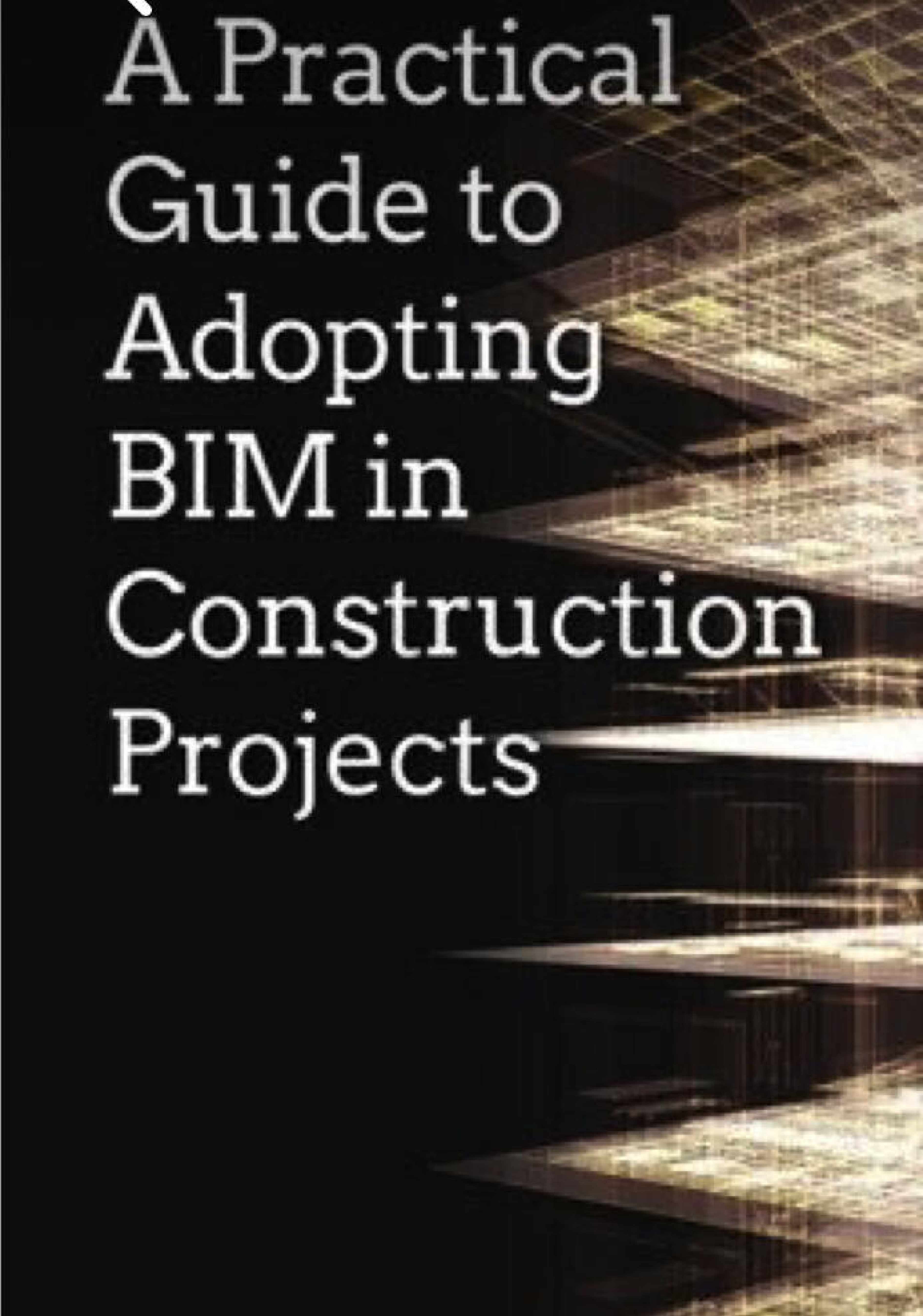
# A Practical Guide to Adopting BIM in Construction Projects



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# 1 EXECUTIVE SUMMARY

## 1.1 What is BIM?

Building Information Modelling or BIM is a digital representation of the complete physical and functional characteristics of a built asset. A BIM model can contain information on design, construction, logistics, operation, maintenance, budgets, schedules and much more. This depth of information contained within BIM enables a richer analysis than traditional processes and it has the potential to integrate large quantities of data across several disciplines throughout the building's lifecycle.

## 1.2 Productivity Gain

Productivity gain is one of the major benefits of using BIM and is the top metric organisations expect to improve when they adopt the technology. Primarily, BIM realises this gain through its ability to:

- foster communication and coordination
- identify errors early
- reduce rework
- reduce costs
- improve quality.

A project's contractual structure also has an impact on BIM's effectiveness on a project. As a seamless integration between the design and construction activities is the most cost effective use of BIM, it lends itself well to design and build, turnkey projects or Integrated Project Delivery. The traditional design – tender – build process can also use BIM, just not as effectively.

## 1.3 Benefits

Most international papers on BIM identify cost savings of between 7% and 20% on the total lifecycle of a project. The exact savings are difficult to calculate as the counterfactual is unknown, owing to the huge variability there can be in project outcomes, i.e., if a project goes to plan and cost, one cannot know how many overruns there would have been without the influence of BIM on better detailed design.

Recent data from the UK, where BIM's introduction is being accelerated by the government, has identified project savings of 19%. New Zealand's Building and Construction Productivity Partnership has produced a brochure *Productivity Benefits of BIM* which summarises BIM economic benefit information from around the world. See www.buildingvalue.co.nz/publications. At these levels of savings it becomes evident that any construction industry will benefit from an earlier introduction and deeper penetration of the technology.

Significant benefits accrue when BIM models are used for managing a facility post-construction. Less information is available on this aspect of BIM efficiency but, anecdotally, savings are large as institutions move from reactive to preventative maintenance.

The case for using BIM is compelling, and the aim of this BIM Handbook is to provide assistance for those starting to use BIM on live projects. It uses proven methodologies and is the result of experienced practitioners coming together to write the Handbook they'd like to use.

# 2 INTRODUCTION

## 2.1 What is BIM?

As defined by BuildingSmart:

"BIM is a digital representation of physical and functional characteristics of a building.

As such it serves as a shared knowledge resource for information about a building,

forming a reliable basis for decisions during its lifecycle from inception onward."

**"BIM is the sharing of structured information."**

i See **Appendix D** for a glossary of terms relating to BIM. D

## 2.2 Overview of the New Zealand BIM Handbook

### 2.2.1 Purpose

The purpose of the Handbook is to:

- promote the use of BIM throughout the project lifecycle
- create a common language for the industry to use
- clarify the briefing process for designers and constructors
- improve the level of coordination in both design and construction phases
- create a clear path for the future development of the industry.

### 2.2.2 Focus

The Handbook does not cover every aspect of BIM in detail. Its primary focus is on:

- the people directly involved in the BIM process
- defining the BIM process, methodologies and interfaces
- the design and construction phases of the building lifecycle.

### 2.2.3 Associated Documents

The New Zealand BIM Handbook is a general reference document that to be used as a planning tool by clients and consultants and contractors to clarify the services that will be provided.

When implementing BIM on a project a Project BIM Brief and BIM Management Plan outlining the project's particular requirements should be prepared. A template for these plans is provided in the Appendices to this Handbook.

## 2.3 The Benefits of Using BIM

**Experience from other countries and case studies document many benefits from the successful integration of BIM into the design, construction and asset management of buildings. These include:**

**Coordination**

- Models show the spatial relationships of building elements and, just like real buildings, virtual models are comprised of virtual components and elements.
- Relationships between elements are updated as the modeller modifies the model.
- Drawings are derived from the model by viewing it from whatever vantage points are required, including slicing it to produce floor plans and sections.
- Drawings are derived from a single "federated model" – many of the errors caused by a lack of coordination between documents are eliminated.

**Communication**

- 3D images can be immediately grasped by most people and are less susceptible to misinterpretation than 2D images.
- BIM improves communication between designers and anyone relying on, or affected by, the proposed building including clients, building assessors, local communities and contractors.
- BIM provides an opportunity to engage clients, contractors and other stakeholders much earlier in the design process where the greatest value can be derived from their input.

**Data Management**

- Generates graphical representations of building elements.
- Modelling software manages data associated with each element of the building. This data is updated automatically as changes are made to the model.
- Reports produced at any time reflect the current state of the model.
- Being digital, this data can be easily stored and transmitted, and rapidly searched, sorted and filtered as required.

**Analysis and Simulation**

The relative ease of accurately recalculating performance following changes to the model allows different design options to be explored and optimised. Data associated with the model can be used for:

- Quantity take-off and costing.
- Simulation of various aspects of the proposed building's behaviour such as structural, thermal, acoustic, lighting and fire performance.

**Improved Productivity During Construction**

BIM improves construction quality, improves on-site safety, shortens construction programmes and reduces costs by allowing:

- better planning of site activities and optimisation of the construction sequence
- quicker and more accurate set out
- more prefabrication off site as building elements can be modelled, documented and manufactured with greater precision
- possible linkage to computer controlled machinery using digital model files.

**Better Information for Facility Management**

Data generated during design and construction can be readily passed on to Facility Managers to assist them in operating and maintaining buildings more effectively. With appropriate procedures in place, capturing this data is easier than with traditional paper based methods.

# 3 PROJECT INCEPTION

The period commencing after the client has engaged a lead consultant, and concluding when the consultant team is engaged. The term "consultant" is used to include the construction contractor for procurement strategies where the contractor is engaged during the design phase. The priority is to define the project's scope sufficiently to allow more substantive planning to commence.

**Key tasks**

- Assessing project feasibility.
- Briefing, including BIM requirements.
- Drafting a project programme.
- Assessing procurement strategies.
- Engaging the consultants necessary to carry out the work.

Unless the client is very familiar with BIM it is recommended that they work with the Lead Consultant to identify and document the BIM strategy for the project.

The Lead Consultant may act as the Design BIM Manager for the development of the preliminary Project BIM Brief at this stage, or engage a suitable Design BIM Manager to assist with this process, if they do not have the skills or capability to complete the task themselves. Depending on a number of factors, it may be appropriate not to recommend a formal requirement for BIM on the project at all.

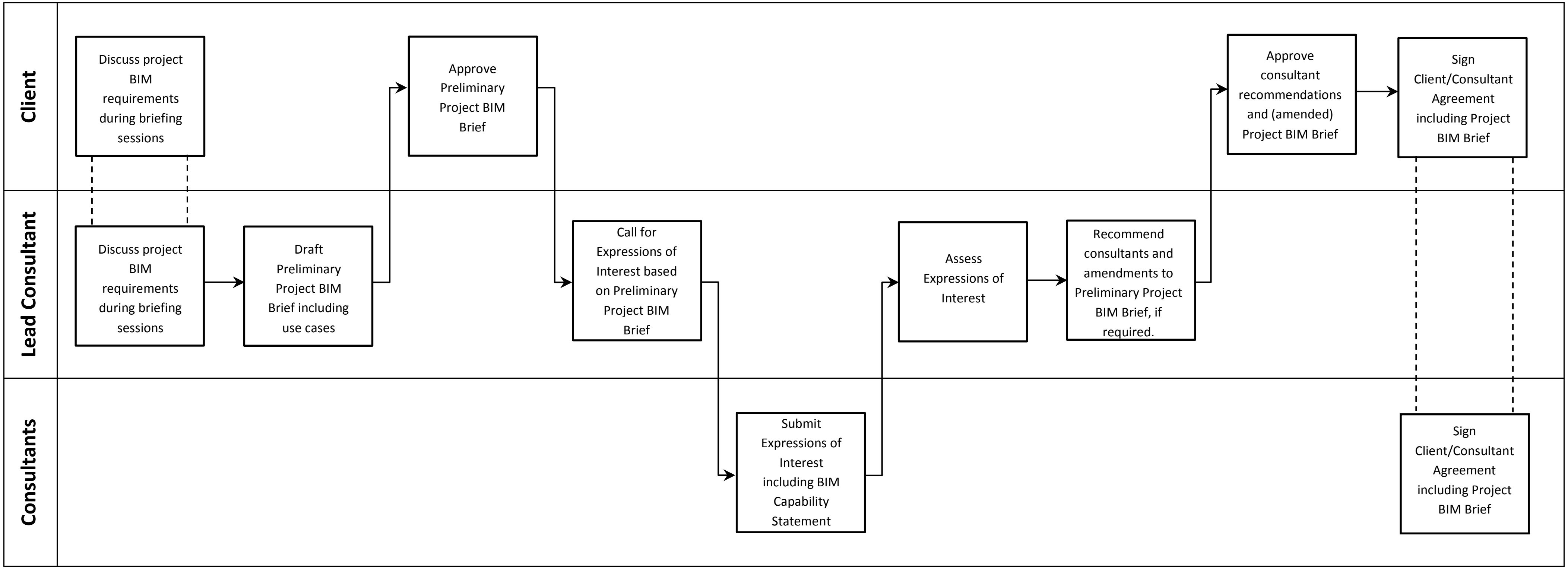
Where the Lead Consultant will not also act as the Design BIM Manager, the role of Design BIM Manager is procured using the preliminary Project BIM Brief as a basis for scoping their role. The Design BIM Manager is procured, and commences by finalising the Project BIM Brief for use in procuring other design consultants.

i See **Appendix E** for the description of BIM roles. E ➡

Defining the BIM strategy in the Preliminary Project BIM Brief is a key to ensuring that all project participants understand their role. Figure 2.0 outlines a typical workflow for the development of the Project BIM Brief.

**Figure 2.0 BIM Project Inception Steps**

The Design BIM Manager shall discuss the benefits, limitations and implications of potential BIM uses for the project, and the availability and capability of suitable consultants. The process includes assessing the client's understandings and expectations regarding BIM.



## 3.1 Preliminary Project BIM Brief

The Preliminary Project BIM Brief should as a minimum outline the following:

- project definition
- proposed procurement methodology
- required BIM uses cases
- consultant selection requirements.

i See **Appendix A** for a Preliminary BIM Brief Template. A

### 3.1.1 Project Definition

A clear brief and an understanding of the constraints associated with a project are essential prerequisites for a successful project. It should outline:

- the client's understandings and expectations regarding BIM
- benefits, limitations and implications of potential BIM uses for the project
- availability and capability of suitable consultants.

### 3.1.2 Procurement Strategy

The project procurement strategy will define the process and management of the BIM model creation. It is imperative that the decision to use Design-Bid-Build (DBB), Design and Construct (D&C), Integrated Project Delivery (IPD) be determined during project inception so that BIM can be properly structured and managed to support the procurement strategy.

The contracts will define:

- the integration or separation of risk and responsibilities for the design and construction contracting entities
- the Level of Development (LOD) required and the division of responsibilities. For example, there may be only one BIM Manager throughout the project if IPD or D&C is used and potentially two, a Design and a Construction BIM Manager, if DBB is used. Similarly, contractually defined risk will also determine whether there are separate design and construction BIM models, or whether they can be combined into one model.

The procurement strategy will also determine the level of client involvement at each project stage. This should be made clear to the client during the assessment of options.

### 3.1.3 BIM Uses on a Project

The first step in a project for which BIM is being considered is to identify which BIM uses are appropriate for realising project goals and aligning these with team capabilities. Many of the difficulties associated with implementing BIM stem from not adequately defining its uses at the outset.

BIM uses are deliberately not presented as being intrinsically linked to project phases. It is much more appropriate to select BIM uses that support project goals at the beginning of the project and then plan how they will be deployed during different phases of the project.

With BIM, the effective management of data is essential for anything beyond basic geometrical modelling. Each specific BIM use has significant data sets associated with it which have to be managed over extended periods of time. Each additional use multiplies the effort and associated cost required to manage a model.

Any non-essential data makes finding required information more difficult. Select uses carefully and, before adding any data to the model, always ask the question: “What benefit does it add, who will need this information, and what are their requirements?” Once BIM uses have been finalised, many aspects of planning the implementation of BIM can be resolved with greater certainty.

i See **Appendix C** for the requirements associated with each BIM use. C

**BIM Uses Included in the Handbook**

1. Design authoring
2. Design reviews
3. 3D coordination
4. Existing conditions modelling
5. Phase planning (4D modelling)
6. Cost estimation
7. Site analysis
8. Engineering analysis
    a) Energy
    b) Fire
    c) Lighting
    d) Mechanical
    e) Structural
    f) Other
9. Spatial programming
10. Site utilisation planning
11. Construction system design
12. Digital fabrication
13. 3D control and planning

14. Record modelling
15. Asset management
16. Space management and tracking
17. Building (preventative) maintenance scheduling
18. Building system analysis
19. Sustainability (Green Star / NABERS) evaluation
20. Code validation
21. Disaster planning.

