Singapore BIM Guide

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Singapore BIM Guide

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Disclaimer

The Singapore BIM Guide is a general reference guide and users should consider the suitability of recommendations in the Singapore BIM Guide carefully before embarking upon any integration into their current working practices.

Comments and Updates

It is expected that this Guide will undergo a relatively rapid evolution process, as the industry adapts to the implications and advantages of BIM methodology. We welcome comments, proposed changes and additions to the Singapore BIM Guide, and encourage readers to share your feedback or discuss issues online at:

www.facebook.com/bcabim;
bimsg.wordpress.com.

Feedback will be gathered and continuously reviewed; they will be collated to form new revisions at appropriate intervals. Feedback by email can also be sent to huang_yixiang@bca.gov.sg.

Acknowledgements

Various representatives in the industry were involved in the development of the Singapore BIM Guide. BCA would like to thank them for sharing their valuable perspectives, their efforts to gather feedback from fellow colleagues, and their enthusiasm and commitment in reviewing the many drafts preceding this document. Our hope is that as the Singapore BIM Guide is improved with future versions, our progress and experiences will help others as well.

The Singapore BIM Guide was initiated by the BIM Steering Committee, set up in 2011.

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Contents

1 Introduction

The ***Singapore BIM Guide*** is a reference guide that outlines the roles and responsibilities of project members when using Building Information Modelling (BIM) at different stages of a project.

It is used as a reference guide for the development of a **BIM Execution Plan,** which will be agreed between the Employer and project members, for the successful implementation of a BIM project.

The Singapore BIM Guide consists of both **BIM Specifications** and **BIM Modelling and Collaboration Procedures**.

BIM Specifications

- It specifies the "*what"* – the **"BIM deliverables"** to be produced by the respective project member(s) at *"what"* stage of a project to meet *"what"* objectives. All the agreed deliverables are indicated in the **"BIM Objective and Responsibility Matrix"** and signed off by the parties involved.

- Each deliverable consists of a set of **BIM model elements** (or **elements**). Each element is a digital representation of the physical and functional characteristics of an actual building component to be used in the project. Lists of typical BIM elements can be found in Appendix A.

- Each element consists of a set of **attributes** that defines its non-geometric properties.

BIM Modelling and Collaboration Procedures

- It defines the ***"how"*** – the steps taken to enable a BIM deliverable to be **created** and **shared** throughout the project.

- A set of **modelling requirements** is provided to guide the project members in creating their BIM deliverables to the right **level of detail** at different stages of the project. The modelling guidelines are grouped by architectural, structural and MEP disciplines in this version of the document, and can be found in Appendix B.

- A set of **collaboration procedures** is also provided to guide the project members in sharing of their deliverables with other project members.

In summary, a BIM project requires careful planning to define an agreed set of BIM specifications, modelling and collaboration procedures to enable the successful execution of the project.

The use of BIM can be incorporated into the project as part of the scope of services under the Principal Agreement, under which reference can be made to the Singapore BIM Guide. In addition, the Employer can consider using the BIM Particular Conditions. (A sample of the Conditions can be found in Appendix E)

1.1 BIM Execution Plan

To effectively introduce BIM into the project delivery process, it is important for the project team to develop a BIM Execution Plan at the early stages of a project. It outlines the overall vision along with implementation details for the team to follow throughout the project. It is usually defined at the start of the project and when new project members have been appointed so as to accommodate their participation.

A BIM Execution Plan helps the Employer and project members to document the agreed BIM specifications, level of detail and processes for the BIM project. The Principal Agreement shall make reference to the BIM Execution Plan to define the roles and responsibilities of the project members for their BIM deliverables.

