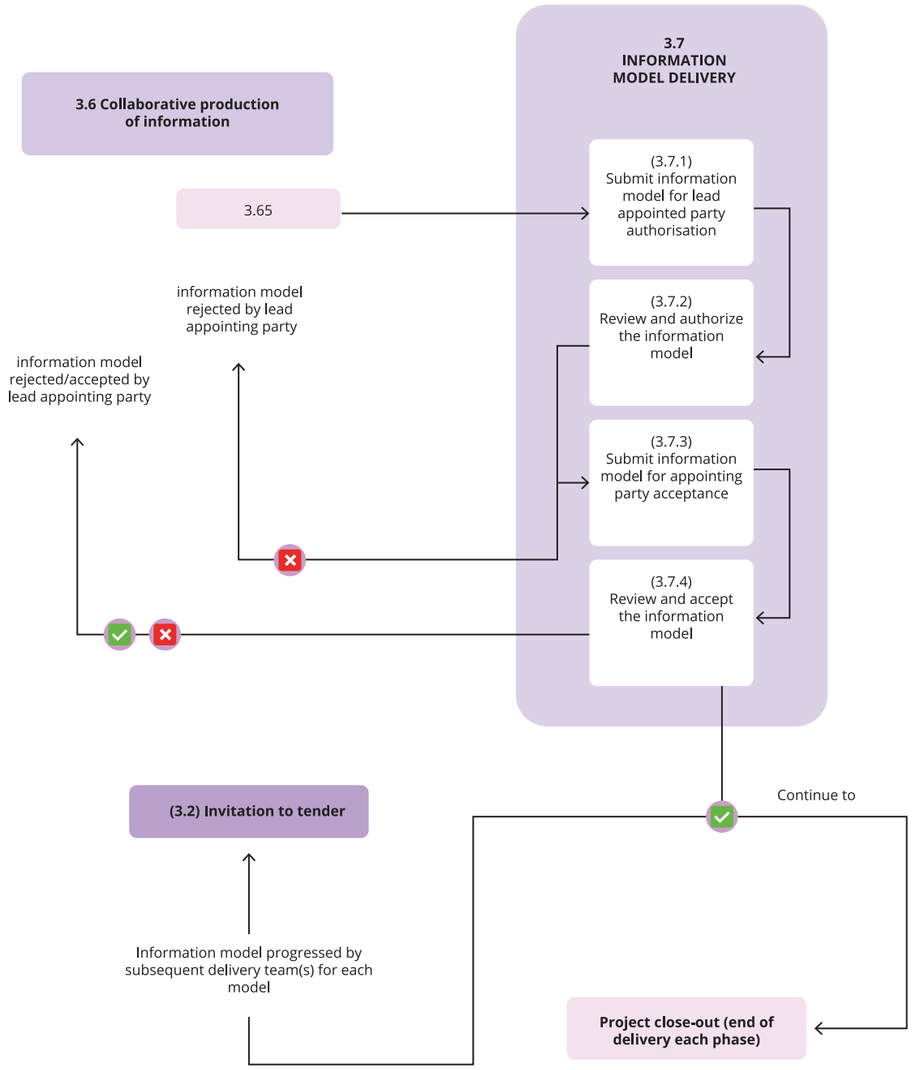
Each task team must review the information within the information container prior to its sharing within the CDE of the project. More importantly, the task team should be able to consider the information requirements of the lead appointed party, the required LOI, and information that are necessary for coordination by other task teams.

3.6.5 Information Model Review

The delivery team must conduct a review of the information model in accordance to the information production methods and procedures of the project. Regarding this matter, the delivery team needs to facilitate the continuous coordination of information across each element of the information model.



3.7 Information Model Delivery



3.7.1 Submit Information Model for Lead Appointed Party Authorisation

Generally, it is understood that each task team must submit their information to the lead the appointed party to be authorised within the project CDE for the delivery of the information model to the appointing party.

3.7.2 Review and Authorize the Information Model

The lead appointed party must conduct a review of the information model in accordance to the information production methods and procedures of the project. Accordingly, each tasks team is required to submit their information for appointing party acceptance within the project CDE if the review is successful.