**BIM Use Selection**

Use a structured process to select BIM uses that support project goals and objectives and take into consideration team capabilities.

Goals should be based on measurable performance criteria, e.g.:

- reducing project duration
- reducing re-work
- improving quality or safety
- improving building operability/maintainability.

The cost/benefit and risk of each BIM use should be analysed. Some BIM uses are inherent in the natural design and construction process and may be obtained "for free". Others will come at a cost that must be balanced against the overall benefits achieved.

#### 3.1.4 Consultant Selection

The Preliminary Project BIM Brief should be included in any documentation sent to potential consultants from whom EOIs are sought.

As part of selecting the most appropriate consultants for the project, compare their capability for each BIM use with those specified in the Preliminary Project BIM Brief.

The Design BIM Manager should be selected based on the Preliminary Project BIM Brief. Following their appointment, their first objective is to finalise the Project BIM Brief so that design consultants can be selected against this more refined Project BIM Brief. The Design BIM Manager assists with the assessment of design consultant capability and makes recommendations as to their suitability and compliance against the Project BIM Brief, so that these factors can be considered in the final selection.

Following assessment, it is possible that some of the BIM uses in the Preliminary Project BIM Brief will need to be modified – the required capability may not be available for some uses, or there may be opportunities to take advantage of a consultant's capabilities that the assessor was not aware of, or the Project BIM Brief had not foreseen.

The Design BIM Manager's and Lead Consultant's recommendations, including any amendments to the Project BIM Brief should be sent to the client for their evaluation and approval.

When the client is satisfied with the Lead Consultant's recommendations, a Client/Consultant Agreement, with the Project BIM Brief appended, is signed by both parties.


The *BIM Project Execution Planning Guide* by the Computer Integrated Construction Research Programme, Penn State University (*Penn State BIM Guide*) is a very useful reference that can be used in conjunction with the BIM Handbook. It describes a four step procedure for planning the execution of BIM projects, and includes supporting worksheets, checklists, templates and worked examples. The first step is the selection of BIM uses based on project goals and objectives.
Download a copy from www.engr.psu.edu/ae/cic/bimex/download.aspx

# 4 PROJECT EXECUTION PLANNING

Planning and documenting the process involved to provide a successful BIM implementation.

**Key tasks**

- Assigning BIM roles and responsibilities to team members.
- Resolving brief items to the extent necessary for project planning at this time.
- Finalising how BIM will be used on the project.
- Identifying any special client requirements regarding information standards, e.g., software types, file formats, CAD and modelling standards, room numbering conventions, naming conventions, asset classification codes, standard cost reporting formats, facility management data types.
- Defining client deliverables required in addition to design and construction documentation, e.g., presentation models for marketing purposes, brief compliance reports, programme and cost planning updates.
- Developing a BIM Management Plan (BMP).

## 4.1 Project Kick-off Meeting

After consultant engagement, the Design BIM Manager should facilitate a project kick-off BIM orientation meeting. This should be attended by all key players in the project, not just those directly involved in the documentation. The kick-off meeting's purpose is to:

1. Discuss and determine the client's requirements with respect to BIM.
2. Discuss and agree the BIM uses.
3. Identify the responsible party for each BIM use.

The Penn State Project Execution Planning Guide (see section 3) illustrates process maps for each defined BIM use. These may prove a useful tool in developing the overall BIM Management Plan.

## 4.2 Roles and Responsibilities

The following are the key roles relating to BIM for a project. How other team members (e.g., Quantity Surveyor, Project Manager, Design Manager) interact with the BIM process needs to be included in the BIM Management Plan.

i See **Appendix E** for a description of BIM Roles. E

Some roles may pre-exist, or exist earlier than their immediate responsibilities require during the project cycle. Where this occurs, it is advantageous that reviews of work done prior to that role's core involvement be included as options in their scope. For example, an owner of a new development may already have a Facility Manager for prior developments, in which case the project will benefit from their review from an early stage.

#### 4.2.1 Design BIM Manager

This individual shall serve as the main point of contact with the client and the design team for BIM related issues. Their key role is to act as technology manager with respect to BIM, facilitating and reviewing compliance with the execution of the BIM Management Plan by all parties, throughout the design stages. During the construction stages their role varies according to the procurement strategy; it may include reviews of the Construction BIM Manager's compliance with the BIM Management Plan.

#### 4.2.2 Design BIM Coordinators

All major technical disciplines (architecture, structural, MEP, interior design, etc.) shall assign an individual to the role of lead Design BIM Coordinator to coordinate their work with the entire design team. These individuals shall have the relevant BIM experience required for the complexity of the project.

#### 4.2.3 Construction BIM Manager

This individual shall have the appropriate level of relevant BIM experience required for the project complexity and procurement delivery strategy. Their key role is to act as technology manager with respect to BIM, facilitating and reviewing compliance with the execution of the BIM Management Plan by all parties, throughout the construction stages. During the design stages, their role varies according to the procurement strategy.

#### 4.2.4 Subcontract BIM Coordinators

All major trades (HVAC, electrical, steelwork, etc.) shall assign an individual to the role of lead Subcontract BIM Coordinator to coordinate their work with the entire construction team. These individuals shall have the relevant BIM experience required for the complexity of the project.

#### 4.2.5 Facility BIM Manager

The owner may elect to appoint a Facility BIM Manager alongside or subsequent to the Construction BIM Manager's role being undertaken. The Facility BIM Manager's key role is to maintain the BIM model and integrate it with any FM system being utilised for the project. If engaged at a suitable time, the Facility BIM Manager may also provide advice to the project team where applicable.

# 5 BIM MANAGEMENT PLAN

The BIM Management Plan (BMP) is developed iteratively. The initial BMP should only include what is necessary to allow the project team to proceed with confidence until the next iteration of the BMP is released.

i See **Appendix B** for resources to assist with the development of BMPs. B ⇨

The BIM Management Plan defines how the project will be executed, monitored and controlled with regard to BIM.

The BMP shall align the project procurement strategy needs and requirements with the client brief, technical standards, team member skills, construction industry capability and technology maturity. Through this process, the team members and the project management shall jointly agree on how, when, why, to what level and for which project outcomes BIM will be used.

In those projects where construction information is available during the design phase (using the D&C or IPD project procurement strategies), the BMP shall address both design and construction activities. Where a DBB (traditional) procurement strategy is used, a separate BMP for design and, potentially, for construction shall be developed and submitted to the client with specific attention to model and data handover from the design team to the construction team.

The BMP should be considered a living document and shall be continually developed and refined throughout the project development lifecycle to ensure the project remains on schedule and meets briefed requirements. Include the proposed method for facilitating this (e.g. scheduled review meetings) in the initial BMP.

## 5.1 Typical Contents of a BIM Management Plan

Project:

- identification
- team members and contacts
- roles and responsibilities
- objectives
- procurement strategy
- BIM uses
- deliverables
- programme
- project location data, levels and grids
- site segmentation.

Model:

- naming protocols for space, room, equipment, system, material, assets
- element classification system
- object information parameters

- units of measurement and dimensional accuracy
- location, origin and orientation of models
- applying equipment naming conventions
- view naming protocols
- transfer procedure/schedule.

Federated model:

- coordination resolution protocol
- clash detection reporting
- clash detection batches.

Outputs:

- visualisation requirements
- construction sequencing requirements (4D)
- cost estimation modelling Requirements (5D)
- O&M manual requirements.

Procedures and protocols:

- collaboration procedures for information exchange
- model element authoring including Levels of Development (LOD)
- model structure
- model coordination and management
- transfer procedure/schedule

Standards:

- quality control
- modelling standards
- CAD and drawing standards
- file and document naming and numbering conventions.

Technological:

- hardware
- ITC network/project collaboration platform
- digital folder structure
- software.
- file types.

## 5.2 Design BMP

The Design BIM Manager shall submit the BMP to the client for review and approval before the start of preliminary design. The Design BMP, at a minimum, shall address the following*:*

a. BIM development schedule and progress submittal aligned to the Project Schedule in compliance with the client's submission instructions. Schedule to include:

   - Proposed meetings and their purpose (design coordination/clash detection, BMP review, etc.).
   - Progress BIMs per design document submission. Specify the period in which the Progress BIM recipient is to advise the author/s whether it satisfies their specified requirements, or not.

b. Exchange considerations

   - Provide the strategy for model exchange and handover including strategy for establishing and managing shared file server, if used.
   - Strategy for hosting, transfer, and access of data between technical disciplines (use of model server, extranet, permitted uses, access rights, security, etc.). A technical evaluation of the options to match the Information Technology (IT) technical needs to the size and complexity of the project, and to provide access by the design/construction team and various project stakeholders, peer reviewers, etc.
   - File exchange protocol.
   - Legal status the design model will have for construction (binding, informational, reference, reuse).

c. Modelling considerations

   - The proposed development of model elements throughout the project, including the Level of Development (LOD) of each and the author responsible for developing it at each phase of the project.
   - Strategy for import of client functional area requirement (Programme for Design (PFD)) information.
   - Methods for showing functionality of occupants' requirements (proximity of spaces, walking distances, sightlines, etc.) and circulation paths for the delivery, supply, processing and storage of materials, e.g., graphics, animated models.
   - Methods for showing major building equipment space clearance reservations for operations, repair, maintenance and replacement, e.g., graphics, animated models.
   - Energy modelling strategies.
   - Strategy for updating and coordinating changes during construction into the final BIM model deliverable files.
   - Strategy for integration of Facility Management information (e.g., COBie).

## 5.3 Construction BMP

After bid award, the contractor shall, if required by the client, submit a Construction BMP outlining the strategy and schedule for using BIM technology to execute construction related activities and project coordination. The Construction BMP, at a minimum, shall address the following:

a. Strategy for compliance with project BIM requirements.

b. BIM qualifications, experience and contact information for the Construction BIM Manager and subcontract BIM coordinators for all trades.

c. List of subcontractors using digital fabrication.

d. Proposed subcontractor meetings and their purposes (design coordination/clash detection, BIM Management Plan review, etc.) integrated into project schedule.

e. Exchange considerations

   - Strategy for software compatibility, file formats, hosting, transfer, and access of data between trades (use of model server, extranet, access security, etc.). A technical evaluation of the options to match the IT technical needs to the size and complexity of the project, and to provide access by the design/construction team and various stakeholders, fabricators, etc.

   - Proposed BIM software to be used by the contractor and fabrication modellers.

f. Modelling considerations

   - Strategy to assure all trade information is modelled and coordinated.

   - Methods for showing major building equipment space clearance reservations for operations, repair, maintenance and replacement, e.g., graphics, animated models.

   - Constructability analysis with BIM.

   - Proposed trade coordination strategy (clash detection).

g. Proposed use of digital fabrication.

h. Utilisation of 4D scheduling and construction sequencing technology.

i. Integration of as-built conditions and commissioning data into an as-built/record BIM.

   a. Strategy for updating and coordinating changes during construction into the final BIM deliverable.

   b. Strategy for integration of Facility Management information (e.g., COBie).

# 6 COLLABORATION PROCEDURES

The success of a BIM enabled project delivery process is highly dependent upon the level at which the entire design/construction team can collaboratively produce and manage information for the duration of the project. This section documents some of the management procedures that can be used for this purpose.

## 6.1 Collaboration Standards

In the absence of existing documented information management standards mandated by the client, the BIM team shall nominate or develop the ***Collaborative Information Management Standard*** to be used on the project. Any amendments considered necessary to these standards must be documented. When the ***Collaborative Information Management Standard*** and amendments have been agreed by the BIM Team they shall be adopted, included as part of the BMP, and managed for consistent application by the Design and Construction BIM Managers.

At a minimum, the ***Collaborative Information Management Standard*** shall address the following:

- lines of responsibility
- modes of communication
- reporting procedures
- approval and sign-off procedures
- information management and exchange protocols
- model sharing protocols
- model coordination procedures
- model and drawing versioning procedures.

## 6.2 Federated Model Creation

The Design Team BIM Manager shall manage the process of bringing all the various design team models together into a single “federated model”. This means a model consisting of linked but distinct component models and other data sources that do not lose their identity or integrity by being so linked. A change to one component model in a federated model does not create a change in another component model in that federated model.

If all designers are using the same modelling platform then this could be undertaken within the native file format, or through export into an open transfer format (e.g., IFC). If different platforms are used project review tools should be used to integrate and validate merged models. There may be benefits in using specific review software, even if all team members are using the same platform.

The method for creating and managing the federated model should be agreed and documented in the BMP.

## 6.3 Facilitating BIM Coordination

Face-to-face meetings in which BIM models are used for design review and clash detection/coordination are the preferred means of facilitating technical discipline coordination. However, different project circumstances will determine the most appropriate approach. Remote means of conducting BIM coordination, such as web conferencing, should only be considered when no other practical alternatives exist.

Consideration should be given to establishing a BIM Coordination Room (typically a physical room set aside for this purpose) configured and equipped to allow multiple parties to view the federated model. Coordination sessions should include all designers. Where clashes are detected, resolution should be agreed and those impacted make the changes required in their respective models (not within the federated model).

The party responsible for providing the facilities shall be determined during the development of the BIM Management Plan (BMP). A current clash list shall be produced and circulated to all parties (key stakeholders) before each meeting, then be updated once the revised models have been released into the federated model and a new clash detection process undertaken.

## 6.4 Technology Platform and Software

### 6.4.1 IT Requirements

In consultation with project team members, the Design BIM Manager shall prepare a brief for the IT requirements to support project activities and liaise with the project IT Manager/s to identify potential issues and ascertain the most appropriate file hosting systems, e.g. shared file servers, online collaboration systems, cloud based systems. Where project requirements exceed available capacity, the Design BIM Manager shall seek authority for increasing capacity or formulate strategies and procedures, in consultation with the IT Manager/s, to work within the limitations of the system. It is the responsibility of the Design BIM Coordinators to notify team members of procedures designed to make the most effective use of IT systems.

A similar process is applicable for the Construction BIM Manager and Subcontract BIM Coordinators.

### 6.4.2 Approved BIM Software for Projects

Unless specified by clients for compatibility with their existing systems, all BIM software used on the project shall comply with the **Software Assessment Criteria** within the BIM Management Plan. Document software pre-selected for the project in the Project BIM Brief.

### 6.4.3 Software Compatibility and Data Flow Testing

Software used for design and construction BIM work shall be tested for compatibility by the Construction BIM Manager. The use of software that is not Industry Foundation Class (IFC) compliant in the preparation of models is only permitted with the approval of the BIM Manager. Versioning of software shall be managed by the BIM teams throughout the project lifecycle.

## 6.5 File Storage and Security

### 6.5.1 Project Folder Structure

Maintaining consistent file naming and structure is critical for referenced (linked) files to function properly across design teams and for end users such as facilities managers to retrieve files quickly once the project is complete. For this reason, the design and construction teams shall define a file protocol for the team during the development of the BIM Management Plan (BMP) and apply the digital folder and file naming conventions included in the agreed ***BIM Modelling Standards***.

a. **BIM folders** - BIM files shall be sorted by model files and sheet files.

- Model files - original files from other disciplines should be linked from their discipline folder location and relative path to models. Model file names shall follow file naming convention outlined in the BMP.
- Sheet files - PDF and native file formats of the most current sheets shall be maintained in this folder and organised with sheet file naming outlined in the ***CAD/Drawing Standards***.

b. **Support files** - standard items needed for the project, such as a project specific symbols, applications (lisp, script, etc.), logos and graphics. Project-specific model content can also be placed here.

c. **Coordination files** - Files for construction coordination (clash detection) shall be managed by the Construction BIM Manager, and organised by date as the project progresses.

d. **Other folders** - renderings, analyses, environmental rating schemes (e.g., Green Star), etc. will have their own folders.