By developing a BIM Execution Plan, the Employer and project members can:

- Clearly understand the strategic goals for implementing BIM on the project;
- Understand their roles and responsibilities for Model creation, maintenance and collaboration at different stages of the project;
- Design a suitable process to participate in the implementation;
- Define the content, level of detail and by when the Model is to be delivered to meet which objective;
- Outline additional resources
- Provide a baseline plan to measure progress throughout the project; and
- Identify additional services needed in the contract

The content of a BIM Execution Plan includes the following:

- Project information;
- BIM goal & uses;
- Each project member's roles, staffing and competency;
- BIM process and strategy;
- BIM exchange protocol and submittal format;
- BIM data requirement;
- Collaboration procedures and method to handle shared Models;
- Quality control; and
- Technology infrastructure & software

The BIM Execution Plan will be appended with additional information as it is continually developed throughout the project lifecycle to facilitate changing project needs, e.g. with the addition of participants at later stages. Updates to the BIM Execution Plan should be made with the permission of the Employer or his appointed BIM Manager and should not go against conditions of the Principal Agreement.

The Singapore BIM Guide serves as a guide for the development of the BIM Execution Plan, which specifies project-specific requirements, and contains details on how the project will be

executed, monitored and controlled with regard to BIM deliverables, in order to satisfy the project objectives. Please refer to Appendices C and D for two examples of a BIM Execution Plan template. It is important to note that these template examples are based on US practices. Users are expected to interpret content appropriately and customize for local practices, where necessary.

1.4 Definitions

The terms below help to define the terms used in this Guide.

BIM **"Building Information Modelling"**

A collection of defined model uses, workflows, and modelling methods used to achieve specific, repeatable, and reliable information results from the "Model" (See definition of "Model"). Modelling methods affect the quality of the information generated from the model. When and why a model is used and shared impacts the effective and efficient use of BIM for desired project outcomes and decision support.

BEP **"BIM Execution Plan"**

A document that lays out how BIM will be implemented on a particular project as a result of the collective decision by the members of that project, with the approval of the Employer. The BIM Execution Plan is not a contractual document, but the work product of a contract. (refer to Chapter 1.1, Page 2)

BIM Manager A person, firm, or corporation appointed by the Employer to coordinate the use of BIM in a project and ensures the appropriate implementation of the BIM Execution Plan among project members. Depending on the nature of the project (e.g. budget, delivery method etc), there may be more than one BIM manager in a project, and this role could be carried out by an existing project member (e.g. project manager, architect etc).

Please refer to Chapter 3.9.1 (Page 24) for a list of the responsibilities of the BIM Manager.

Constructability Evaluation of whether a design can actually be built, and how it will be done. Constructability for different disciplines:

- Architect — The ability for the design to be constructed as envisioned
- Engineer — The ability for specified performance criteria to be met after actual construction
- Contractor — Feasibility, means, and methods of constructing a project, based on components such as costs, schedule, materials and labour

BIM should not just be about creating models useful for documentation, but also about creating models that are constructible.

Employer The owner of the Project, including any government or statutory body.

IFC **"Industry Foundation Class"**

A vendor-neutral, open data exchange specification. It is an object-oriented file format developed for the building industry and is commonly used in Building Information Modelling to facilitate interoperability between software platforms. IFC was originally developed in 1995 by a group of American and European AEC firms and software vendors through the International Alliance for Interoperability (IAI). Since 2005 it has been maintained by buildingSMART International. More information can be found at http://buildingsmart-tech.org/

Interoperability In the context of BIM, it is defined as the ability to manage and communicate electronic product and project data between collaborating firms' and within individual companies' design, procurement, construction, maintenance, and business process systems.

Level of detail (Refer to Chapter 2.2, Page 5)

Model In this guide, the "Model" shall refer to a model produced through BIM. (See definition of "BIM") It is an object-based digital representation of the physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its lifecycle from inception onward.

A basic premise of Building Information Modelling (BIM) is collaboration by different project members at different stages of the life cycle of a facility to insert, extract, update or modify information in the BIM process to support and reflect the roles of each project member.