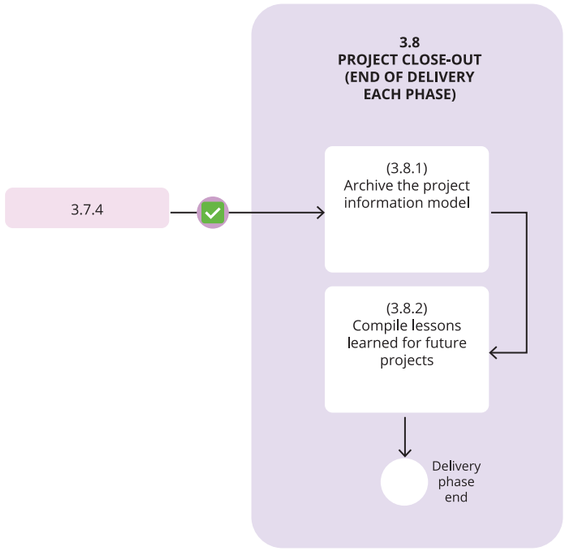
3.7.3 Submit Information Model for Appointing Party Acceptance

Similarly, each task team must submit their information for appointing party review and acceptance within the project CDE.

3.7.4 Review and Accept the Information Model

The appointing party is expected to perform a review of the information model in accordance to the information production methods and procedures of the project.

3.8 Project Close-out (End of Delivery Each Phase)



3.8.1 Archive the Project Information Model (PIM)

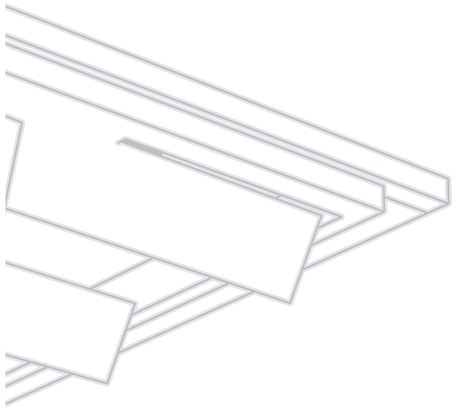
Regarding this matter, all information containers within the project CDE in accordance to the information production methods and procedures of the project must be stored in an archive upon acceptance of the completed PIM.