#### 6.5.2 Data Security

Design teams shall establish a data security protocol to prevent any possible data corruption, virus "infections," and data misuse or deliberate damage by their own employees or outside sources. Both the design team and construction teams shall establish adequate user access rights to prevent data loss or damage during file exchange, maintenance, and archiving.

### 6.6 Change Management

Open and clear management of change is a key part to a successful project. Change can occur during the design, construction or operation phases of a project. It may be as a result of a change in client brief, design development, specific site conditions, final equipment selection or change of end use. This Handbook outlines the process for managing change within the BIM environment but it does not address commercial or contractual implications.

The BMP should clearly show who owns each model at each design stage. Changes should be made by the owner of the model. This requires there to be an owner for each model through the entire project lifecycle.

For the building services trades it is reasonably clear where a specific trade contractor takes over from a specific designer. For architecture and structure, the responsibility for maintenance of the model during the construction phase through to producing the as -built model needs to be confirmed.

If there is no "use case" selected that requires an as-built model, the benefits of investing in maintaining the models during construction need to be confirmed.

#### 6.6.1 Design Phase

It is expected that, at the early stage of the design, modelled elements will change in size and location as the concepts are developed. As the design progresses the impact of change on other disciplines increases.

- Where models are being exchanged during a design phase they should be accompanied by a document transmittal that notes the reason for issue and significant changes made.
- Formal issues of the model should be accompanied by a document transmittal and include embedded sheets with all changes since last formal issue clouded.

### 6.6.2 Construction Phase

Changes during the construction phase will generally impact on physical works on site, cost and time.

- Changes may be issued as 2D sheets with all changes clouded accompanied by a document transmittal.
- Updated issues of the model should be accompanied by a document transmittal and include embedded sheets with all changes since last issue clouded.

### 6.6.3 Operation Phase

The ownership of the model shall pass to the owner a pre-determined period after practical completion (this period to allow completion of the as-built model).

- Changes relating to modifications to the space should follow the design and construction steps outlined above.
- Maintenance modifications will generally be made via the Facilities Management system. (Interfacing between the BIM model and FM systems is outside the current scope of this Handbook.)

Note: the nature of the document transmittal will vary from project to project. The format and what it contains should be agreed and included in the overall project execution plan.

# 7 MODELLING AND DOCUMENTATION PRACTICE

**Key tasks**

- Planning the modelling process.
- Establishing modelling and documentation standards.
- Creating model content (objects/elements).
- Creating models.
- Developing and updating models.
- Sharing models with other project team members and stakeholders.
- Coordinating models.
- Extracting information and documents from models.
- Managing all of these activities.

## 7.1 Planning the Modelling Process

"Begin with the end in mind." The deliverables required in the form of documents and data will determine the model views and models that need to be created. The information that needs to be extracted for various purposes determines the data that has to be inputted. It is important that nothing in excess of this is added – otherwise it just becomes "noise" and increases management effort.

Before modelling begins, the project team shall review the deliverables required and define the graphic and data items necessary to deliver them. At a minimum, they shall address the following:

- definition of model views
- definition of constituent/discipline models
- definition of items to be included in the models
- definition of model objects/elements required
- definition of information exchanges
- assignment of model element author responsibilities
- model development including the LOD of each element at programme milestones. This should be documented in an LOD table. Any variations to the element LOD reference specification for elements should be documented, as required.

i See **Appendix B** for general information on LOD. B

i See **Appendix B** for guidance on model development and using LOD Tables. B

- definition of parameters for each element at each LOD necessary to support chosen BIM uses
- coordination of models including the sequence of clash detection and definition of coordination precision
- publication of models and exports of documents and data.

The coordination schedule, planned model publications and exports of documents and data should be recorded in the project programme.

## 7.2 Quality Control

Quality control measures shall be applied to all aspects of modelling and documentation to eliminate errors and achieve desired project outcomes. The principle underpinning these measures can be summarised as "*Model to a standard, check to a standard*."

In addition to agreeing standards as part of the development of the BIM Management Plan, the project team should agree protocols and procedures for checking compliance regularly throughout the project. Quality control measures that should be applied at different times are described in the following section.

i See **Appendix C** for examples of quality control procedures. C ➡

## 7.3 General Modelling Requirements

### 7.3.1 Ability to Reuse Data

The ability to own, reuse, and properly manage building data throughout the facility lifecycle accrues significant advantages for stakeholders. Consequently, the accurate creation, management and stewardship of building information during project creation are of utmost importance. Data created during planning and refined during the project execution process can provide a valuable resource for Facility Management (FM). **Final BIM Deliverables** requires that as-built BIM model(s) be submitted at the end of construction for this purpose.

### 7.3.2 Modelling Standards

In the absence of existing documented modelling standards mandated by the client, the BIM team shall nominate the ***BIM Modelling Standards*** to be used on the project. Any amendments considered necessary must be documented.

When the ***BIM Modelling Standards*** and amendments have been agreed by the BIM team they shall be managed for consistent application by the relevant Design and/or Construction BIM Manager.

At a minimum, the ***BIM Modelling Standards*** shall address the following:

- model setup including project templates
- team member modelling protocols including definition of authorised uses
- model naming conventions
- view naming conventions
- system naming conventions (services, etc.)
- element naming conventions (walls, partitions, doors, windows, etc.)
- materials and finishes naming conventions
- properties/parameters to be included for model objects
- object property/parameter naming conventions.

## 7.4 Model Set-up and Authoring

### 7.4.1 Good Modelling Practice

It is expected that individual Design BIM Coordinators will document and implement good modelling practice with their teams.

### 7.4.2 Creating Model Objects/Elements

Model elements to standards agreed by the project team. Model elements shall be derived from the following sources:

a. National BIM Object Library: a consistently formatted library of generic and proprietary Model Elements.

b. Proprietary Model Elements: elements created by and acquired from manufacturers often have more information than is prudent to keep in the BIM model; the appropriate level of detail should be retained for the design element. However, embedded performance data shall remain for analysis and specification purposes.

c. Custom created model elements: custom model elements that are created shall utilise appropriate BIM Authoring tool templates to create custom elements.

### 7.4.3 Model Geographical Location (MGL)

The spatial coordination (coordinates) of the master BIM file shall be set at the beginning of the project. Once established, spatial coordinates shall only be changed by mutual consent of the team.

A geo-reference to accurately locate the building within the site and to give it a physical location context at larger scales should be included in the BIM file. The relevant Design and/or Construction BIM Manager shall geo-reference site plans and building models for site layout surveying and future Geographic Information System (GIS) use.

Latitude and longitude points for GIS purposes shall also be defined. The BIM model origin and latitude/longitude points shall be located at an agreed point on site that is readily accessible during construction and will not be displaced. The MGL reference will always “read” as 0,0,0 – the project origin will read whatever the distance is from the MGL reference to the lowest left hand point of the building structural grid.

#### 7.4.4 Points of Reference

The relevant Design and/or Construction BIM Manager shall provide a 3D grid for incorporation into the spatial coordination model. This will provide the viewer with a quick point of reference when navigating through the model. Room information shall also be incorporated.

#### 7.4.5 Requirements for Modelling Space

a. The method of measurement for floor area adopted for the project will be the defining kernel of space counting procedures for the client and form the basis for the Programme for Design (PFD). The method of measurement for floor area shall be defined before modelling begins.

b. Space information imported from the Architectural Programming Software PFD export shall be the source for space creation in BIM.

c. Areas of 0.5 $m^2$ or greater shall be tracked and identified by name, even if those spaces are not listed in the Architectural Programming Software PFD export.

d. Spatial data shall be generated and associated with bounding elements (walls, doors, windows, floors, columns, ceilings).

e. The defined method of measurement for floor area shall be used when modelling each functional space in the PFD, using the appropriate space/object BIM tool to capture and carry the information. Spaces shall be represented and broken down into functional spaces (e.g. office areas, amenities, plant rooms) as defined in the PFD even though they may be parts of a larger physical space.

f. A physical space may contain several areas that are treated individually in the PFD spatial programme. If two areas have different functional space classifications, even though they are within the same physical space, they shall be modelled as two separate spaces.

g. Space/area schedules and diagrams shall be dynamically updated from the model geometry.

h. Client spatial requirements shall be validated through reports generated from the BIM.

#### 7.4.6 Metadata

The BIM model, all spaces and all equipment shall be uniquely named and contain required metadata. Suggested metadata fields are to be defined.

### 7.5 Model Management

The relevant Design and/or Construction BIM Manager shall check that models are being developed in compliance with the agreed LOD Bable and monitor model development against the programme and quality standards.

i See **Appendix B** for general information on LOD. B ➡

i See **Appendix B** for guidance on model development and using LOD Tables. B ➡

## 7.6 Model Development and Level of Development (LOD)

### 7.6.1 Key Points of this Topic

- Level of Development (LOD) is a means of defining the extent to which a model element has been developed, from conception in the mind of the designer through to its construction and operation.
- The basis for the concept of LOD is recognition that model elements evolve at different rates throughout the design process. It follows that LOD should only be used to describe model elements, not models as a whole.
- LOD represents the extent to which information about an element can be relied on for decision-making purposes at a particular point in time.
- The value of LOD, incorporated in an LOD table, is that it provides a means of communicating expectations about the development of model elements between team members throughout the design and construction process for planning, management and coordination purposes.
- An element has only progressed to a given LOD when all stated requirements have been met. It should also be considered that the requirements are cumulative i.e., any model element is required to have achieved all the requirements of the previous LOD.
- The resources devoted to developing and maintaining LOD tables should be proportional to the degree that they assist management of the project. They are a tool, not an end in themselves.

### 7.6.2 Level of Development versus Level of Detail

LOD is sometimes interpreted as Level of Detail rather than Level of Development. However there are important differences. Level of Detail is essentially how much detail is included in the model element. Level of Development is the degree to which the element's geometry and attached information has been thought through – the degree to which project team members may rely on the information when using the model. In essence, Level of Detail can be thought of as input to the element, while Level of Development is reliable output.

### 7.6.3 LOD Notations

LOD notations are comprised of numbers at intervals of 100 to allow users of the system the flexibility to define intermediate LODs. Defining additional LODs can be crucial in some circumstances, particularly for contractual reasons, e.g., the handover of models from the design team to the construction team.

#### 7.6.4 Aspects of LOD

The LOD concept encompasses a number of aspects of designed elements:

- type of information: Graphic or non-graphic
- type of graphic information: 2D or 3D
- degree of precision and amount of graphic detail
- type of non-graphic information: embedded in model elements, linked to model elements, independent of model elements
- amount, quality and relevance of non-graphic information.

### 7.7 Model Sharing

#### 7.7.1 During Design Phases

The Design BIM Coordinators shall be responsible for providing:

- a federated BIM fully coordinated and assembled in a model checking software format, e.g., Navisworks, Solibri
- separate copies of each technical discipline model in the original software authoring tool - these will be combined into a federated model by the Design Team BIM Manager
- a 2D plan set, derived from the assembled BIM, for contract bidding.

#### 7.7.2 During Construction Bidding

a. The use of BIM and the specific BIM uses required will be included in the bid documents. Standards will be announced and reviewed with potential bidders and then reviewed with the selected contractor and major subcontractors prior to the start of construction.

b. The contractor shall have access to the design BIM model(s) during bidding. The solicitation for bids shall define the legal status of the model to the bidders (binding, informational, reference, reuse) by determining the Contract Record Document (the BIM model(s)) or the extracted 2D plan set.

c. Regardless of whether or not the design BIM model(s) is a Contract Record Document, after a contract is awarded for construction the following shall be provided to the appropriate contractor entities, as needed:

- a fully coordinated and assembled federated BIM in a model checking software format, e.g., Navisworks, Solibri
- coordinated design BIM model(s) and all native BIM files.

#### 7.7.3 During the Construction Phase

a. It is the contractor's responsibility to assure that all major trades are modelled and used for clash detection, construction phasing, and installation coordination.

b. Subcontractors' fabrication models shall be coordinated with the design model. Any corrections to the design model that need to be made prior to fabrication and construction shall be reported to the design team in the form of a Request for Information (RFI). Clash reports may also be issued by the contractor as background information for RFIs and submittals.

## 7.8 Model Coordination

### 7.8.1 Model Structure and Format for Coordination

The BIM(s) shall consist of objects and elements that represent the actual dimensions of the building elements and the building equipment that will be installed on the project (as specified in the agreed LOD).

BIM coordination requires the following model structure and features.

a. The relevant Design and/or Construction BIM Manager shall establish the floor elevation protocol so that the Technical Discipline/Trade BIMs will be modelled at the correct elevation.

b. Clearance reservations: all models shall include separate 3D representations of required clearances for all mechanical equipment for repair, maintenance, and replacement, light fixture access, overhead cable tray access, etc. These clearance/access models should be in a separate object style for each trade and clearly labelled as such.

c. The granularity of elements in the model shall correspond with the proposed sequence of the installation at the site (e.g., not one wall element for the entire floor).

d. All 3D model files submitted for clash detection shall be "clean"; all extraneous 2D references and/or 3D elements shall be stripped from the models.

### 7.8.2 Grades of Coordination

The relevant Design and/or Construction BIM Manager shall assign one of the following levels to each coordination/clash detection set:

a. **Level One Collisions** are reported collisions that are considered critical to the design and construction process. The highest priority is assigned to rectifying them as soon as possible after detection.
b. **Level Two Collisions** are reported collisions that are considered important to the design and construction process. They should be rectified during design phases.
c. **Level Three Collisions** are reported collisions that while considered important to the correctness of the model will generally be changing on a regular basis throughout the design and construction process. They can be assigned a lower level of priority and should be rectified before phase submissions of the models.

### 7.8.3 Quality Control Checks Prior to Coordination

Modellers should perform the following minimum checks prior to BIM coordination meetings:

- All files have been exported from the constituent models in the format specified by the relevant Design and/or Construction BIM Manager for use with the model coordination software.

- Prior to exporting models that include light fittings, make sure that light sources are turned off.
- All objects have been modelled as 3D solids, not wire frame or lines.
- All models should be “clean”, i.e., they should contain only relevant 3D data and no extraneous 2D data, or any x-referenced files.
- All elements are identifiable by the agreed clash detection colours.
- The architect is to check that spaces have been designed according to the room schedule and that spaces are aligned with surrounding walls.
- The structural engineer is to check that load bearing structures and openings in them match with corresponding components in the architectural model.
- MEP designers are to perform spatial coordination of their own systems and clash detection between systems they have designed themselves.

## 7.9 Model Handovers and Sign-off Procedures

Prior to designated handovers, all models shall be checked using agreed procedures and published in the formats described in section 7.11.

Each modelling team shall include a model description document (MDD) that includes crucial information about the model with each model it publishes and sign-off that it complies with the agreed specification. Name the MDD so that it can be readily associated with the correct model. The document shall describe the contents of the model and explain its purpose and limitations.
A record of updates will be provided to the Lead BIM Consultant with each transfer.

## 7.10 Transition of Model Ownership

Depending on the use cases selected, the ownership of the BIM will change during the project life cycle. It will start with the design team then transfer to the contractor and finally to the client (or their FM provider). In this context the “ownership” of the model refers to the party that has primary responsibility for the model at that stage. It does not refer to ownership from an Intellectual Property perspective.

- Whilst each discipline/trade model is owned by the organisation producing it, the federated model is owned by the Design/Construction/FM BIM Manager.
- At any stage of the project, there shall only be one federated model owner.
- In a traditional fully “design” – “bid” – “build” contract, the ownership should start with the design team, transfer to the contractor on award of contract and to the client a defined period after practical completion.
- In a traditional “design and build” contract, ownership should be with the contractor during the design and construction phase and transfer to the client at a defined period after practical completion.
- In a partial design – bid”– complete design while building contract, ownership should pass to the contractor at a pre-agreed point. This will vary from project to project. To maximise the benefits of integrating the construction phase activities this transfer should be as soon as is practical after the first packages are issued for construction. Ownership shall transfer to the client at a defined period after practical completion.

- When ownership has passed to the Construction BIM Manager, and design is still being completed, the Construction BIM Manager needs to coordinate with design Discipline Lead BIM Coordinators to ensure that all design phase BIM activities are completed efficiently.
- The latest information shall always be included within the federated model. If design is still being undertaken when construction/fabrication models are available for some trades, the design Discipline Lead BIM Coordinators need to coordinate with the Construction/Fabrication Lead BIM Coordinators.
- Model handover procedures outlined in section 7.9 shall be followed at the transition of model ownership.
- The timing of transfer of model ownership shall be included in the BMP.