The following are definitions related to the Model:

- **Final Design Model** The stage of completion of this model is suitable to be published as 2D design drawings that can be used for tender in Design-Bid-Build projects. In other types of procurement methods, this model is regarded as the last version of the consultants' model in the Design stages. This model is also used in the Construction stage as reference, to develop the Construction Model.

  A model that has not reached this stage of completion stated above is referred to as a "Model".
- **Model Author** The party responsible for developing the content of a specific BIM model element to the level of detail required for a particular project stage. (See Chapter 2.3.1, Page 9)
- **Model User** Any individual or entity authorised to use the BIM model on the project, e.g. for analysis, estimating or scheduling. (See Chapter 2.3.2, Page 10)

Principal Agreement Agreement for services, supply and/or construction which that party has entered into for the project.

RFI **"Request For Information"**

It is commonly raised by the contractor to the consultant to confirm the interpretation of a detail, specification or note on the construction drawings or to secure a documented directive or clarification from the architect or client that is needed to continue work.

2. BIM Specifications

This chapter defines *"**what**"* BIM deliverables are required at different stages of the project, and the responsibilities of project members for the deliverables.

2.1 BIM Deliverables

BIM project deliverables should be agreed upon together with deliverable dates at the start of the project and after the main project members have been appointed so as to accommodate their participations. The following models and other outputs can be expected from the project,

- Site model
- Massing model
- Architectural, structural, MEP models
    - For regulatory submissions
    - For coordination and / or clash detection analysis
    - For visualization
    - For cost estimation
- Schedule and phasing program (In BIM or spreadsheet)
- Construction and fabrication models
- Shopdrawings
- As-built model (in native proprietary or open formats)
- Data for facility management
- Other additional value-added BIM services

Important: Some deliverables require data to be generated from a BIM model, as users of the data may not have the resources to access the BIM model itself.

2.2 Level of Detail and Project Stages in the Singapore BIM Guide

The most important part of a BIM deliverable is the amount and quality of the information it contains. This information comes in the form of geometric and non-geometric attributes that are stored in each single BIM element (or assembly of elements).

Table 1: Examples of Geometric and Non-Geometric Attributes of BIM Elements

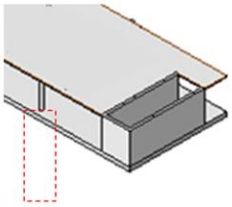
	Geometric attributes	Non-geometric attributes
Examples	• Size • Volume • Shape • Height • Orientation	• System data • Performance data • Regulatory compliance • Specifications • Cost

The attributes of a BIM element will change at different project milestones, due to the different types of information expected at different times. Globally, there are many ways of describing the attributes expected for each BIM element at each milestone, such as the VA Object / Element Matrix, available at www.cfm.va.gov/til/bim/BIMGuide/modreq.htm . It is important to note that the matrix is based on US practices. Users are expected to interpret content appropriately and customize for local practices, where necessary.

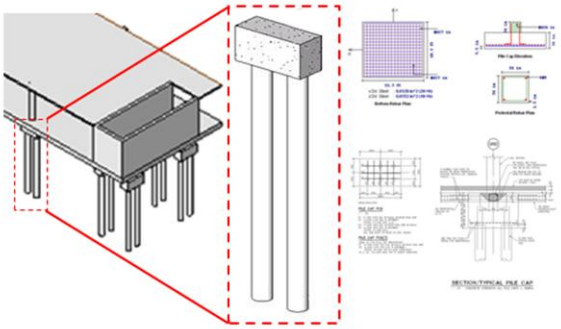
In the Singapore industry, it is recommended that **attributes of a BIM element should be determined by current practices**.

Typical BIM elements in a project can be found in Appendix A, categorized according to each discipline and sub-discipline, where applicable. The level of detail expected from the attributes of each BIM element will depend on the requirements of the project, including the needs of parties who will receive the BIM deliverables.