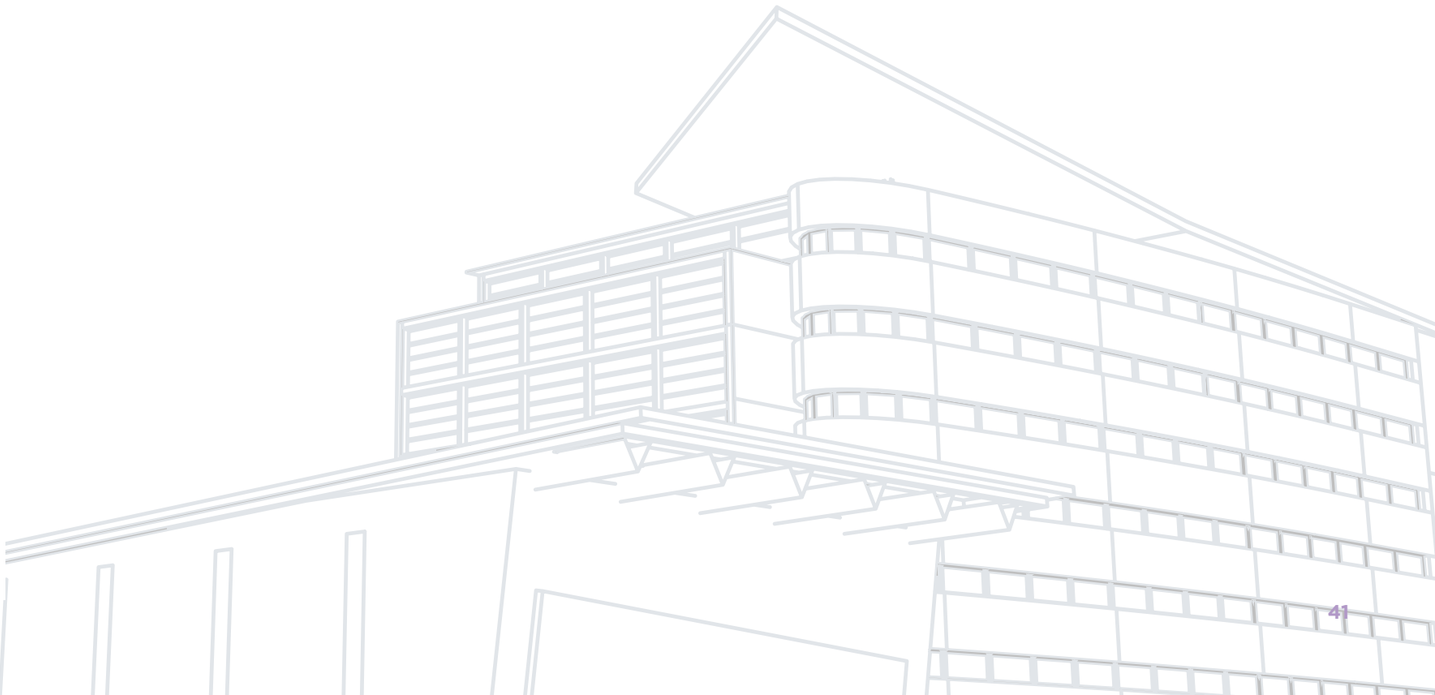
Tips

Files that will be stored in an archive may consist of building plan approval, tender model, as-built model, and others.

3.8.2 Compile Lessons Learned for Future Projects

On another note, the appointing party should capture the lessons learned during the project in collaboration with each of the lead appointed party by recording them in a suitable knowledge store which will be called upon by future projects. Furthermore, it is recommended for the lessons learned to be captured throughout the entire project.





Section 04

SECTION 4: BIM MODELLING AND DOCUMENTATION PRACTICE

In this section, the guidance on modelling and documentation best practice will be further elaborated by taking into account the following key considerations:

4.1 Model Development Methodology

BIM model development methodology enables the project team to specify the details and the reliability of model elements at various phases in the project life-cycle. In this case, model development methodology must be embedded in the BEP because it provides the basis for reliable structured project information, collaboration, coordination, and data that are utilised by the project team members.

The following provides an explanation on the differences between the Level of Development (LOD), Level of Detail (LOd), and Level of Information (LOI). The detail comparison between the three levels are summarised in **APPENDIX A.**

4.1.1 Level of Development (LOD)

The LOD is defined as the content and reliability of Building Information Models throughout construction project life-cycle. Using elements with predetermined LOD allows determining the expected BIM content on the object level at different phases.

4.1.2 Level of Detail (LOd)

LOD is generally described as the properties of an object at a given LOd level. More importantly, the properties of a model element at a given LOd level refer to the characteristics which include the properties from the previous LOd level. In this case, the examples of attributes of LOd are size, volume, shape, height, and orientation.

4.1.3 Level of Information (LOI)

The LOI growth is defined as the progress of a projects throughout its life-cycle. Particularly, all the information requirements will be developed into the design intent of elements or systems during the early phase of assessing the client needs in order to meet the EIR. More importantly, LOI is used to indicate the level of information that is linked to the object. Specifically, an object with a high level of information comprises of manufacturer-specific data sheets and maintenance instruction.

4.2 Discipline Modelling Guidelines

A number of important recommendations on how the designer intends to create the model elements based on the agreed deliverables in the BEP at different phases will be comprehensively described in this section.

The modelling guidelines need to be developed according to the requirements stated in the BEP. Meanwhile, the LOD of the BIM elements produced at each phase needs to be specified in the BEP according to the tables provided in APPENDIX B. Regarding this matter, a set of modelling guidelines for key model elements at different phases of a project is believed to assist the project team in modelling the elements.