## 7.11 Final BIM Deliverables

One of the primary benefits of the BIM model for the client or building operator is being able to use it for Facilities Management upon occupancy. Information that matures during the construction process is to be captured in the appropriate models on an on-going basis throughout the construction phase. The use of these models is a developing methodology and, presently, multiple formats of information are required. Unless the project procurement strategy realigns these responsibilities, the client shall receive the following:

**3D Geometric Deliverables – Construction Coordination Model**

The contractor shall be responsible for providing the client consolidated as-built model(s) for all building systems. The model(s) shall be fully coordinated and align with the design model for architecture and structure. The required instructions on file/folder setup shall also include:

1. Contractor – native file formats of the final consolidated as-built model(s) for building systems used in the multi-discipline coordination process (version as agreed in BIM Management Plan).

2. Contractor – Industry Foundation Class (IFC) file format of the consolidated building systems models (version as agreed in BIM Management Plan).

**3D Geometric Deliverables – Design Intent Model**

The design team is to ensure that the design intent model remains current with all approved changes for overall scope. It is NOT expected that product specific information will be added to this model. Provide model information for architecture and structure teams and the required instructions on file/folder setup, as follows:

1. Design team - native file format(s) of design model (version as agreed in BIM Management Plan).

2. Design team - IFC file format (version as agreed in BIM Management Plan).

**Data Deliverables**

1. Contractor – provide a Facility Management spreadsheet or database file, e.g., COBie, containing room and product data information.

2. Design team – provide room/space data in an agreed format, e.g., COBie, to be included in the contractor database.

**2D Deliverables**

1. Contractor – provide as-built drawings in archive standard PDF format with fully bookmarked pages.
2. Design team – produce one printed set of final documents generated from the design intent model:
    a. in archive standard PDF format with fully bookmarked pages
    b. DWG format (latest current version) with bound views to each sheet.

### 7.11.1 Submission of Digital Deliverables

All digital deliverables are to be submitted on DVD/CD, USB, in the cloud, etc., with the data clearly organised and software version(s) labelled.

## 7.12 Requirements for 2D Drawings

### 7.12.1 General

2D drawing information for the purposes of assembling a printed set of plans shall be derived from the BIM model(s) to the fullest extent possible. All BIM information shall aim to be fully parametric so that all applicable information regarding fixtures and/or elements can be used to generate schedules. Where required by the BMP, editable text files shall be attached to fixtures/elements to aid in calculations.

### 7.12.2 CAD/Drawing Standards

In the absence of existing documented CAD/drawing standards mandated by the client, the BIM team shall nominate the CAD/Drawing Standards to be used on the project. Any amendments considered necessary to these standards must be documented.

At a minimum, the CAD/Drawing Standards shall address the following:

- drawing naming conventions
- layer naming conventions
- sheet sizes
- title blocks
- cross-referencing
- drawing scales
- line styles and line weights
- gridlines
- dimensioning
- typefaces
- annotations and keynoting
- labelling and tagging
- abbreviations

- symbols
- representation of materials and finishes
- schedules
- legends.

# 8 PROJECT PHASES

The following sets out the core BIM activities aligned to the NZCIC Design and Documentation Guidelines and should be read in conjunction with them. The requirements described here for each phase are those required on a BIM-based project in addition to those set out in the Guidelines.

At each phase the LOD for each model element shall be as defined in the BMP.

For each phase identify items not included in the model and make sure they are described and coordinated in the discipline drawings, schedules, specifications and BOQs, to the extent required by the phase.

At each phase the constituent and consolidated models shall be coordinated to the defined level.

## 8.1 Concept Design

- BIM kick-off meeting.
- Initial model sharing with design team for strategic analysis and options appraisal.
- Identify key model elements (e.g., prefabricated components) and create concept level parametric objects for all primary elements.
- Enable design team access to BIM data.
- Depending on Project BIM Brief: BIM data used for environmental performance and area analysis.

## 8.2 Preliminary Design

- Create preliminary level parametric objects for all secondary model elements.
- Agree extent of performance specified (D&C) work.
- Depending on Project BIM Brief: BIM data used for environmental performance and area analysis.

## 8.3 Developed Design

- Data sharing for design coordination, technical analysis and addition of specification data, including data links between models.
- Integration/development of generic/bespoke design components.
- Depending on Project BIM Brief: BIM data used for environmental performance and area analysis.
- Depending on Project BIM Brief: 4D and/or 5D assessment.

## 8.4 Detailed Design

- Same as developed design phase plus:
- Enable access to model by tenderers.

## 8.5 Construction Design

- Depending on Project BIM Brief: export data for building control analysis.
- Data sharing for conclusion of design co-ordination and detailed analysis with subcontractors.
- Detailed modelling, integration and analysis.
- Create production level parametric objects for all major elements (where appropriate and information exists this may be based on tier 2 suppliers' information).
- Link specification to the model.
- Final review and sign-off of model.

- Enable access to model by specialist subcontractors and/or specialists.
- Integration of subcontractor performance specified (D&C) work model information into BIM model data.
- Depending on Project BIM Brief: review construction sequencing (4D) with contractor.
- Depending on Project BIM Brief: site plant and equipment incorporated in model.
- All facility management information including commissioning reports, operation and maintenance manuals, warranties, product data, and contact details for manufacturers, suppliers and contractors.

## 8.6 As Built Models and Data

Refer Final BIM Deliverables section 7.11.

# NEW ZEALAND BIM HANDBOOK APPENDICES

# Appendix A

# BIM Management Plan Template

**Section A:** **Project Information**

| | | |
|---|---|---|
| **Project Name:** | | |
| **Client :** | | |
| **Outline Programme:** | **Design** – | |
| | **Construction** – | |
| **Project Description** | | |
| **Project Procurement Methodology** | | |

**Section B:** **Project Team Leaders**

| Role | Company | Responsible Person | email |
|---|---|---|---|
| Client | | | |
| Project Manager | | | |
| Design Manager | | | |
| Architect | | | |
| Quantity Surveyor | | | |
| Structural Engineer | | | |
| Services Engineer | | | |
| Fire Engineer | | | |
| | | | |

**Section C:** **Design Phase BIM Managers (Refer 4.2)**

| Role | Company | Contact | email |
|---|---|---|---|
| Design BIM Manager | | | |
| Project Manager - BIM Coordinator | | | |
| Architect - BIM Coordinator | | | |
| Quantity Surveyor- BIM Coordinator | | | |
| Structural Engineer- BIM Coordinator | | | |
| Services Engineer - BIM Coordinator | | | |
| Fire Engineer- BIM Coordinator | | | |
| | | | |

**Section D:** **Construction Phase BIM Management (Refer 4.2)**

| Role | Company | Contact | email |
|---|---|---|---|
| Construction BIM Manager | | | |
| Project Manager - BIM Coordinator | | | |
| Quantity Surveyor- BIM Coordinator | | | |
| Façade – BIM Coordinator | | | |
| Pre-cast – BIM Coordinator | | | |
| Mechanical – BIM Coordinator | | | |
| Electrical – BIM Coordinator | | | |
| Plumbing - BIM Coordinator | | | |
| Fire Protection - BIM Coordinator | | | |
| | | | |

**Section E:** **Software**

| Discipline | Platform | File Exchange Format(s) |
|---|---|---|
| Architecture | | |
| Structure | | |
| Services | | |
| Quantity Surveyor | | |
| Coordination Platform | | |
| Project Manager | | |
| Client | | |
| | | |

**Section F:** **Project Model Uses (Refer 3.1.3 and Appendix C)**

| | BIM Use Case | Use on Project | Owner | Users |
|---|---|---|---|---|
| 1 | Design authoring | | | |
| 2 | Design reviews | | | |
| 3 | 3D co-ordination | | | |
| 4 | Existing conditions modelling | | | |
| 5 | Phase planning (4D modelling) | | | |
| 6 | Cost estimation | | | |
| 7 | Site analysis | | | |
| 8 | Engineering analysis<br>a) Energy<br>b) Fire<br>c) Lighting<br>d)Mechanical<br>e) Structural<br>f) Other | | | |
| 9 | Spatial programming | | | |
| 10 | Site utilisation Planning | | | |
| 11 | Construction system design | | | |
| 12 | Digital fabrication | | | |
| 13 | 3D control and planning | | | |
| 14 | Record modelling | | | |
| 15 | Asset management | | | |
| 16 | Space management and tracking | | | |
| 17 | Building (preventative) maintenance scheduling | | | |
| 18 | Building system analysis | | | |
| 19 | Sustainability (Green Star / NABERS) evaluation | | | |
| 20 | Code validation | | | |
| 21 | Disaster planning | | | |

**Section F: Design Phase Model Element LOD**

**Model Element Author (MEA): A- Architect, S –Structural, MEP – Services**

**Level of Development – refer 7.6 and Appendix B**

| **Model Element** | **Concept Design** | | **Preliminary Design** | | **Developed Design** | | **Detailed Design** | |
|---|---|---|---|---|---|---|---|---|
| | **MEA** | **LOD** | **MEA** | **LOD** | **MEA** | **LOD** | **MEA** | **LOD** |
| **SITE** | | | | | | | | |
| Boundaries | | | | | | | | |
| Topography | | | | | | | | |
| Orientation | | | | | | | | |
| Access | | | | | | | | |
| Drainage | | | | | | | | |
| Services other than drainage | | | | | | | | |
| Paving | | | | | | | | |
| Landscape structures | | | | | | | | |
| Subsite conditions | | | | | | | | |
| Soft landscaping | | | | | | | | |
| | | | | | | | | |
| **SPATIAL** | | | | | | | | |
| Functional relationships | | | | | | | | |
| Circulation/egress | | | | | | | | |
| Relationships to exterior | | | | | | | | |
| Spaces - primary | | | | | | | | |
| Spaces - secondary & services | | | | | | | | |
| Overall building form | | | | | | | | |
| | | | | | | | | |
| **PRIMARY ARCHITECTURAL ELEMENTS** | | | | | | | | |
| Building mass | | | | | | | | |
| Floors | | | | | | | | |
| Columns, posts | | | | | | | | |
| Walls, curtain walls, partitions | | | | | | | | |
| Lift shafts | | | | | | | | |
| Stairs, ramps | | | | | | | | |
| Roofs | | | | | | | | |
| | | | | | | | | |
| **SECONDARY ARCHITECTURAL ELEMENTS** | | | | | | | | |
| Windows | | | | | | | | |
| Doors | | | | | | | | |
| Ceilings | | | | | | | | |
| Skylights | | | | | | | | |
| Openings, penetrations | | | | | | | | |
| Screens, sunscreens | | | | | | | | |
| | | | | | | | | |

| Model Element | Concept Design | | Preliminary Design | | Developed Design | | Detailed Design | |
|---|---|---|---|---|---|---|---|---|
| | MEA | LOD | MEA | LOD | MEA | LOD | MEA | LOD |
| **STRUCTURAL ELEMENTS** | | | | | | | | |
| Floors | | | | | | | | |
| Columns, posts | | | | | | | | |
| Structural Walls | | | | | | | | |
| Lift shafts | | | | | | | | |
| Stairs, ramps | | | | | | | | |
| Roofs | | | | | | | | |
| Footings | | | | | | | | |
| Bracing | | | | | | | | |
| **ROOM LAYOUTS** | | | | | | | | |
| Fixtures | | | | | | | | |
| Fittings | | | | | | | | |
| Equipment | | | | | | | | |
| Furniture | | | | | | | | |
| Finishes | | | | | | | | |
| **SERVICE OUTLETS** | | | | | | | | |
| Lighting | | | | | | | | |
| Mechanical | | | | | | | | |
| Hydraulic | | | | | | | | |
| Electrical | | | | | | | | |
| Data/Communication | | | | | | | | |
| Fire | | | | | | | | |
| **SERVICE PLANT & RETICULATION** | | | | | | | | |
| Service plant & equipment | | | | | | | | |
| Vertical mechanical ductwork | | | | | | | | |
| Hydraulic risers | | | | | | | | |
| Electrical risers | | | | | | | | |
| Large rigid horizontal ductwork | | | | | | | | |
| Gravity waste pipes | | | | | | | | |
| Cable trays & ducts | | | | | | | | |
| Small flexible ductwork | | | | | | | | |
| Supply pipework | | | | | | | | |
| **COST ESTIMATE & SCHEDULE OF QUANTITIES** | | | | | | | | |
| Floor area | | | | | | | | |
| Cladding areas | | | | | | | | |
| Schedules | | | | | | | | |
| **PROGRAMME** | | | | | | | | |
| Demolition | | | | | | | | |
| Design | | | | | | | | |
| Construction | | | | | | | | |
| | | | | | | | | |

# Appendix B

# Level of Development

**Key points of this topic**

- Level of Development (LOD) is a means of defining the extent to which a model element has been developed, from conception in the mind of the designer through to its construction and operation.
- The basis for the concept of LOD is recognition that model elements evolve at different rates throughout the design process. It follows that LOD should only be used to describe model elements, not models as a whole. To do otherwise negates its reason for being.
- LOD represents the extent to which information about an element can be relied on for decision-making purposes at a particular point in time.
- The value of LOD, incorporated in an LOD table, is that it provides a means of communicating expectations about the development of model elements, between team members throughout the design and construction process for planning, management and coordination purposes.
- An element has only progressed to a given LOD when all requirements stated have been met. It should also be considered that the requirements are cumulative, i.e., any model element is required to have achieved all the requirements of the previous LOD.
- The resources devoted to developing and maintaining LOD tables should be proportional to the degree that they assist management of the project. They are a tool, not an end in themselves.

**Level of Development versus Level of Detail**

LOD is sometimes interpreted as Level of Detail rather than Level of Development, however there are important differences. Level of Detail is essentially how much detail is included in the model element. Level of Development is the degree to which the element's geometry and attached information has been thought through – the degree to which project team members may rely on the information when using the model. In essence, Level of Detail can be thought of as input to the element, while Level of Development is reliable output.

**LOD Notations**

LOD notations are comprised of numbers at intervals of 100 to allow users of the system the flexibility to define intermediate LODs. Defining additional LODs can be crucial in some circumstances, particularly for contractual reasons, e.g., the handover of models from the design team to the construction team.

**Aspects of LOD**

The LOD concept encompasses a number of aspects of designed elements:

- type of information: graphic or non-graphic
- type of graphic information: 2D or 3D
- degree of precision and amount of graphic detail
- type of non-graphic information: embedded in model elements, linked to model elements, independent of model elements
- amount, quality and relevance of non-graphic information.