For example, the piling BIM element below shows how its geometric information changes throughout a project, and how this information is represented.



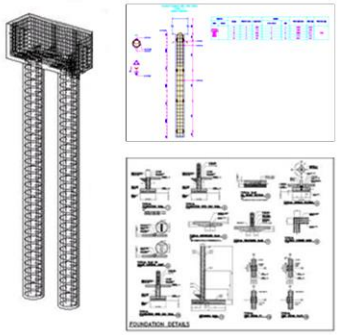
A: At early design stages, no information of piling is required.



B: As the design develops, structural analysis and design is used to develop the piling required, and can be represented as 2D documentation, for authority approval.

The pilecap and piles are also accurately modeled and located in the BIM model.

Details such as rebars can be represented in 2D.



C: During the construction stage, more detailed information is required from the piling, which can be generated from BIM analysis and detailed design models in the form of 2D shopdrawings.

Rebars can be represented in a part of the 3D BIM model as well.

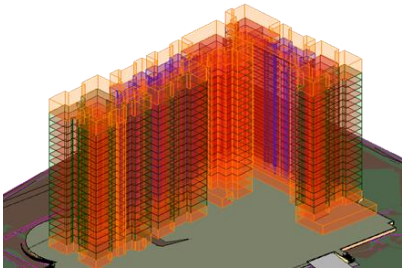
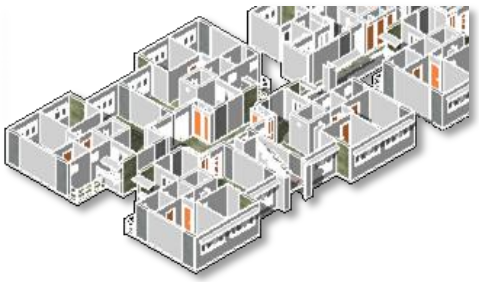
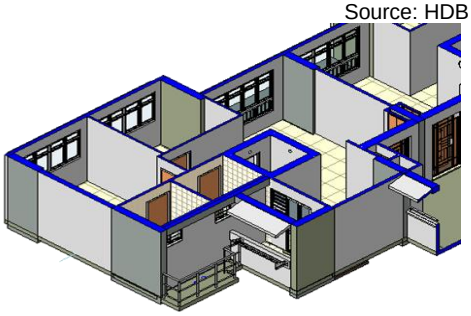
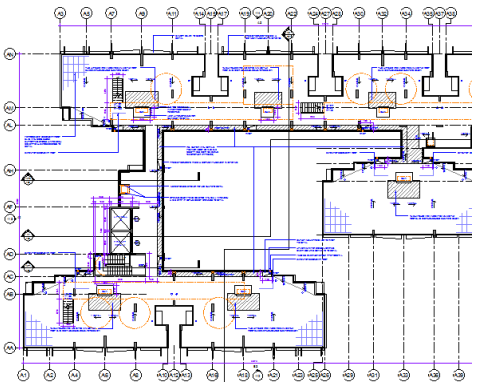
Here is another example showing the addition of non-geometrical information to a BIM element at a later stage of the project.

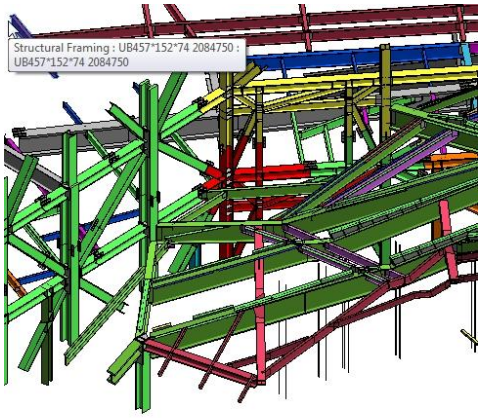
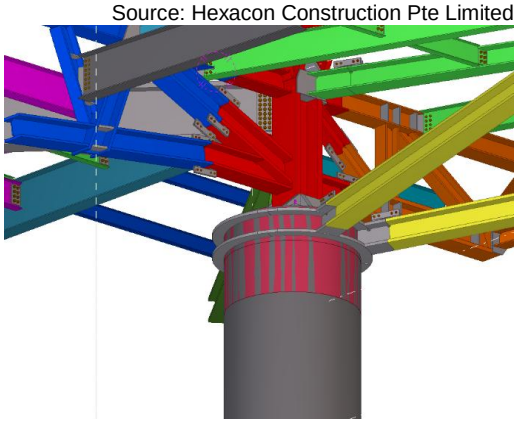
A: The project does not require the rack equipment BIM element to have too much detail in its geometric form.