The recommended best practices that should be produced by the project team are listed below:

a) Architectural Modelling Best Practices
b) Structural Modelling Best Practices
c) Mechanical Modelling Best Practices
d) Electrical Modelling Best Practices
e) Civil Modelling Best Practices

Apart from that, other considerations in developing the best practices may cover the followings:

4.2.1 Modelling Guidelines for E-Submission

On a similar note, it is important to consider modelling the guidelines for Malaysia E-Submission for regulatory and approval purposes. The requirements for E-submission can be found at **https://www.mybimcentre.com.my/.**

4.2.2 Model Location and Orientation

The origin or base point of the project should be clearly defined and must comply with the modelling best practices.

4.2.3 Cross-Disciplinary Model Coordination

Every discipline should share their models with other or among discipline members at regular intervals for reference purposes. Specifically, each discipline model should be provided in a native or neutral format for easy reference and utilisation by other disciplines in relation to other projects. Apart from that, it is recommended for the project team to map out a comprehensive coordination process flow which further indicates the interactions between the client and the project team.

On another note, the respective models should be checked, approved, and validated as “fit for coordination” prior to model coordination. In this case, a successful BIM coordination requires a careful planning and clear understanding of different types of coordination process (i.e. design coordination, clash detection, space validation). Accordingly, the coordination best practices should be produced by the project team until the coordinated model is achieved.

4.2.4 Revision Model Management

Furthermore, it is important to note that the model will rapidly evolve during each phase of the project. Hence, any potential changes should be tracked and documented, especially when the model creation task is divided into a few smaller packages and handled by different individuals.

Meanwhile, it should be noted that various software of mechanisms is available to assist modellers in managing and monitoring the design change. Accordingly, model author for each discipline should work with their respective BIM software vendor in order to familiarise themselves with the use of these software mechanisms with the aim of ensuring that the design changes can be managed effectively. Apart from that, the BIM coordinator for each discipline can play the role of maintaining a register to record the latest information incorporated in the model. In other words, they should work closely with the BIM manager to promote the coordination among different versions of the model shared or exchanged.

4.2.5 Model and Drawing Production

On a more important note, it is necessary for the project team to agree on the standard for models and 2D drawings that form part of the contract documents. Generally, 2D drawings include plans, sections, elevations, details, and RFIs. Nevertheless, it is crucial for all the drawing sheets produced by the project team to comply with the current industry standard for drawings.

Meanwhile, the project team should create and publish drawings directly from BIM models (i.e. established through the linking of views, callouts, and elevations). Therefore, any drawings or documents that are not produced from BIM models should be clearly labelled.

Other than that, it is important for the project team to show their agreement by documenting the common naming convention and drawing numbering systems for model views, legends, schedules, drawing sheets, and links. Overall, the purpose is to provide a common reference to the corresponding design drawings, submission drawings, tender drawings, working drawings, and as-built drawings.

4.2.6 Data Security and Saving

A data security protocol should be established to prevent any possible data corruption, virus as well as data misuse or deliberate damage by project team members, other employees, or outside sources. Accordingly, listed below are the recommendations for data security and saving:

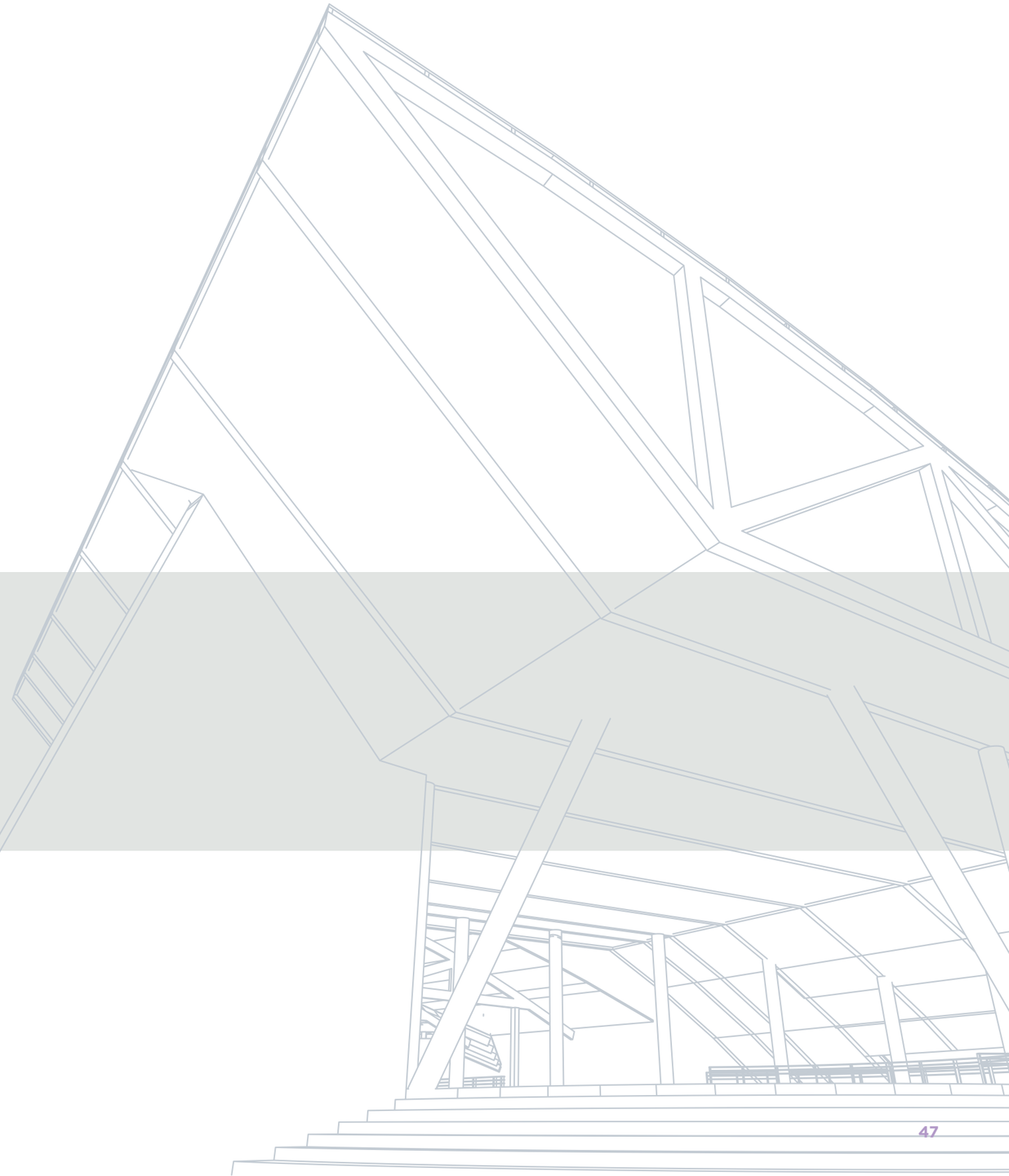
a) Establish appropriate cybersecurity procedure to support data security protocol,
b) Develop server and strategy (e.g. platforms, storage) to prevent data loss or damage during file exchange, maintenance, and archiving (rephrase),
c) All BIM project data should reside on network servers and subjected to regular back-ups,
d) Access on project team members to All BIM project data held on the network servers must be accessible to project team members through controlled access permissions,
e) The project team should identify a person-in-charge to monitor all data security and saving.

4.2.7 Quality Assurance and Quality Control

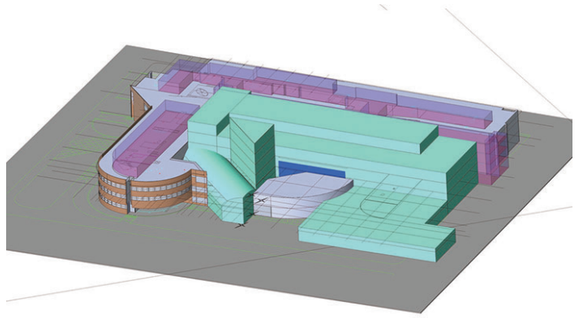
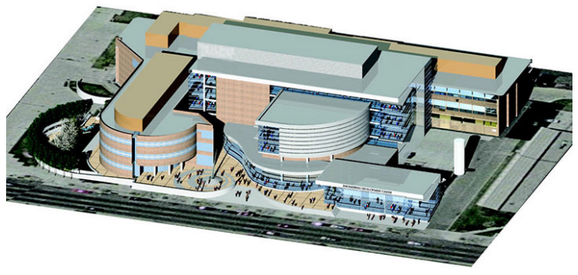
A quality assurance plan for the models should be established by the BIM manager with the aim of ensuring appropriate checks on information integrity and data security. In this case, each project team members should be responsible for performing quality control checks of their design, dataset, and model properties prior to the submission of their deliverables.