While all of these aspects contribute to the concept of LOD, they do not define it - LOD is the sum value of them. Essentially, when all of these aspects are taken into consideration, LOD represents the extent to which information about an element can be relied on for decision-making purposes at a particular point in time. This is the most crucial notion in the context of collaborative working arrangements.

| | LOD 100 | LOD 200 | LOD 300 | LOD 400 | LOD 500 |
|---|---|---|---|---|---|
| **Model Content Requirements** | Overall building massing indicative of area, height, volume, location, and orientation may be modelled in three dimensions or represented by a symbol or other data. | Model elements are modelled as generalised systems, objects or assemblies with approximate quantities, size, shape, location, and orientation. Non-geometric information may also be attached to model elements. | Model elements are modelled as specific assemblies accurate in terms of quantity, size, shape, location, orientation, and interfaces with other building elements. Non-geometric information may also be attached to model elements. | Model elements are modelled as specific assemblies that are accurate in terms of size, shape, location, quantity, and orientation with complete fabrication, assembly, and detailing information. Non-geometric information may also be attached to model elements. | Model elements are modelled as constructed assemblies (a field verified representation) actual and accurate in terms of size, shape, location, quantity and orientation. Non-geometric information may also be attached to model elements. |
| **Authorised Uses** | | | | | |
| **Construction** | | | Suitable for the generation of traditional construction documents and shop drawings. | Model elements are virtual representations of the proposed element and are suitable for construction. | |
| **Analysis** | The model may be analysed based on volume, area and orientation by application of generalised performance criteria assigned to the representative model | The model may be analysed for performance of selected systems by application of generalised performance criteria assigned to the representative model elements. | The model may be analysed for performance of selected systems by application of specific performance criteria assigned to the representative model elements. | The model may be analysed for performance of approved selected systems based on specific model elements. | |

| | | | | | |
|---|---|---|---|---|---|
| | elements. | | | | |
| **Cost Estimating** | The model may be used to develop a cost estimate based on current area, volume or similar conceptual estimating techniques (e.g., square feet or floor area, condominium unit, hospital bed, etc.) | The model may be used to develop cost estimates based on the approximate data provided and conceptual estimating techniques (e.g., volume and quantity of elements or type of system selected). | The model may be used to develop cost estimates based on the specific data provided and conceptual estimating techniques. | Costs are based on the actual cost of specific elements at buyout. | |
| **Schedule** | The model may be used for project phasing and overall duration. | The model maybe sued to show ordered, time-scaled appearance of major elements and systems. | The model may be used to show ordered, time-scaled appearance of detailed elements and systems. | The model may be used to show ordered, time-scaled appearance of detailed specific elements and systems including construction means and methods. | |
| **Other Authorised Uses** | Additional authorised uses of the model developed to a Level 100, if any, are as follows. | Additional authorised uses of the model developed to a Level 200, if any, are as follows. | Additional authorised uses of the model developed to a Level 300, if any, are as follows. | Additional authorised uses of the model developed to a Level 400, if any, are as follows. | The model may be utilised for maintaining, altering, and adding to the project. |

# Appendix C

# BIM Uses

| REF | BIM USE | DESIGN | CONSTRUCTION | OPERATION |
|---|---|---|---|---|
| 1. | Design authoring | ☐ | ☐ | |
| 2. | Design reviews | ☐ | | |
| 3. | 3D Coordination | ☐ | ☐ | |
| 4. | Existing conditions modelling | ☐ | ☐ | ☐ |
| 5. | Phase planning (4D modelling) | ☐ | ☐ | ☐ |
| 6. | Cost estimation | ☐ | ☐ | ☐ |
| 7. | Site analysis | ☐ | | |
| 8. | Engineering analysis<br>a) Energy<br>b) Fire<br>c) Lighting<br>d)Mechanical<br>e) Structural<br>f) Other | ☐<br>☐<br>☐<br>☐<br>☐<br>☐ | | |
| 9. | Spatial Programming | ☐ | | |
| 10. | Site utilisation planning | ☐ | | |

| | | | | |
|---|---|---|---|---|
| 11. | Construction system design | | ☐ | |
| 12. | Digital fabrication | | ☐ | |
| 13. | 3D control and planning | | ☐ | |
| 14. | Record modelling | | ☐ | ☐ |
| 15. | Asset management | | | ☐ |
| 16. | Space management and tracking | | | ☐ |
| 17. | Building (preventative) maintenance scheduling | | | ☐ |
| 18. | Building system analysis | | | ☐ |
| 19. | Sustainability (Green Star / NABERS) evaluation | ☐ | | |
| 20. | Code validation | ☐ | ☐ | |
| 21. | Disaster planning | ☐ | | ☐ |

| **Design Authoring** |
|---|
| Description: |
| A process in which-software is used to develop a Building Information Model based on criteria that are important to the building's design. Two groups of applications at the core of BIM-based design process are design authoring tools, and audit and analysis tools.<br>Design authoring tools are a first step towards BIM and the key is connecting the 3D model with a powerful database of properties, quantities, methodologies, costs and schedules. |
| Potential Value: |
| • Transparency of design for all stakeholders<br>• Better control and quality control of design, cost and schedule<br>• Powerful design visualisation<br>• True collaboration between project stakeholders and BIM users<br>• Improved quality control and assurance |
| Resources Required: |
| • Design authoring software and / or design analysis software |
| Team Competencies Required: |
| • Ability to create and develop a BIM<br>• Knowledge of construction methodology<br>• Design and construction experience |

| **Design Review** |
|---|
| Description: |
| A process in which stakeholders view a 3D model and provide their feedbacks to validate multiple design aspects.<br>These aspects include evaluating meeting the programme, previewing space aesthetics and layout in a virtual environment, and setting criteria such as layout, sightlines, lighting, security, ergonomics, acoustics, textures and colours, etc.<br>This BIM use can be done by using computer software only or with special virtual mock-up facilities. Virtual mock-ups can be performed at various levels of detail depending on project needs. An example of this is to create a highly detailed model of a small portion of the building, such as a façade, to quickly analyse design alternatives and solve design and constructability issues. |
| Potential Value: |
| • Easily communicate the design to the owner, construction team and end users<br>• Get instant feedback on meeting programme requirements, owner's needs and building or space aesthetics<br>• Greatly increase coordination and communication between different parties. More likely to generate better decisions for design<br>• Eliminate costly and timely traditional construction mock-ups<br>• Different design options and alternatives may be easily modelled and changed in real-time during design review base on end users and/or owner feedbacks<br>• Create shorter and more efficient design and design review process<br>• Evaluate effectiveness of design in meeting building programme criteria and owner's needs<br>• Enhance the health, safety and welfare performance of their projects (for instance, BIM can be used to analyse and compare fire-rated egress enclosures, automatic sprinkler system designs, and alternate stair layouts) |
| Resources Required: |
| • Design review software<br>• Interactive review space<br>• Hardware which is capable of processing potential large model files |

| Team Competencies Required: |
|---|
| • Ability to manipulate, navigate, and review a 3D model<br>• Ability to model photo realistically including textures, colours and finishes and easily navigable by using different software or plug-ins<br>• Strong sense of coordination. Understanding roles and responsibilities of team members<br>• Strong understanding of how building/facility systems integrate with one another |

| **3D Coordination** |
|---|
| Description: |
| A process used throughout the coordination process to determine conflicts of geometry within the BIM that would result in problems on site. This process can be completed by using clash avoidance software which will automate the process of manually checking for conflicts within the BIM. The goal of 3D coordination is to eliminate the major system conflicts prior to installation. |
| Potential Value: |
| • Coordinate building project through a model<br>• Reduce and eliminate on site conflicts which reduces RFIs significantly, compared to other methods<br>• Visualise construction<br>• Increase productivity<br>• Reduced construction cost; potentially less variations<br>• Reduced re-work on site<br>• Decrease construction time<br>• Increase productivity on site<br>• More accurate as-built drawings |
| Resources Required: |
| • Design authoring software<br>• Model review application<br>• Clash detection software |
| Team Competencies Required: |
| • Ability to deal with people and project challenges<br>• Ability to manipulate, navigate, and review a 3D model<br>• Ability to run clash detection software<br>• Knowledge of BIM model applications for facility updates<br>• Knowledge of building systems |

| **Existing Condition Modelling** |
| --- |
| Description: |
| A process in which a project team develops a 3D model of the existing conditions for a site, facilities on a site, or a specific area within a facility. This model can be developed in multiple ways, including laser scanning and conventional surveying techniques, depending on what is desired and what is most efficient. Once the model is constructed, it can be queried for information, whether it is for new construction, refurbishment or a modernisation project. |
| Potential Value: |
| • Use as an input to design and construction activities<br>• Provides documentation of environment for future uses<br>• Enhances the efficiency and accuracy of existing conditions documentation<br>• Aids in future modelling and 3D design coordination<br>• Provides an accurate representation of work that has been put into place<br>• Real-time quantity verification for accounting purposes<br>• Use for visualisation purposes<br>• Provides detailed layout information<br>• Pre-disaster planning<br>• Post-disaster record<br>• Use as a verification process for completed works |
| Resources Required: |
| • Conventional surveying equipment<br>• 3D laser scanning hardware and software<br>• Design authoring software<br>• Laser scanning point cloud manipulation software |

| Team Competencies Required: |
|---|
| • Ability to manipulate, navigate and review a 3D model<br>• Knowledge of Building Information Model authoring tools<br>• Knowledge of 3D laser scanning tools<br>• Knowledge of conventional surveying tools and equipment<br>• Ability to sift through mass quantities of data that is generated by a 3D laser scan<br>• Ability to determine what level of detail will be required to add "value" to the project<br>• Ability to generate Building Information Model from 3D laser scan and/or conventional survey data |

| **Phase Planning (4D Modelling)** |
|---|
| Description: |
| A process in which a 4D model (3D models with the added dimension of time) is used to effectively plan the phased occupancy in a renovation, retrofit or addition, or to show the construction sequence and space requirements on a building site. 4D modelling is a powerful visualisation and communication tool that can give a project team, including the owner, a better understanding of project milestones and construction plans. |
| Potential Value: |
| • Better understanding of the phasing sequence by the owner and project participants and showing the critical path of the project<br>• Monitor actual progress on site against programme and critical path activities<br>• Identification of programme sequencing or phasing issues<br>• Dynamic phasing plans of occupancy offering multiple options and solutions to space conflicts<br>• Integrate planning of human, equipment and material resources with the BIM model to better programme and cost estimate the project<br>• Identify opportunities for staged handover<br>• Space and workspace conflicts identified and resolved ahead of the construction process<br>• Marketing purposes and publicity<br>• More readily constructible, operable and maintainable project<br>• Monitor procurement status of project materials<br>• Increased productivity and decreased waste on job sites<br>• Conveying the spatial complexities of the project, planning information, and support conducting additional analyses |
| Resources Required: |
| • Design authoring software |

| |
|---|
| • Scheduling software<br>• 4D modelling software |
| Team Competencies Required: |
| • Knowledge<br>•<br>• of construction programming and general construction process. A 4D model is connected to a programme, and is therefore only as good as the programme to which it is linked.<br>• Ability to manipulate, navigate and review a 3D model.<br>• Knowledge of 4D software: import geometry, manage links to programmes, produce and control animations, etc. |

| **Cost Estimation (5D Cost Estimation)** |
|---|
| Description: |
| A process in which BIM can be used to assist in the generation of accurate quantity take-offs and cost estimates throughout the lifecycle of a project. This process allows the project team to see the cost effects of their changes, during all phases of the project, which can help curb excessive budget overruns due to project modifications. Specifically, BIM can provide cost effects of additions and modifications, with potential to save time and money and is most beneficial in the early design stages of a project. |
| Potential Value: |
| • Precisely quantify modelled materials<br>• Quickly generate quantities to assist in the decision-making process<br>• Generate more cost estimates at a faster rate<br>• Better visual representation of project and construction elements that must be estimated<br>• Provide cost information to the owner during the early decision making phase of design and throughout the lifecycle, including changes during construction<br>• Saves estimator's time by reducing quantity take-off time<br>• Allows estimators to focus on more value-adding activities in estimating such as identifying construction assemblies and generating pricing and factoring risks, which are essential for high quality estimates<br>• Added to a construction schedule (such as a 4D Model), a BIM developed cost estimate can help track budgets throughout construction<br>• Easier exploration of different design options and concepts within the owner's budget<br>• Quickly determine costs of specific objects<br>• Easier to strain new estimators through this highly visual process |
| Resources Required: |
| • Model-based estimating software |

| |
|---|
| • Accurately built design model<br>• Cost data |
| Team Competencies Required: |
| • Ability to define specific design modelling procedures which yield accurate quantity take-off information<br>• Ability to identify quantities for the appropriate estimating level (e.g., room boundary, NZIQS elements to objects) upfront<br>• Ability to manipulate models to acquire quantities usable for estimation<br>• Ability to adjust a cost plan to suit data available in the model over the duration of design phase. |

| **Site Analysis** |
|---|
| Description: |
| A process in which BIM/GIS tools are used to evaluate properties in a given area to determine the most optimal site location for a future project. The site data collected is used to first select the site and then position the building based on other criteria. |
| Potential Value: |
| • Use calculated decision making to determine if potential sites meet the required criteria according to project requirements, technical factors, and financial factors<br>• Decrease costs of utility demand and demolition<br>• Increase energy efficiency<br>• Minimize risk of hazardous material<br>• Maximize return on investment |
| Resources Required: |
| • GIS software<br>• Design authoring software |
| Team Competencies Required: |
| • Ability to manipulate, navigate, and review a 3D model<br>• Knowledge and understanding of local authority's system (GIS, database information) |

| **Engineering Analysis (Lighting, Energy, Mechanical, Other)** |
| --- |
| Description: |
| A process in which analysis software uses the BIM to assess the performance of various system options–to determine the most effective engineering solution based on owner performance requirements or design codes. Modelled performance data is first compared to physical commissioning results, then is the basis for what will be passed on to the owner and/or operator for building's systems monitoring or use in the buildings operation (e.g., energy analysis, emergency evacuation planning, etc.). These analysis tools and performance simulations can significantly improve the design of the facility and its energy consumption during its lifecycle in the future. |
| Potential Value: |
| • Automating analysis and saving time and cost<br>• Save time and cost on developing separate analysis models<br>• Improve the quality and reduce the cycle time of the design analyses<br>• Improved commissioning of systems<br>• Achieve optimum, energy-efficient design solution by applying various rigorous analyses<br>• Improve specialised expertise and services offered by the design firm<br>• More efficient building operation by applying post occupancy audit and analysis tools for engineering systems analyses |
| Resources Required: |
| • Design authoring tools<br>• Engineering analysis tools and software |
| Team Competencies Required: |
| • Ability to manipulate, navigate, and review a 3D Model<br>• Ability to assess a model through analysis tools<br>• Knowledge of construction means and methods<br>• Design and construction experience |

| **Structural Analysis** |
|---|
| Description: |
| A process in which analytical modelling software utilises the BIM design authoring model so to determine the behaviour of a given structural system. With the modelling minimum required standards for structural design and analysis are used for optimisation. Based on this analysis further development and refinement of the structural design take place to create effective, efficient, and constructible structural systems. The development of this information is the basis for what will be passed onto the digital fabrication and construction system design phases.<br>This BIM use does not need to be implemented from the beginning of the design to be beneficial. Often structural analysis is implemented at the connection design level to make fabrication quicker, more efficient and for better coordination during construction. Another application is that this relates and ties into construction system design, examples include but are not limited to: erection design, construction–methodology and staging. The application of this analysis tool allows for performance simulations that can significantly improve the design, performance and safety of the facility over its lifecycle. |
| Potential Value: |
| • Save time and cost on creating extra models<br>• Improve specialised expertise and services offered by the design firm<br>• Achieve optimum efficient design solutions by applying various rigorous analyses<br>• Improve the quality and accuracy of the design analyses<br>• Reduce the iteration time of the design analyses |
| Resources Required: |
| • Design authoring tools<br>• Structural engineering analysis and design tools and software |
| Team Competencies Required: |
| • Ability to create, manipulate, navigate, and review a 3D structural model<br>• Ability to assess a model through engineering analysis tools<br>• Knowledge of constructability methods<br>• Knowledge of analytical modelling techniques<br>• Knowledge of structural behaviour and design<br>• Design experience<br>• Integration expertise pertaining to building systems as a whole<br>• Experience in structural sequencing methods |

| **Facility Energy Analysis** |
|---|
| Description: |
| Facility energy analysis is a process in the facility design phase in which one or more building energy simulation programmes use a properly adjusted BIM to conduct energy assessments for the current building design. The core goal of this BIM use is to inspect building energy standard compatibility and seek opportunities to optimise a proposed design to reduce a structure's life-cycle costs. |
| Potential Value: |
| • Save time and costs by obtaining building and system information automatically from BIM model instead of inputting data manually<br>• Improve building energy prediction accuracy by auto-determining building information such as geometries and volumes precisely from BIM<br>• Help with Green Star assessment and building energy code verification<br>• Optimise building design for better building performance efficiency and reduce building life-cycle cost |
| Resources Required: |
| • Building energy simulation and analysis software<br>• Detailed local weather data<br>• National/local building energy standards |
| Team Competencies Required: |
| • Knowledge of basic building energy systems<br>• Knowledge of compatible building energy standards<br>• Knowledge and experience of building system design<br>• Ability to manipulate, navigate, and review a 3D model<br>• Ability to assess a model through engineering analysis tools |