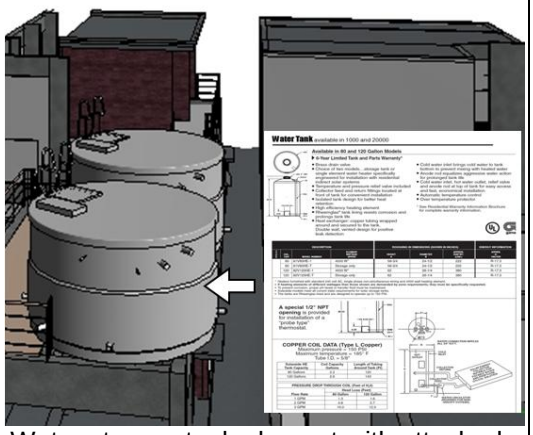
B: After the project handover, an Operation & Maintenance manual is attached to the rack element, containing information needed during the facility management stage.

Table 2 shows examples of BIM Deliverables that can be expected in current practice.

Table 2: Comparison of BIM Deliverables with Traditional Drawing Scales

Project Stages • Milestones	2D Drawing Scales	BIM Deliverables	
		General Level of Detail of each BIM Model Element / Assembly	Examples
Conceptual Design • Outline Planning Permission • Project feasibility	1:200 to 1:1000	Building massing studies or other forms of data representation with indicative dimensions, area, volume, location and orientation	Source: HDB  Massing model
Schematic / Preliminary Design • Planning Approval • Design & Build Tender Documentation	1:200	Generalized building component or system with approximate dimensions, shape, location, orientation, and quantity. Non-geometric properties may be provided.	Source: HDB  Preliminary design model
Detailed Design • Building Plan Approval • Continued Design & Build Tender Documentation; or • Design-Bid-Build Tender Documentation	1:100	More detailed version of a generalized building component or system with accurate dimensions, shape, location, orientation, and quantity. Non-geometric properties should be provided.	Source: HDB  Detailed section model  Detail drawings generated from BIM

Project Stages • Milestones	2D Drawing Scales	BIM Deliverables	
		General Level of Detail of each BIM Model Element / Assembly	Examples
Construction • Constructability • Fabrication	1:5 – 1:100	BIM element is modeled with complete fabrication and assembly details over and above the Detailed Design stage where applicable or useful for construction works; otherwise, details may be represented in 2D CAD drawings to complement the Detailed Design stage level of detail.	Source: Hexacon Construction Pte Limited  • Steel framing by sub-contractor • Has specific geometry size and dimension • Connections are not seen because this construction uses welding, not bolting • Can generate shop drawings • Able to specify fabrication • Able to specify assembly details
As-Built • TOP / CSC • Final Completion	1:100	BIM element is similar in level of detail to the Detailed Design stage, but updated with changes during Construction stage.	Source: Hexacon Construction Pte Limited  Comparison of As-Built Structural model (above) with actual site (below) 

Project Stages • Milestones	2D Drawing Scales	BIM Deliverables	
		General Level of Detail of each BIM Model Element / Assembly	Examples
Facility Management • O & M	1:50	BIM element is modeled as an actual constructed building component or system and is an as-built representation of the actual completed building.	Source: HDB  Water storage tank element with attached specification PDF

2.3 BIM Objective & Responsibility Matrix

The BIM Objective and Responsibility Matrix (Table 3) indicates the basic BIM deliverables required to meet each objective. It also shows which project members are involved in each objective, and indicates whether the selected project member is a **model author** or **model user** for each deliverable.