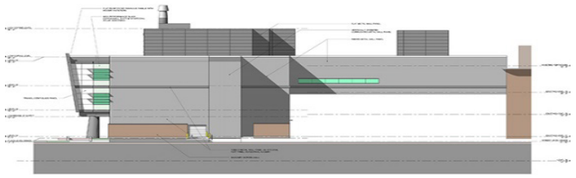
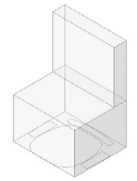
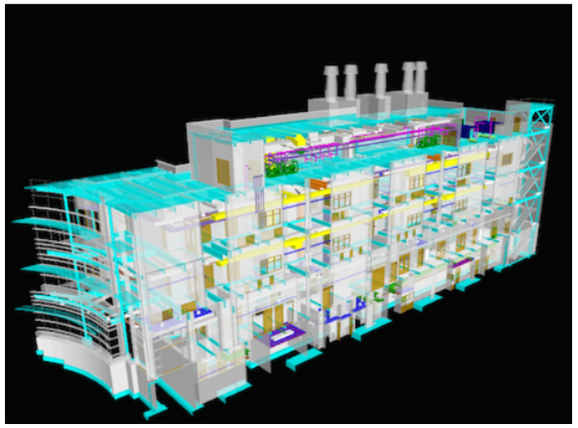
Other than that, BIM coordinator for each discipline is also responsible to establish a quality control procedure that verifies the accuracy of the discipline model in accordance to the modelling best practices. Accordingly, listed below are the important considerations that must be taken into account when creating a quality assurance plan:

a) Modelling best practices: Ensure that the models and components are created based on the modelling best practices.
b) Template: Develop each model using the template agreed in the BEP.
c) Dataset validation: Ensure dataset is produced with correct data and versioning.
d) Interference check: Detect any clashes between the two components using clash detection software.



APPENDIX A: Comparison between Level of Development (LOD), Level of Details (LOd) and Level of Information (LOI)

PHASE	LEVEL OF DEVELOPMENT	LEVEL OF DETAIL	OBJECT	LEVEL OF INFORMATION		
Planning	LOD 100- Conceptual 	Object (or structure) is graphically represented in the model using symbols (e.g. by a line or surface) or generic (i.e. dimensions and quantities are not defined). Accordingly, this represents the overall geometric expression of the object.		Description Width Depth Height Manufacturer Model	: : : : : :	Office chair - - - - -
Preliminary Design	LOD 200- Approximate Geometry 	Object (or structure) is geometrically represented as a generic object with approximate quantities, sizes, dimensions, location, and orientation. The function of the objects are described and the model is further divided into a number of discipline models.		Description Width Depth Height Manufacturer Model	: : : : : :	Office chair 700mm 450mm 1100mm

PHASE	LEVEL OF DEVELOPMENT	LEVEL OF DETAIL	OBJECT	LEVEL OF INFORMATION		
Detail Design	LOD 200- Approximate Geometry 	Object (or structure) is graphically represented as a specific object that represents quantities, sizes, dimensions, location, and orientation. The overall function, performance, and material of the object are described in detail.		Description Width Depth Height Manufacturer Model	: : : : : :	Office chair arms, wheels 700mm 450mm 1100mm - -
Construction	LOD 300- Precise Geometry 	Object (or structure) is graphically represented and possibly as a supplier-specific object with the quantities, sizes, dimensions, location, and orientation. Objects are detailed for fabrication, assembly, prefabrication as well as contain the installation information.		Description Width Depth Height Manufacturer Model	: : : : : :	Office chair arms, wheels 685mm 430mm 1085mm Herman Mille, Inc Mirra
Close-out/ Handover	LOD 500- As-built 	The (or structure) quantities, sizes, dimensions, location, and orientation of the object is confirmed on site (as built).		Description Width Depth Height Manufacturer Model Purchase date	: : : : : : :	Office chair arms, wheels 685mm 430mm 1085mm Herman Mille, Inc Mirra 01/02/2013