| **Spatial Programming** |
|---|
| Description: |
| A process in which a spatial programme is used to efficiently and accurately assess design performance in regard to spatial requirements outlined by the client. The developed BIM-allows the project team to analyse space and understand the complexity of space standards and regulations. Critical decisions are made in this phase of design and bring the most value to the project when needs and options are discussed with the client and the best approach is analysed. |
| Potential Value: |
| • Efficient and accurate assessment of design performance in regard to spatial requirements by the owner |
| Resources Required: |
| • Design authoring software |
| Team Competencies Required: |
| • Ability to manipulate, navigate and review a 3D model |

| Site Utilisation Planning |
|---|
| Description: |
| A process in which BIM is used to graphically represent both permanent and temporary facilities on site during multiple phases of the construction process. It may also be linked with the construction programme to convey space and sequencing requirements. Additional information incorporated into the model can include labour resources, materials with associated deliveries and equipment location. Because the 3D model components can be directly linked to the programme, site management functions such as visualised planning, short-term re-planning, and resource analysis can be analysed over different spatial and temporal data. |
| Potential Value: |
| • Efficiently generate site usage layout for temporary facilities, assembly areas, and material deliveries for all phases of construction<br>• Quickly identify potential and critical space and time conflicts<br>• Accurately evaluate site layout for safety concerns<br>• Select a feasible construction scheme<br>• Effectively communicate construction sequence and layout to all interested parties<br>• Easily update site organisation and space usage as construction progresses<br>• Minimise the amount of time spent performing site utilisation planning |
| Resources Required: |
| • Design authoring software<br>• Scheduling software<br>• Model integration software<br>• Detailed existing conditions site plan |
| Team Competencies Required: |
| • Ability to create, manipulate, navigate, and review a 3D model<br>• Ability to manipulate and assess construction programme with a 3D model<br>• Ability to understand typical construction methods<br>• Ability to translate site knowledge to a technological process |

| **Construction System Design (Virtual Mockup)** |
|---|
| Description: |
| A process in which 3D system design software is used to design and analyse the construction of a complex building system (e.g., form work, glazing, tie-backs, etc.) in order to increase planning. |
| Potential Value: |
| • Increase constructability of a complex building system<br>• Increase construction productivity<br>• Communicate understanding of complex construction sequences<br>• Decrease language barriers<br>• Increase safety awareness of a complex building system |
| Resources Required: |
| • Design authoring software |
| Team Competencies Required: |
| • Ability to manipulate, navigate and review a 3D model<br>• Ability to make appropriate construction decisions using a 3D system design software<br>• Knowledge of typical and appropriate construction practices for each component |

| **Digital Fabrication** |
| --- |
| Description: |
| A process that uses digitised information to facilitate the fabrication of construction materials or assemblies. Some uses of digital fabrication can be seen in sheet metal fabrication, structural steel fabrication, pipe cutting, prototyping for design intent reviews, etc. It assists in ensuring that the downstream phase of manufacturing has minimum ambiguities and enough information to fabricate with minimal waste. An information model could also be used with suitable technologies to assemble the fabricated parts into the final assembly. |
| Potential Value: |
| • Save time and cost on creating extra models<br>• Ensuring quality of information<br>• Minimise tolerances through machine fabrication<br>• Increase fabrication productivity and safety<br>• Reduce lead times<br>• Reduce dependency on 2D paper drawings |
| Resources Required: |
| • Design authoring software<br>• Machine readable data for fabrication<br>• Fabrication methods |
| Team Competencies Required: |
| • Ability to understand and create fabrication models<br>• Ability to manipulate, navigate, and review a 3D model<br>• Ability to extract digital information for fabrication from 3D models<br>• Ability to manufacture building components using digital information<br>• Ability to understand typical fabrication methods |

| **3D Control and Planning (Digital Layout)** |
|---|
| Description: |
| A process that uses an information model to layout facility assemblies or automate control of equipment's movement and location. The information model is used to create detailed control points and aid in assembly layout. An example of this is layout of walls using a total station with points preloaded and/or using GPS coordinates to determine if proper excavation depth is reached. |
| Potential Value: |
| • Decrease layout errors by linking model with real world coordinates<br>• Increase efficiency and productivity by decreasing time spent surveying in the field<br>• Reduce rework because control points are received directly from the model<br>• Decrease/eliminate language barriers |
| Resources Required: |
| • Machinery with GPS capabilities<br>• Digital layout equipment<br>• Model transition software ( software that takes a model and converts it into usable information) |
| Team  Competencies Required: |
| • Ability to create, manipulate, navigate and review a 3D model<br>• Ability to interpret if model data is appropriate for layout and equipment control. |

| **Record Modelling** |
|---|
| Description: |
| Record modelling is the process used to depict an accurate representation of the physical conditions, environment and assets of a facility.<br>The record model should, at a minimum, contain information relating to the main architectural, structural and MEP elements. It has the ability to be the culmination of all the BIM throughout the project, including linking operation, maintenance, and asset data to the as-built model (created from the design, construction, 4D coordination models, and subcontractor fabrication models) to deliver a record model to the owner or Facility Manager.<br>Additional information, including equipment and space planning systems, may be necessary if the owner intends to utilise the information in the future. |
| Potential Value: |
| ● Aid in future modelling and 3D design coordination for renovation<br>● Improve documentation of environment for future uses, e.g., renovation or historical documentation<br>● Aid in the consenting process (e.g., continuous change vs. specified code.)<br>● Minimise facility handover dispute (e.g., link to contract with historical data highlights expectations and comparisons drawn to final product.)<br>● Ability for embedding future data based upon renovation or equipment replacement<br>● Provide owner with accurate model of building, equipment and spaces within a building to create possible synergies with other BIM uses<br>● Minimise building handover information and required storage space for this information<br>● Better accommodate owner's needs and wants to help foster a stronger relationship and promote repeat business<br>● Easily assess client requirement data such as room areas or environmental performance to as-designed, as-built or as-performing data |
| Resources Required: |
| ● 3D model manipulation tools<br>● Compliant model authoring tools to accommodate required deliverables<br>● Access to essential information in electronic format<br>● Database of assets and equipment with metadata (based on owner’s capabilities) |

| Team Competencies Required: |
|---|
| • Ability to manipulate, navigate and review a 3D model<br>• Ability to use BIM application for building updates<br>• Ability to thoroughly understand facility operations processes to ensure correct input of information<br>• Ability to effectively communicate between the design, construction and facilities management teams |

| Asset Management |
|---|
| Description: |
| A process in which an organised management system is bi-directionally linked to a record model to efficiently aid in the maintenance and operation of a facility and its assets. These assets, consisting of the physical building, systems, surrounding environment and equipment, must be maintained, upgraded, and operated at an efficiency which will satisfy both the owner and users in the most cost effective manner. It assists in financial decision-making, short-term and long-term planning and generating scheduled work orders.<br>Asset management uses the data contained in a record model to populate an asset management system which is then used to determine cost implications of changing or upgrading building assets. The bidirectional link also allows users to visualise the asset in the model before servicing it, potentially reducing service time. |
| Potential Value: |
| • Store operations, maintenance owner user manuals, and equipment specifications for faster access.<br>• Perform and analyse facility and equipment condition assessments<br>• Increase the opportunity for measurement, tuning and verification of systems during building occupation (optimise building efficiency)<br>• Maintain up-to-date facility and equipment data including, but not limited to, maintenance schedules, warranties, cost data, upgrades, replacements, damages/deterioration, maintenance records, manufacturer's data and equipment functionality<br>• Provide one comprehensive source for tracking the use, performance and maintenance of a building's assets for the owner, maintenance team and financial department<br>• Produce accurate quantity take-offs of current company assets which aid in financial reporting, bidding, and estimating the future cost implications of upgrades or replacements of a particular asset.<br>• Allow for future updates of record model to show current building asset information after upgrades, replacements, or maintenance by tracking changes and importing new information into model<br>• Aid financial department in efficiently analysing different types of assets through an increased level of visualisation<br>• Automatically generate scheduled work orders for maintenance staff |
| Resources Required: |
| • Asset management system<br>• Ability to bidirectional link facilities record model and asset management system. |

| Team Competencies Required: |
| --- |
| • Ability to manipulate, navigate and review a 3D model (preferred but not required)<br>• Ability to manipulate an asset management system<br>• Knowledge of construction and the operation of a building (replacements, upgrades, etc.)<br>• Pre-design knowledge of which assets are worth tracking, whether the building is dynamic or static, and the end needs of the building to satisfy the owner<br>• Knowledge of related financial software |

| **Space Management and Tracking** |
|---|
| Description: |
| A process in which BIM is used to effectively distribute, manage and track appropriate spaces and related resources within a facility. A facility building information model allows the facility management team to analyse the existing use of the space and effectively apply transition planning management towards any applicable changes. Such applications are particularly useful during a project's renovation where building areas are to remain occupied. Space management and tracking ensures the appropriate allocation of spatial resources throughout the life of the facility. This use benefits from the utilisation of the record model. This application often requires integration with spatial tracking software. |
| Potential Value: |
| • More easily identify and allocate space for appropriate building use<br>• Increase the efficiency of transition planning and management<br>• Proficiently track the use of current space and resources<br>• Assist in planning future space needs for the facility |
| Resources Required |
| • Bi-directional 3D model manipulation; software and record model integration<br>• Space mapping and management input application (Mapguide, Maximo, etc.) |
| Team Competencies Required: |
| • Ability to manipulate, navigate, and review record model<br>• Ability to assess current space and assets and manage appropriately for future needs<br>• Knowledge of facility management applications<br>• Ability to effectively integrate the record model with the Facility Management's application and appropriate software associated with the client's needs |

| **Building (Preventative) Maintenance Scheduling** |
| --- |
| Description: |
| A process in which the functionality of the building structure (walls, floors, roof, etc) and equipment serving the building (mechanical, electrical, plumbing, etc) are maintained over the operational life of a facility. A successful maintenance programme will improve building performance, reduce repairs and reduce overall maintenance costs. |
| Potential Value: |
| • Plan maintenance activities proactively and appropriately allocate maintenance staff<br>• Track maintenance history<br>• Reduce corrective maintenance and emergency maintenance repairs<br>• Increase productivity of maintenance staff because the physical location of equipment/system is clearly understood<br>• Evaluate different maintenance approaches based on cost<br>• Maintenance approaches based on cost<br>• Allow facility managers to justify the need and cost of establishing a reliability centred maintenance programme |
| Resources Required |
| • Design review software to view record model and components<br>• Building Management System (BMS) linked to record model<br>• Computerised Maintenance Management System (CMMS) linked to record model |
| Team Competencies Required: |
| • Ability to understand and manipulate CMMS and building control systems with record model<br>• Ability to understand typical equipment operation and maintenance practices<br>• Ability to manipulate, navigate and review a 3D model |

| **Building Systems Analysis** |
|---|
| Description: |
| A process that measures how a building's performance compares to the specified design. This includes how the mechanical system operates and how much energy a building uses. Other aspects of this analysis include, but are not limited to, ventilated facade studies, lighting analysis, internal and external CFD airflow, and solar analysis. |
| Potential Value: |
| ● Ensure building is operating to specified design and sustainable standards<br>● Identify opportunities to modify system operations to improve performance<br>● Create "what if" scenarios and change different materials throughout the building to show better or worse performance conditions |
| Resources Required |
| ● Building systems analysis software (energy, lighting, mechanical, other) |
| Team Competencies Required: |
| ● Ability to understand and manipulate CMMS and building control systems with record model<br>● Ability to understand typical equipment operation and maintenance practices<br>● Ability to manipulate, navigate and review a 3D model |

| **Sustainability** |
|---|
| Description: |
| A process in which a BIM project is evaluated based on NZGBC Green Star, NABERS NZ or other sustainable criteria. BIM enables more sustainable practices to be adopted at all stages of a facility's life including planning, design, construction, and operation.<br>The use of BIM technologies facilitates more sustainable design techniques through the capture and incorporation of key data into the decision-making process, thereby enabling the sustainability profiles of different building/system designs to be compared. It also enables complex energy and material usage analysis, facilitates more efficient coordination of supply chains and reduces the need for rework and subsequent wastage.<br>Applying sustainable features to a project in the planning and early design phases is more effective (ability to impact design) and efficient (cost and schedule of decisions). This comprehensive process creates an integrated building design philosophy that aims to include all team players from the very beginning of the project, thus providing valuable insights. This integration may require contractual integration in the planning phase. In addition to achieving sustainable goals, seeking NZGBC certification requires submission of certain calculations, documentation, and verification. Energy simulation, calculations, and documentation can be performed within an integrative environment when responsibilities are well defined and clearly shared. |
| Potential Value: |
| • Facilitates interaction, collaboration and coordination of team members early in the project process which is considered to be favourable to sustainable projects<br>• Enables early and reliable evaluation of design alternatives<br>• Availability of critical information early helps efficient problem resolution in terms of cost premium and schedule conflicts<br>• Shortens the actual design process by the help of early facilitated design decisions. Shorter design process is cost effective and provides more time for other projects.<br>• Leads to delivery better project quality<br>• Reduces documentation load after design and accelerates certification because concurrently prepared calculations can be used for verification<br>• Reduces operational costs of the facility due to the energy performance of the project. It optimises building performance via improved energy management<br>• Increases the emphasis on environmentally friendly and sustainable design<br>• Assists project team with potential future revisions throughout the life cycle |
| Resources Required |
| • Design authoring software |

| Team Competencies Required: |
|---|
| • Ability to create and review a 3D model<br>• Knowledge of up-to-date NZGBC Green Star/NABERS NZ credit information<br>• Ability to organise and manage the database |

| **Code Validation** |
| --- |
| Description: |
| A process in which code validation software is used to check the model parameters against project specific codes. Code validation is currently in its infant stage of development and is not in widespread use. Code validation should become more prevalent within the design industry in the future. |
| Potential Value: |
| • Validate that building design is in compliance with specific codes<br>• Code validation done early in design reduces the chance of code design errors, omissions or oversights that would be time consuming and more expensive to correct later in design or construction<br>• Code validation done automatically while design progresses gives continuous feedback on code compliance<br>• Reduced turnaround time for 3D BIM review by local code officials or reduced time that needs to be spent meeting with council inspectors, visiting the site, etc., or fixing code violations during defect or close-out phase<br>• Saves time on multiple checking for code compliance and allows for a more efficient design process since mistakes cost time and money |
| Resources Required |
| • Local (or central) authority with resources (people and systems) to accept, review and manage the approval of consent applications<br>• Local code knowledge<br>• Model checking software<br>• 3D model manipulation |
| Team Competencies Required: |
| • Ability to use BIM authoring tool for design and model checking tool for design review<br>• Ability to use code validation software and previous knowledge and experience with checking codes |

| **Disaster Planning** |
|---|
| Description: |
| A process in which emergency responders would have access to critical building information in the form of a model and information system. The BIM would provide critical building information to the responders that would improve the efficiency of the response and minimise the safety risks. The dynamic building information would be provided by a building management system (BMS), while the static building information, such as floor plans and equipment schematics, would reside in a BIM. These two systems would be integrated via a wireless connection and emergency responders would be linked to an overall system. The BIM coupled with the BMS would be able to clearly display where the emergency was located within the building, possible routes to the area, and any other harmful locations within the building. |
| Potential Value: |
| • Provide police, fire, public safety officials, and other emergency services with access to critical building information in real-time<br>• Improve the effectiveness of emergency response<br>• Minimise risks to responders |
| Resources Required |
| • Design review software to view record model and components<br>• Building Automation System (BAS) linked to record model<br>• Computerised Maintenance Management System (CMMS) linked to record model |
| Team Competencies Required: |
| • Ability to manipulate, navigate, and review BIM for facility updates<br>• Ability to understand dynamic building information through BMS<br>• Ability to make appropriate decisions during an emergency |

# Appendix D

# Glossary

**4D BIM** A 3D model linked to time or scheduling data. Model objects and elements with this data attached can be used for construction scheduling analysis and management. It can also be used to create animations of project construction processes.

**5D BIM** Usually a 4D BIM linked to cost data. The time data adds another dimension to cost data, allowing expenditure to be mapped against the project programme for cash flow analysis, etc.

**AE, AEC, AECFM** Abbreviations for Architect/Engineer, Architect/Engineer/Contractor, Architect/Engineer/Contractor/Facility Manager.