Project members indicated in the matrix:

- Architect (Arc)
- Civil or Structural Engineer (Str)
- Mechanical, Electrical & Plumbing Engineer (MEP)
- Quantity Surveyor (QS)
- Contractor (CON)
- Facility Manager (FM)

Project members involved in the matrix are not limited to the above six professions. Other representatives can be added to the BIM Project Objectives & Responsibility Matrix, such as:

- Sub-Contractor
- Specialist Sub-Contractor
- Interior Designer
- Landscape Designer

2.3.1 Model Author

The model author is a party responsible for creation and maintenance of a specific model to the level of detail prescribed in the BIM Project Objectives & Responsibility Matrix. In creating and maintaining the model, the model author does not convey any ownership right of the model. Any subsequent model author's or model user's right to use, modify and transmit the model is specifically limited to the scope of the project. The Employer may specify for ownership of the model in the Principal Agreement. Before providing the model to

model users, it is recommended that the model author should perform quality control checks of their models (Refer to Chapter 3.6, page 21)

2.3.2 Model Users

Model users are parties authorised to use the model on the project. The model is provided in native or neutral (IFC) format for the model users' convenience and use related to the project. Although model authors have checked the accuracy and quality of the model before sharing with model users, model users should use the model for reference only, and also check, verify and otherwise confirm the accuracy of the model. Where inconsistency is found in the model, the model user shall promptly notify the model author for clarification. The model users shall make no claim against the author in connection with the use of the model. The model users shall also indemnify and defend the model author against all claims from or related to subsequent use or modification by the model users.

2.3.3 Disclaimers

In the event that the BIM Manager has multiple roles in the project, i.e. being a BIM Manager and an Architect, an additional column for BIM Manager is added to enable the individual to be clear of his separate responsibilities throughout the project. It is up to the BIM Manager to decide on what he wants to indicate in the column – e.g. indicate his level of involvement in for each objective, etc.

Table 3: BIM Objective & Responsibility Matrix (Basic)

BIM Project Objective	BIM Manager	Project members involved in fulfilling the objective A – model author; U – model users						
		Arc	Str	MEP	QS	Con	FM	Others
Conceptual Design *Building massing studies or other forms of data representation with indicative dimensions, area, volume, location and orientation*								
1. All project members appointed at this stage to agree on needs, objectives, process and outcomes of the project. **Suggested Deliverable** • **BIM Execution Plan agreed and signed by related parties**								
2. Create site BIM models for master plan site study and feasibility analysis. - Site Analysis - Apply an Outline Planning Permission if necessary **Suggested Deliverable** • **Site Model**								
3. Create and compare BIM massing models - Space areas and volumes - No. of massing models depend on no. of conceptual design alternatives **Suggested Deliverables** • **BIM Massing Models**								