Source: https://www.gsa.gov

APPENDIX B: LOD of the BIM Elements

This table indicates LOD expected for each model element at different project phases. The BIM manager is responsible to amend each of the cells and is allowed to add or remove elements required from the list to suit a project requirement.

Model Element List : Determine model element (e.g. Door, Foundation, Slab, Ductwork etc.)
Required : Define if a group element need to be modelled for a project
Quantity Measurement : Data required for quantity take-off
AUT : Model author
LOD : Level of Development required
LOd : Level of Detail required
LOI : Level of Information required

Model Element List	Required	Quantity Measurement	Category Code	Project Phase											
				Concept Design		Developed Design		Technical Design		Submission for Approval		Construction		As- Built	
				AUT	LOD, LOd, LOI	AUT	LOD, LOd, LOI	AUT	LOD, LOd, LOI	AUT	LOD, LOd, LOI	AUT	LOD, LOd, LOI	AUT	LOD,
Room space	Yes/ No	m^2	RS												
Floor	Yes/ No	m^2	FLR												
Door	Yes/ No	Nos.	DOR												

GLOSSARY

Asset Information Requirement (AIR)
Information requirements in relation to the operation of an asset

Appointed party
Receiver of information concerning works, goods, or services from a lead appointed party.

Appointing party
Provider of information concerning works, goods, or services.

Asset
Item, matter, or entity that has a potential or actual value to an organisation.

Building Information Modelling (BIM)
Modelling technology and associated set of process to produce, communicate, analyse, and use the digital information models throughout the construction project life-cycle.

Common Data Environment (CDE)
Agreed source of information for any given project or asset, that is used for collecting, managing, and dissemination of each information container through a managed process.

Client
Actor responsible for initiating a project and approving the brief.

Exchange Information Requirement (EIR)
Information requirements in relation to an appointment

Information
Reinterpretable representation of data in a formalised manner that is suitable for communication, interpretation, or processing.

Information container
Named persistent set of information retrievable from within a file, system, or application storage hierarchy.

Information requirements
Specification of what, when, how, and for whom the information is produced.

Life-cycle
Life of the asset from the definition of its requirements to the termination of its use which covers its conception, development, operation, maintenance support, and disposal.

Object
Refer to model element or components.

Organisational Information Requirement (OIR)
Information requirements in relation to the organisational objectives.

Operational phase
Part of the life-cycle that describes when an asset is used, operated, and maintained.

Phase
Refer to phases of construction project life-cycle.

Project Information Model (PIM)
Information requirements in relation to the delivery of an asset

Project Information Requirement (PIR)
Information requirements in relation to the delivery of an asset

Stage
Represent the level of BIM maturity in Malaysia

Stakeholders
Refer to individuals in the project team such as client, consultants, contractors, or team members within an organisation.

BIBLIOGRAPHY

AEC (UK) Committee (2012) 'AEC (UK) BIM Protocol v2.0 - Implementing UK BIM Standards for the Architectural, Engineering and Construction industry.', *Aec (Uk)*, (September), p. 46.

Building and Construction Authority (2013) 'Singapore BIM Guide - Version 2.0', *Cornet*, p. i-60.

CIDB Malaysia (2015) *Construction Industry Transformation Programme 2016-2020*. doi: 10.1007/s13398-014-0173-7.2.

CIDB Malaysia (2016) *BIM Guide Malaysia*, *MyBIM Malaysia*. Available at: http://www.bimcenter.com.my/bim-guide/ (Accessed: 1 June 2017).