**Architectural Programming Software (APS)** A software application (based on a database) used to analyse and manage data about the spatial requirements of a building (room function type, required proximities to other functions, building service requirements, floor area, etc.). It is also used to generate a spatial Programme for Design, or brief, for a project and to assess design proposals against the brief.

**Binding** See **Legal Status of the Design Model to Construction**

**BIM Coordination Room** A purpose-designed room set up to facilitate the coordination of digital models by members of the BIM team. It includes IT infrastructure such as cabling, projectors and/or Smart Boards that allow the room's occupants to view models together for coordination, collaborative design, etc.

**BIM Management Plan (BMP)** A formal document that defines how the project will be executed, monitored and controlled with regard to BIM. A BMP is developed at project initiation to provide a master information/data management plan and assignment of roles and responsibilities for model creation and data integration throughout the project. BMP is used in preference to a BIM Execution Plan in the Handbook because it conveys a broader scope.

**Building Information Management (Data Definition)** Building Information Management supports the data standards and data requirements for BIM use. Data continuity allows for the reliable exchange of information in a context where both sender and receiver understand the information.[1]

**Building Information Model (BIM) (Product)** An object-based digital representation of the physical and functional characteristics of a facility. The Building Information Model serves as a shared

[1] Semantic interoperability

knowledge resource for information about a facility, forming a reliable basis for decisions during its lifecycle from inception onward.[2]

**Building Information Modelling (BIM) (Process)** A collection of defined model uses, workflows and modelling methods used to achieve specific, repeatable, and reliable information results from the model. Modelling methods affect the quality of the information generated from the model. When and why a model is used and shared impact on the effective and efficient use of BIM for desired project outcomes and decision support.

**Building Management System (BMS)** A network of integrated computer components that is used to monitor and control a wide range of building operations such as HVAC, security/access control, lighting, energy management, maintenance management and fire safety control.

**Bulletin** A brief update, report or advisory note on an issue circulated to members of the project team.

**CAD** Computer Aided Design. A geometric/symbol based computer drawing system that replicates hand drawing techniques.

**Casework** Cabinetry, joinery items.

**Computer Aided Facility Management (CAFM)** An IT system that supports Facility Management administration. CAFM systems focus on space management issues including the allocation, amount and location of spaces. They also include owner, employee and cost information. A Computerised Maintenance Management System (CMMS) focuses on facility maintenance and is often part of CAFM. CMMS can manage asset information, maintenance history, equipment documentation, fleet maintenance and staff and subcontractor activities. CAFM and CMMS are often used interchangeably and, for most practical purposes, there is little difference between the two systems. See also Integrated Workplace Management System (IWMS).

**Computerised Management Maintenance System (CMMS)** See above.

**CBI** The Co-ordinated Building Information system of New Zealand. Used in this document to describe the work section classification system used to organise specifications in New Zealand. Can also be used for structuring information libraries, for CAD layering, classification of generic and branded product information, and for classification of BIM objects.

**CFD** Computational Fluid Dynamics. A branch of fluid mechanics that uses computer programmes to simulate the behaviour of fluids and gases when interacting with surfaces. In an architectural context CFD is used to analyse airflows around buildings, ventilation patterns, stack effects in multi-storey buildings, fire/smoke behaviour, etc.

[2] National BIM Standards BIM product definition

**Conceptual Design** The phase of the design process in which the overall scope and nature of the project is determined in response to the site, planning considerations and the client's brief, budget and programme.

**Construction BIM Management Plan** A BIM Management Plan for the construction phase of a project.

**Construction Operations Building Information Exchange (COBie)** A system for capturing information during the design and construction of projects that can be used for Facility Management purposes including operation and maintenance. A key element of the system is a preformatted Excel spreadsheet used for recording this information. COBie eliminates the current process of transferring massive amounts of paper documents to facility operators after construction has been completed. COBie eliminates the need for as-built data capture after building handover and helps to reduce operational costs.

**Deliverables** The product of engineering and design efforts to be delivered to the client as digital files and/or printed documents. Typically, these would be the concept submittal and the corrected final design. A deliverable may have multiple phases.

**Design and Construct (D&C)** The project procurement method in which the client enters into one contract for the design and construction of a building or project with an organisation, generally based on a building company which provides all project management, design, construction and project delivery services.

**Design-Bid-Build (DBB)** The project procurement method in which the client enters into separate contracts for the design and construction of a building or project. Design and documentation services are generally provided by a professional design consultancy, the documents are used for bidding (tendering) purposes and the successful bidder, generally a building company, enters into a contract with the client to build the project. Often referred to as the 'traditional' method of procurement.

**Design BIM Management Plan** A BIM Management Plan for the design phases of a project.

**Design Development** The phase of the design process in which the general relationships represented in the schematic design phase are resolved in more detail. During this phase the dimensions of all major elements are defined and forms of construction finalised.

**DOE** US Department of Energy.

**Facility Management (FM)** The process of managing and maintaining the efficient operation of facilities including buildings, properties and infrastructure. The term is also applied to the discipline concerned with this process.

**Facility Manager** A person responsible for the facility management of buildings, properties or infrastructure.

**FF&E** Furniture, fixtures and equipment.

**Geographic Information System (GIS)** A system that integrates hardware, software, and data for capturing, managing, analysing and displaying all forms of geographically referenced information.

**gbXML** Green Building Extensible Markup Language (XML). A digital file format for exchanging sustainability information in simulation applications.

**Globally Unique Identifier (GUID)** A unique code identifying each object/space. A GUID should not be confused with "code" in "room code," "equipment code" or "space code." The GUID assigned by the BIM authoring tool persists through room name changes and various other modifications, allowing the object/space to be tracked throughout the project execution process.

**HVAC** Heating, ventilation and air conditioning.

**Industry Foundation Class (IFC)** A system of defining and representing standard architectural and construction-related graphic and non-graphic data as 3D virtual objects[3] to allow data exchange among BIM tools, cost estimation systems, and other construction-related applications in a way that preserves the ability to perform analysis on those objects as they move from one BIM system to another. IFC files saved or exported from BIM-authoring software can be used for the following tasks:[4]

- coordination of BIM models and related design disciplines
- clash detection
- rules-based checking
- Building Code compliance
- sharing models between different BIM-authoring software
- COBie data derived from BIM models
- energy testing data derived from BIM models
- systems simulation.

**Informational** See **Legal Status of the Design Model to Construction**

**Integrated Project Delivery (IPD)** The project procurement method in which the client enters into a contract with a number of organisations including design consultants and building contractors at the earliest stages of the project to create an integrated team. It is characterised by an expectation that the team will work collaboratively to deliver a product that meets the client's requirements.

**Integrated Workplace Management System (IWMS)** An enterprise-class software platform that integrates five key components of functionality, operated from a single technology platform and database repository: real estate management, project management, facilities and space management, maintenance management, and environmental sustainability.

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[3] IFC also sometimes refers to its non-proprietary file extension, "IFC."

[4] As of May 2009, IFC2x4 has its feature set frozen and is concluding the beta-1 test phase.

**Interoperability** The Institute of Electrical and Electronics Engineers defines interoperability[5] as “the ability of two or more systems or components to exchange information and to use the information that has been exchanged”. James A. O'Brien and George M. Marakas, authors of *Management Information Systems*, further define interoperability as “being able to accomplish end-user applications using different types of computer systems, operating systems, and application software, interconnected by different types of local and wide area networks”. Semantic interoperability refers to the ability to interpret the information exchanged automatically to produce results that are deemed useful by the end users of both systems.

**Life Cycle Analysis (LCA)**. The whole-of-life impact of various initiatives on the environment. In an architectural context LCA is concerned with the impact of the construction and operation of buildings on the environment. This includes assessing the sustainability of building materials (embodied energy, potential for recycling or reuse, etc.).

**Lead BIM Coordinator** A person who performs an intermediary role between the BIM Manager and the modelling team. He/she implements the BIM Manager’s modelling standards and protocols and deals with the day-to-day coordination of team members to achieve project goals.

**Legal Status of the Design Model to Construction:**

- Binding: Imposing a legal (contractual) obligation between the author/s and recipient/s. Used in this context to mean a design model that represents what has to be constructed under the terms of the contract.
- Informational: A design model that conveys non-binding information relevant to the project that may be useful to its recipient/s. No formal claims are made about its accuracy and it is provided on an ‘as is’ basis.
- Reference: A design model that is intended to be used for ‘read-only’ purposes such as recording model development at different stages of the project or clash detection. Once design models are designated ‘Reference’, they shall not be edited further. Reference design models can be used as the basis for bid preparation but cannot form part of the contract documents. A model has to be designated “Binding” for this purpose. Reference models shall be sufficiently accurate for their intended purpose.
- Reuse: A design model authorised by its authors for modification or further development by its recipients.

**Level of Development (LOD)**

The American Institute of Architects *Document E202 – 2008 Building Information Modelling protocol Exhibit* defines Level of Development as follows: “The Level(s) of Development (LOD) describes the

[5] Institute of Electrical and Electronics Engineers. IEEE Standard Computer Dictionary: A Compilation of IEEE Standard Computer Glossaries. New York, NY: 1990.

level of completeness to which a model element is developed". It describes the steps through which a BIM element can logically progress from the lowest level of conceptual approximation to the highest level of representational precision The document defines five LODs as described below. Each subsequent level builds on the previous level and includes all the characteristics of the previous levels.

The levels defined (with associated content requirements) are:

- **LOD 100 Conceptual**: Overall building massing indicative of area, height, volume, location and orientation may be modelled in three dimensions or represented by other data.
- **LOD 200 Approximate Geometry**: Model elements are modelled as generalised systems or assemblies with approximate quantities, size, shape, location and orientation. Non-geometric information may also be attached to model elements.
- **LOD 300 Precise Geometry**: Model elements are modelled as specific assemblies accurate in terms of quantity, size, shape, location and orientation. Non-geometric information may also be attached to model elements.
- **LOD 400 Fabrication**: Model elements are modelled as specific assemblies accurate in terms of quantity, size, shape, location and orientation with complete fabrication, assembly and detailing information. Non-geometric information may also be attached to model elements.
- **LOD 500 As-built**: Model elements are modelled as constructed assemblies actual and accurate in terms of quantity, size, shape, location and orientation. Non-geometric information may also be attached to model elements.

Level of Development, by definition, applies to individual model elements. Do not use LOD to describe the BIM model as a whole – use descriptions based on project phase, e.g., schematic design model. A collaboration matrix or Model Progression Specification, as described in AIA *Document E202*, provides a means of specifying the various LODs required for Model Elements at each phase of the project.

**Mechanical Electrical Plumbing (MEP)** Referring to this group of building services or the engineering disciplines associated with them.

**Mechanical Electrical Plumbing Fire (MEPF)** Referring to these building services or the engineering disciplines associated with them.

**Model Geographic Location (MGL)** The situation of the model on the earth in terms of its latitude and longitude.

**Model View Definition (MVD)** An IFC View Definition, or Model View Definition, defines a subset of the IFC schema that is needed to satisfy one or many exchange requirements of the AEC industry. A MVD defines a subset of the IFC Schema providing implementation guidance for all IFC concepts (classes, attributes, relationships, property sets, quantity definitions, etc.) used within this subset. It thereby represents the software requirement specification for the implementation of an IFC interface to satisfy the exchange requirements.

**OmniClass** The OmniClass Construction Classification System is a classification system for the construction industry, developed by the Construction Standards Institute (CSI) and is used as a classification structure for electronic databases. As the basis of its tables, OmniClass incorporates other existing systems currently in use, including *MasterFormat™* for work results, *UniFormat* for elements, and EPIC (Electronic Product Information Cooperation) for structuring products.

**Programme for Design (PFD)** A formal quantitative schedule of spaces and fixtures, furniture and equipment that informs the design process. A detailed development of the design brief derived from analysis of the client's brief, design guidelines and design assessment criteria. It can be manually compiled or generated with the assistance of purpose designed Architectural Programming Software.

**Progress BIMs** BIM models other than those specified in **Final BIM Deliverables** to be provided at specified milestones in the project programme to demonstrate or record progress. They can be used as a design tool by the design or construction teams only or form part of the deliverables for the client. If Progress BIMs are required, they shall be specified in the BIM Management Plan (BMP) and the following details for each included:

- programme milestone
- Level of Development
- features to be modelled
- recipient, e.g., design team only, client.

The same delivery requirements for 3D geometric deliverables specified in **Final BIM Deliverables** apply to Progress BIMs unless otherwise noted in the BMP.

**Reference** See **Legal Status of the Design Model to Construction**

**Request for Information (RFI)** A documented request for information on a matter from one party to another. They are usually managed through formal procedures agreed by members of the project team.

**Reuse** See **Legal Status of the Design Model to Construction**

**Schematic Design** The phase of the design process in which the general arrangement of the project, including indicative room sizes and layout, overall form of the building/s and its/their relationship to the site, is determined.

**SPD** Supply, processing and distribution of materials.

**Submission Instructions** Written instructions outlining the submissions to be made throughout a project, including their format, timing and who is to submit them. They can be part of the project brief.

**Superintendent's Instruction (SI)** A written instruction, or a written confirmation of a verbal instruction, from the Superintendent nominated in the contract to the contractor. Generally confined to items that represent a variation to the contract. Also referred to as Architect's Instructions, depending on the term used in the contract.

**Uniformat** A classification system for building elements (including designed elements) that forms the basis of Table 21 of the Omniclass system. A product of the Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC).

**Variation Order (VO)** A written authorisation issued by the Superintendent or client's agent to the contractor to proceed with work which will result in a variation to the contract sum. Generally issued after the receipt of a quotation for the variation.

**Wayfinding** All of the methods which people use to orient themselves in physical space and navigate from place to place, i.e., find their way.

# Appendix E

# BIM roles

| Roles: | Lead Consultant | Design BIM Manager | Design BIM Coordinator(s) | Construction BIM Manager | Subcontract BIM Coordinator(s) | Facility BIM Manager |
|---|---|---|---|---|---|---|
| **Tasks:** | | | | | | |
| **Project Inception** | | | | | | |
| Procurement strategy for the project, including:<br>• Design and construction stages and contractual structure<br>• BIM contractual structure | X | | | | | |
| BIM Strategy – define BIM level and uses for Project, BIM roles to be procured, and align with the project procurement strategy. | X,s | | | | | |
| Designing BIM Manager procurement | X | | | | | |
| Updating Project BIM Brief, including:<br>• purpose and uses of BIM for project – refine as needed<br>• level and extent of BIM including 4D (time), 5D (cost) and 6D (FM)<br>• BIM strategy aligned with procurement strategy<br>• long-term responsibilities, including ownership of model<br>• BIM inputs and outputs and scope of post-occupancy evaluation<br>• identifying scope of any required BIM surveys and investigation reports | c | X,s | | | | |
| Obtaining stakeholder signoff on Project BIM Brief | c | X | | | | |
| Commissioning any required BIM surveys and investigation reports | c | x | | | | |
| **Project Definition** | | | | | | |

| Roles: | Lead Consultant | Design BIM Manager | Design BIM Coordinator(s) | Construction BIM Manager | Subcontract BIM Coordinator(s) | Facility BIM Manager |
|---|---|---|---|---|---|---|
| **Tasks:** | | | | | | |
| Assisting with the selection of design consultants (prepare tender and contract content, and assess candidates BIM capability against the Project BIM Brief) | c | X | | r | | |
| Developing outline of BIM Management Plan, including:<br>• more detailed definition of all aspects of the Project BIM Brief<br>• BIM uses at different stages of the project<br>• the applications of BIM to be adopted at different stages of the project<br>• Levels of Development (LOD) to be adopted at each delivery stage of the project and the inclusions<br>• data management strategies, structure, and software<br>• model management strategies and software<br>• collaboration processes | c | X,s,d | c | r | | |
| Obtaining stakeholder signoff on outline BIM Management Plan | c | X | | | | |