BIM Project Objective	BIM Manager	Project members involved in fulfilling the objective A – model author; U – model users						
		Arc	Str	MEP	QS	Con	FM	Others
4. Generate, freeze and store final documentation of the authorized BIM model in the Conceptual Design phase before progression into the Schematic / Preliminary Design stage.								
Schematic / Preliminary Design *Generalized building component or system with approximate dimensions, shape, location, orientation, and quantity. Non-geometric properties may be provided.*								
5. Develop, maintain and update one selected BIM massing model - In preparation for regulatory submission (PP, WP) **Suggested Deliverable** • **Architectural Model**								
6. Develop, maintain and update structural BIM model based on the Architectural Model - Preliminary structural analysis - In preparation for regulatory submission **Suggested Deliverable** • **Structural Model**								
7. Develop, maintain and update MEP BIM model based on the Architectural Model - Preliminary M&E analysis - In preparation for regulatory submission **Suggested Deliverable** • **MEP Model**								
8. Implement design coordination between the Architectural and Structural BIM Models. **Suggested Deliverables** • **Preliminary Design Coordination Report (Architectural and Structural Models only)**								
9. Revise project cost estimates based on the Architectural BIM Model **Suggested Deliverable** • **Preliminary Cost Estimate**								
10. Apply for and obtain Planning Approval								
11. Generate, freeze, and store final documentation of the authorized BIM model in the Preliminary Design stage before progression into the Detailed Design stage.								
Detailed Design *More detailed version of a generalized building component or system with accurate dimensions, shape, location, orientation and quantity. Non-geometric properties should be provided.*								
12. Maintain and update the Architectural Model - In preparation for regulatory submission - In preparation for tender **Suggested Deliverable** • **Architectural Model**								

BIM Project Objective	BIM Manager	Project members involved in fulfilling the objective A – model author; U – model users						
		Arc	Str	MEP	QS	Con	FM	Others
13. Maintain and update the Structural Model, based on the latest Architectural Model - Design, analysis and detailing - In preparation for regulatory submission - In preparation for tender **Suggested Deliverable** • **Structural Model and Calculation**								
14. Maintain and update the MEP Model, based on the latest Architectural Model - Design, analysis and detailing - In preparation for regulatory submission - In preparation for tender **Suggested Deliverable** • **MEP Model and Analysis**								
15. Apply for and obtain Building Plan Approval								
16. Develop MEP cost estimates based on MEP model								
17. Implement design coordination between the Architectural, Structural and MEP Models (before issuing for tender) - Identify element conflicts and interferences - Verify valid headroom and working spaces for building operations and maintenance activities - Penetration conflicts will be addressed **Suggested Deliverables** • **Clash Detection and Resolution Report (Architectural, Structural and MEP Models)** • **Spatial Validation Report**								
18. Produce detailed cost estimation and Bill of Quantities (in accordance with the standard method of measurement) based on BIM models. - In preparation for tender **Suggested Deliverables** • **Detailed Quantity Cost Estimate & BOQ**								
19. Generate, freeze and store final documentation of the authorized BIM model in the Detailed Design stage, and update BIM Execution Plan before progression into the Construction stage.								
Construction *BIM element is modeled with complete fabrication and assembly details over and above the Detailed Design stage where applicable or useful for construction works; otherwise, details may be represented in 2D CAD drawings to complement the Detailed Design stage level of detail.* *Note: Ownership of the BIM Model mentioned in this stage belongs to the Contractor only.*								
20. The contractor will start and continuously update the Detailed Design BIM model to an As-Built BIM Model. The Employer will specify the modelling requirements of the As-Built BIM Model.								

BIM Project Objective	BIM Manager	Project members involved in fulfilling the objective A – model author; U – model users						
		Arc	Str	MEP	QS	Con	FM	Others
21. Produce Construction Models from Architectural, Structural and MEP Models. The models will be produced in stages. **Suggested Deliverables** • **Construction Models with Key Services Coordinated**								
22. Produce schedules of materials, areas and quantities from the BIM databases for contractors' reference **Suggested Deliverables** • **Schedules of materials, areas and quantities**								
23. Sub-contractors and specialist sub-contractors will generate documents based on the Construction Models **Suggested Deliverables** • **Shopdrawings** • **Fabrication models and drawings** • **Combined Services Drawings (CSD)** • **Single Services Drawings (SSD)**								
24. Generate, freeze and store final documentation of the authorized BIM model in the Construction stage before progression into the Facility Management stage.								
As-Built *BIM element is similar in level of detail to the Detailed Design stage, but updated with changes during Construction stage.*								
25. The contractor will prepare the final As-Built BIM Model to reflect amendments in the Architectural, Structural, MEP BIM models and the completed form of the construction verified (e.g. using laser scanning or certified by a third party such as a registered surveyor, where applicable or necessary), before submitting to the consultants. Consultants to confirm and verify that the updates by the contractors were carried out properly. **Suggested Deliverables** • **Final as-built models for each discipline with the necessary third party certifications**								
26. Consultants to confirm if the As-Built models are in accordance to the approved BIM models by the relevant Authorities								
Facility Management *BIM element is modeled as an actual constructed building component or system and is an as-built representation of the actual completed building.*								
27. Incorporate as-built information of major systems and equipment in the BIM model elements for provision to the Facility Manager. **Suggested Deliverables** • **Final as-built models fit for space management, building maintenance and modifications made during occupancy by the FM / Employer**								