Dave, B., Koskela, L. and Kiviniemi, A. (2013) Implementing Lean in construction, Assets.Highways.Gov.Uk. Available at: http://assets.highways.gov.uk/specialist-information/knowledge-compendium/2011-13-knowledge-programme/Lean and the Sustainability Agenda.pdf.

Eleni Papadonikolaki, R. V. and H. W. (2015) 'Supply chain integration with BIM: a graph-based model', Structural Survey. doi: 10.1108/MBE-09-2016-0047.

Harris, F. and McCaffer, R. (2013) Modern Construction. doi: 10.1515/9783990434550.

Hong Kong CIC (2014) 'CIC Building Information Modelling Standards', pp. 0–103.

IPDA (2018) 'Integrated Project Delivery: An Action Guide for Leaders'.

ISO (2018a) 'INTERNATIONAL STANDARD information about buildings and civil building information modelling — Part 1: Concepts and principles', 2018.

ISO (2018b) 'INTERNATIONAL STANDARD information about buildings and civil building information modelling — Part 2: Delivery phase of the assets', 2018.

Penn State (2010) 'Building Information Modeling Execution Planning Guide'.

Sacks, R. and Barak, R. (2013) 'KanBIM workflow management system: Prototype implementation and field testing', Lean Construction ..., (2012), pp. 19–35. Available at: http://www.leanconstruction.org/media/docs/lcj/2013/LCJ_12_004.pdf.

ACKNOWLEDGEMENT

The Construction Industry Development Board (CIDB) Malaysia would like to acknowledge the individuals and organisations for their valuable contributions and insights during the development of the **BIM Guide 5 - BIM Project Guide**

Ar. Mohammad Zaid bin Saad	Jabatan Kerja Raya Malaysia
Ir Ahmad Syukri Bukari	Jabatan Kerja Raya Malaysia
Ir. Abdullah bin Ahmad	Jabatan Kerja Raya Malaysia
Mohd Nor Afandi bin Ramani	Jabatan Kerja Raya Malaysia
Mohd Zulkifli bin Abdullah	Jabatan Kerja Raya Malaysia
Muhammad Nazmi bin Mat Na'ain	Jabatan Kerja Raya Malaysia
Noor Asyikin binti Sepiai	Jabatan Kerja Raya Malaysia
Noorwidhayu binti Mohd Bakri	Jabatan Kerja Raya Malaysia
Norazleen binti Ahmad Zakri	Jabatan Kerja Raya Malaysia
Nur Atira Bt Amran	Jabatan Kerja Raya Malaysia
Ruzaireen binti Kamaruzaman	Jabatan Kerja Raya Malaysia
Suhana binti Che Seman	Jabatan Kerja Raya Malaysia
Zainariah binti Zainal Abidin	Jabatan Kerja Raya Malaysia
Ar. Zarim Abu Bakar	Pertubuhan Arkitek Malaysia (PAM)
Sr. Sharifah Noraini Noreen Syed Ibrahim Al-Jamallulail	Royal Institution Surveyor Malaysia (RISM)
Mohammad Farid A. Hamid	CIDB E-Construct Services Sdn Bhd
Dr. Ahmad Tarmizi Haron	Universiti Malaysia Pahang
Mohd Izzul Fizli Bin Hassan	Universiti Malaysia Pahang
Muhammad Afiq Bin Hasmi	Universiti Malaysia Pahang
Muhammad Syaiful Safwan Bin Nordin	Universiti Malaysia Pahang
Suffian Shahabuddin	6ix Design Office
Melvillyn Max Basusie	Gamuda Engineering Sdn Bhd
Yeoh Ee Leng	Gamuda Industrial Building System Sdn Bhd
Mohd Azizul Hakim Rahimi	HSS Integrated Sdn Bhd
Muhammad Imran Roslan	HSS Integrated Sdn Bhd
Norhasinah Binti Hussin	HSS Integrated Sdn Bhd
Mohd Syazwan Abdullah	NRY Architects Sdn Bhd
Febriyanshah Musazumu bin Saad	NuMagineLab Sdn. Bhd.
Zulkarnain Hasan	Sime Darby Property
Ar. Husam Abdulfatah Haron	TotalBIM Consultants

ISBN 978-967-0997-75-9