| Roles: | Lead Consultant | Design BIM Manager | Design BIM Coordinator(s) | Construction BIM Manager | Subcontract BIM Coordinator(s) | Facility BIM Manager |
|---|---|---|---|---|---|---|
| **Tasks:** | | | | | | |
| **BIM Management Plan, general items:**<br>• definitions<br>• project location data, levels and grids<br>• site segmentation<br>• stakeholder & federated models structure<br>• model authorised uses<br>• project filing structure<br>• document, model, and drawing file naming protocols<br>• naming protocols for space, room, equipment, system, material, assets<br>• element classification system<br>• object information parameters<br>• visualisation requirements<br>• construction sequencing requirements (4D)<br>• cost estimation modelling requirements (5D)<br>• units of measurement & dimensional accuracy<br>• O&M manual requirements | c | X,s,d | c | r | | |
| **BIM Management Plan, model package items:**<br>• project template<br>• design status<br>• applying equipment naming conventions<br>• BIM objects<br>• viewing naming protocol | c | X,s,d | c | r | | |
| **BIM Management Plan, federated model items:**<br>• coordination resolution protocol<br>• clash detection reporting<br>• clash detection batches | c | X,s,d | c | r | | |
| **Developing, coordinating, publishing the Design BMP and verifying that all necessary configurations required for the seamless integration of design and construction model information have been implemented** | | X | | r | r | r |
| **Design – all stages** | | | | | | |

| Roles: | Lead Consultant | Design BIM Manager | Design BIM Coordinator(s) | Construction BIM Manager | Subcontract BIM Coordinator(s) | Facility BIM Manager |
|---|---|---|---|---|---|---|
| **Tasks:** | | | | | | |
| Ensuring development and compliance with the approved Design BMP | c | X,s,d | c | r | r | r |
| **Concept Design** | | | | | | |
| Aligning the requirements and deliverables of different design team members | c | X,s,d | c | | | |
| Coordinating team file management including necessary shared file server or Cloud service | c | X,s,d | c | r | | |
| Ensuring that BIM is used appropriately to test design requirements/criteria for functionality | c | X,s,d | c | r | | |
| Liaising with Design Team BIM and IT Managers to ensure software is installed and operating properly | c | X,s,d | c | r | | |
| Facilitating BIM technical meetings with Discipline Lead BIM Coordinators | c | X,s,d | c | r | | |
| Determining the project BIM geo-reference point(s), and ensuring ALL technical discipline models are properly referenced to the point(s) | c | X,d | c | r | | |
| Liaising with the client's Facilities Management department to determine specific data and file exchange requirements | | X,s | | | | r |
| Coordinating technical discipline BIM development, standards, data requirements, etc. as required with the Design Team BIM Manager | | c | X | r | | r |
| **Preliminary Design** | | | | | | |
| Aligns the requirements and deliverables of different Design Team members | c | X,s,d | c | r | | |
| Coordinating team file management including necessary shared file server or Cloud service | c | X,s,d | c | r | | |
| Assembling and facilitating use of composite federated design models in design coordination/clash detection meetings and providing detection reports based on the identification and resolution of all hard and soft collisions | c | X,s,d | c | r | | |

| Roles: | Lead Consultant | Design BIM Manager | Design BIM Coordinator(s) | Construction BIM Manager | Subcontract BIM Coordinator(s) | Facility BIM Manager |
|---|---|---|---|---|---|---|
| **Tasks:** | | | | | | |
| **Ensuring that BIM is used appropriately to test design requirements/criteria for functionality** | c | R | X | | | |
| **Correctly classifying all spaces and equipment in the model to ensure direct comparison with the Programme for Design (PFD) and downstream use for facility management as required** | c | R | X | r | | |
| **Apply correctly:**<br>• **naming protocols for space, room, equipment, system, material, assets**<br>• **Element classification system**<br>• **Object information parameters** | c | R | X | r | | |
| **Liaising with Design Team BIM and IT Managers to ensure software is installed and operating properly** | c | X,s,d | c | | | |
| **Facilitating BIM technical meetings with Design BIM Coordinators** | c | X,s,d | c | | | |
| **Ensuring ALL technical discipline models are properly referenced to the project BIM geo-reference point(s)** | | R | X | r | | |
| **Liaising with the client's Facilities Management department to determine specific data and file exchange requirements** | | X,s | | | | r |
| **Coordinating technical discipline BIM development, standards, data requirements, etc. as required with the Design BIM Manager** | | c | X | | | |
| **Leading the technical discipline BIM team in its documentation and analysis efforts** | | r | X | | | |
| **Coordinating clash detection and resolution activities** | | r | X | | | |
| **Ensuring coordination within their disciplines and inputting into project coordination/clash detection** | | r | X | | | |

| Roles: | Lead Consultant | Design BIM Manager | Design BIM Coordinator(s) | Construction BIM Manager | Subcontract BIM Coordinator(s) | Facility BIM Manager |
|---|---|---|---|---|---|---|
| **Tasks:** | | | | | | |
| Ensuring proper BIM derived 2D information for paper printing is provided as required | | r | X | | | |
| Extraction of BIM content for visualisation specialists | | x | x | | | |
| Developed Design | | | | | | |
| Assembling and facilitating use of composite federated design models in design coordination/clash detection meetings and providing detection reports based on the identification and resolution of all hard and soft collisions | c | X,s,d | c | r | | |
| Ensuring that BIM is used appropriately to test design requirements/criteria for functionality | c | R | X | | | |
| Correctly classifying all spaces and equipment in the model to ensure direct comparison with the Programme for Design (PFD) and downstream use for facility management as required | c | R | X | r | | |
| Apply correctly:<br>• naming protocols for space, room, equipment, system, material, assets<br>• Element classification system<br>• Object information parameters | c | R | X | r | | |
| Facilitating BIM technical meetings with Design BIM Coordinators | c | X,s,d | c | | | |
| Ensuring ALL technical discipline models are properly referenced to the project BIM geo-reference point(s) | | r | X | | | |
| Ensuring that the design deliverables specified in the contract are provided in conformance with the formats specified | | r | X | | | |
| Leading the technical discipline BIM team in its documentation and analysis efforts | | | X | | | |

| Roles: | Lead Consultant | Design BIM Manager | Design BIM Coordinator(s) | Construction BIM Manager | Subcontract BIM Coordinator(s) | Facility BIM Manager |
|---|---|---|---|---|---|---|
| **Tasks:** | | | | | | |
| Coordinating clash detection and resolution activities | | r | X | | | |
| Ensuring coordination within their disciplines and inputting into project coordination/clash detection | | r | X | | | |
| Ensuring proper BIM derived 2D information for paper printing is provided as required | | r | X | | | |
| Extraction of BIM content for visualisation specialists | | x | x | | | |
| Detailed Design | | | | | | |
| Assembling and facilitating use of composite federated design models in design coordination/clash detection meetings and providing detection reports based on the identification and resolution of all hard and soft collisions | c | X,s,d | c | | | |
| Facilitating BIM technical meetings with Discipline Lead BIM Coordinators | c | X,s,d | c | | | |
| Ensuring that the design deliverables specified in the contract are provided in conformance with the formats specified | c | X,d | c | | | |
| Leading the technical discipline BIM team in its documentation and analysis efforts | | | X | | | |
| Coordinating clash detection and resolution activities | | r | X | | | |
| Ensuring coordination within their disciplines and inputting into project coordination/clash detection | | r | X | | | |
| Ensuring proper BIM derived 2D information for paper printing is provided as required | | r | X | | | |
| Integrating expected performance specified work elements into BIM model data | | | X | r | | |
| Extracting BIM content for visualisation specialists | | x | x | | | |
| Revising, if required, Design BIM Management Plan and Project BIM Brief for issue to tenderers | r | X | | r | | r |

| Roles: | Lead Consultant | Design BIM Manager | Design BIM Coordinator(s) | Construction BIM Manager | Subcontract BIM Coordinator(s) | Facility BIM Manager |
|---|---|---|---|---|---|---|
| **Tasks:** | | | | | | |
| Embedding specification to model | | r | x | | | |
| Finalising review and sign off of model | r | r | X | r | | r |
| **Tender** | | | | | | |
| Reviewing construction sequencing (4D) with contractor / subcontractors | | x | | x | | |
| Enabling access to BIM model to contractor(s). | | X | x | | | |
| Integrating offered performance specified work elements into BIM model data | | | x | r | | |
| **CONSTRUCTION – all stages** | | | | | | |
| Ensuring development and compliance with the approved construction BMP | | r | | X | | |
| Taking overall responsibility for the Construction BIM model creation and information developed during construction | | | | X | | |
| Extracting BIM content for visualisation specialists | | | | x | x | |
| **Construction Implementation** | | | | | | |
| Developing construction BIM Management Plan, based on Design BIM Management Plan and Project BIM Brief | r | r | | X | | r |
| Obtaining stakeholder signoff on construction BIM Management Plan | r | R | | X | | r |
| Ensuring information for Facility Management (e.g. COBie), as required by the BIM Project Brief, is provided for the contractor at nominated submittal milestones | | X,d | c | r | r | r |
| Establishing software protocols for the construction team for efficient delivery of project | | r | | X | c | r |
| Coordinating technical discipline BIM development, standards, data requirements, etc. as required with the construction team BIM Manager | | r | | c | X | r |
| Acting as the main point of contact for BIM and related issues between the construction team, subcontractors, the client, the design team and others as required | | | | X | c | |

| Roles: | Lead Consultant | Design BIM Manager | Design BIM Coordinator(s) | Construction BIM Manager | Subcontract BIM Coordinator(s) | Facility BIM Manager |
|---|---|---|---|---|---|---|
| **Tasks:** | | | | | | |
| **Where a contractor's BIM Coordination Room is required by the Project BIM Brief, providing specifications for it to the client for approval. Ensuring that the construction team has necessary hardware and BIM software properly installed and accessible for project use** | r | r | r | X | c | r |
| **Leading the trade BIM team in its documentation and analysis efforts** | | r | r | R | X | r |
| **Where 4D BIM is required, ensuring construction sequencing and scheduling activities are integrated with the Construction BIM** | | r | | X | c | r |
| **Where 5D BIM is required, ensuring construction cost requirements are integrated with the Construction BIM** | | r | | X | c | r |
| **Where 6D BIM is required, ensuring FM data are integrated with the Construction BIM** | | r | | X | c | r |
| **Facilitating use of composite trade models in construction coordination/clash detection meetings and providing detection reports based on the identification and resolution of all hard and soft collisions** | | r | | X | c | r |
| **Coordinating clash detection and resolution activities** | | r | r | R | X | |
| **Coordinating trade items into the Construction BIM** | | r | r | R | X | r |
| **Communicating with the design team, coordinating the data extraction sets required by the construction trades and ensuring that these requests are met** | c | r | c | X,d | c | |

| Roles: | Lead Consultant | Design BIM Manager | Design BIM Coordinator(s) | Construction BIM Manager | Subcontract BIM Coordinator(s) | Facility BIM Manager |
|---|---|---|---|---|---|---|
| **Tasks:** | | | | | | |
| **Coordinating with the design team to facilitate the documentation of design changes in the field and updating of the BIM in a timely manner** | c | r | c | X,d | c | |
| **Prior to approval and installation, working with subcontract BIM coordinators to integrate 3D fabrication models with the updated design model to ensure compliance with design intent** | | r | | X | c | |
| Commissioning | | | | | | |
| **Coordinating with design team and commissioning Agent to assure Facility Management (e.g., COBie) information, where required, is complete** | c | r | c | X,d | c | R |
| **Trialling integration of the BIM into FM systems** | | c | | c | | X |
| **Coordinating and releasing 'end of construction' BIM record model data** | | | | X | | |
| Completion and use – all stages | | | | | | |
| As-Built Models and Data | | | | | | |
| **Coordinating with the contractor to assure the creation of proper BIM final deliverables** | | R | R | C | c | R |
| **Coordinating update of as-built conditions in the Final Model deliverable** | | | | X | | |
| **Integration of the BIM into FM systems** | | c | c | c | c | X |
| Defects Liability | | | | | | |
| **Maintenance of BIM while the project is in use** | | | | x | | x |
| **Ongoing integration of the BIM into FM systems during DLP** | | | | x | | x |
| Facility Management | | | | | | |
| **Ongoing maintenance of BIM while the project is in use, as asset changes are made** | | | | | | X |

| Roles: | Lead Consultant | Design BIM Manager | Design BIM Coordinator(s) | Construction BIM Manager | Subcontract BIM Coordinator(s) | Facility BIM Manager |
|---|---|---|---|---|---|---|
| **Tasks:** | | | | | | |
| **Ongoing integration of the BIM into FM systems** | | | | | | X |
| **Extracting BIM content for visualisation specialists** | | | | | | x |

**Key to Notations:**

X – Role responsible for a task.

x – Role responsible for an optional task.

R – Role responsible for a review task of work by other parties.

r – Role responsible for an optional review task of work by other parties.

c – Role to be consulted as stakeholder input to the task (when appointed or known).

s – Completion of the task requires specific and detailed consultation with client / owner team stakeholders not shown in this table, including as applicable to the project structure:

- client
- Facility Manager
- major user groups.

d – Completion of the task requires specific and detailed consultation with project team stakeholders not shown in this table, including as applicable to the procurement approach:

- project manager
- design consultants
- cost manager
- construction manager or contractor
- trade subcontractors.

*Notes:*

1. *Where the procurement strategy includes early contractor appointment (D&C, IPD), the task responsibilities between Design BIM Manager and Construction BIM Manager should be amended to suit.*

2. *The task allocations during construction between various parties assume a particular contractual arrangement. These should be amended to suit the actual contractual arrangement.*

# Appendix F

# Reference Documents and Links

- **Reference Documents**

***a. The following standards and documents are cited in the BIM Handbook***

Refer to the *New Zealand BIM Schedule* for additional standards.

ANSI/ASHRAE 140-2007 *Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programmes*

ASTM E2807 2011 *Standard Specification for 3D Imaging Data Exchange, Version 1.0*

*Book of Areas* Australian Institute of Quantity Surveyors (AIQS)

*Construction Operations Building Information Exchange (COBie)* National Institute of Building Sciences

*Document E202 – 2008 Building Information Modelling Protocol Exhibit* American Institute of Architects

*MasterFormat™* Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC)

New Zealand BIM Schedule

*OmniClass* Secretariat for the Omniclass Development Committee

*Uniformat* Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC)

*VA BIM Guide* United States Department of Veteran Affairs 2010

- **BIM information resources**

**b. Video (animated) introductions to BIM**

www.youtube.com/watch?v=5Qj9pI5us7o&feature=email 3:28 minutes.

www.youtube.com/watch?v=FPaja7mLiTE&list=PLlg8ai1ZGTovuwDDAr_85aFD7UbR2AI1d 6:12 minutes.

**c. Documents**

shop.bsigroup.com/Browse-by-Sector/Building--Construction/Building-Information-Modelling/

Download a 20 page overview of BIM by the British Standards Institution from this page.

bim.architecture.com.au/groups/index.html

Download documents on a number of BIM topics from this page of the Australian Institute of Architects/Consult Australia BIM/IPD website. The 33 page *BIM Outreach* document explains BIM to different industry stakeholders including clients, architects and consultants, contractors, Facility Managers and manufacturers.

**d. Websites**

www.wbdg.org/bim/bim.php

This page of the Whole Building Design Guide gives a brief overview of BIM. Much more detailed information can be found by following the links on the page. Many of the links relate to US activities in this area, so not everything will be applicable in New Zealand.

www.buildingvalue.co.nz/publications

This page on the Building and Construction Productivity Partnership gives quick access to key New Zealand BIM publications including the Handbook, the New Zealand BIM Schedule and a brochure outlining the economic benefits of BIM, Productivity Benefits of BIM.

www.natspec.com.au

Click on the BIM logo in the top right hand corner of this page for access to the NATSPEC BIM Portal which contains numerous resources for those interested in implementing BIM.

buildingsmart.com/

buildingSMART International is the preeminent not-for-profit organisation promoting open (non-proprietary) standards for data exchange and the use of BIM internationally. Some of the content of this site will be a bit esoteric for those new to BIM but pages like 'About us' and 'Resources' contain more basic information.

buildingsmart.org.au/

This website of the Australasian chapter of buildingSMART details local activities regarding BIM.

**e. Books**

www.amazon.com/BIM-Handbook-Information-Designers-Contractors/dp/0470541377/ref=sr_1_1?s=books&ie=UTF8&qid=1315186631&sr=1-1

*BIM Handbook: A Guide to Building Information Modelling for Owners, Managers, Designers, Engineers and Contractor* by C. Eastman, P. Teicholz, R. Sacks, K. Liston.

This book provides a comprehensive coverage of BIM in single document.