2.4 Compensation Expectations

The use of BIM software in a project will require much more upfront work compared with the current use of 2D for design and construction. This upfront work starts with design consultants working on the BIM model at various design stages, with builders then taking on the BIM model to expand into construction details. Therefore, it is important to recognise this upstream shift of effort by all the parties in order to achieve the overall project benefits.

The BIM Steering Committee, recognizing that BIM adoption increases efforts at the earlier design stages, recommends a 5% shift in percentage-based consultancy fee payment, from the Construction to Design stages, as illustrated in Table 4. However, this upstream shift of effort does not necessarily result in increased fees. The Employer should also have a clear understanding of the potential cost impact of BIM deliverables, especially for unique modelling and/or data requirements for other additional value-added BIM services (refer to the following page).

Table 4: Example of a Payment Schedule in a BIM Project

Project Stage	% change from non-BIM to BIM payment
Preliminary Design	+2.5
Planning Approval	0
Design Development	+2.5
Tender and Award	0
DESIGN STAGES *	**+5**
Construction Administration	-5
Post construction	0
CONSTRUCTION STAGES *	**-5**
Percentage change in total fees	0

* refers to cumulative percentage fees

Between designers and builders, there may be some cost implications due to this shift in upstream effort. If so, this should be made known in the relevant contractual arrangements of the particular project.

The use of BIM should not increase the final total cost of the project; the expectation is that a project's final total cost will be reduced due to better upfront information and hence reduced risk of abortive works and delays.

2.5 Other Additional Value-added BIM Services

One of the advantages of using BIM is the ability to perform value-added preliminary analyses using the model to optimize the performance of the building digitally. With BIM, digital analysis can deliver immediate and ongoing feedback directly from the model which would inform the consultants at the various design stages on the possible design solutions to be adopted. They allow the design solution to be more efficient, less costly and be of greater quality. However, it should be recognized that a comprehensive energy validation analysis is not part of the base services. The extent of value added by an analysis may differ from project to project, so it is advisable to carry out an analysis which is compatible with the end goals of the project.

If due to unique project requirements, some BIM services found in the BIM Objective & Responsibility Matrix (Table 3) may need to be performed at an earlier project stage. It should be recognized that this requires additional efforts from respective Model Authors, due to less data available at earlier project stages.

Examples include:

- Environmental simulation and analysis (for Concept Design Purpose only)
- Energy validation to estimate energy usage requirements
- Lighting design validation & visualization
- 4D construction scheduling and sequencing (applicable for Design & Build projects)
- Green Mark, RETV, Buildability and Constructability Scores based on BIM model(s)
- BIM model of existing building(s) for master plan site study and feasibility analysis (A&A)
- Providing Structural and MEP system alternatives based on conceptual massing models
- Project cost estimates based on conceptual massing models
- MEP cost estimates based on MEP BIM model
- Clash detection of Architectural, Structural and M&E BIM models at the Schematic / Preliminary Design stage
- High definition laser scanning for BIM documentation
- Schedule for Facility Management

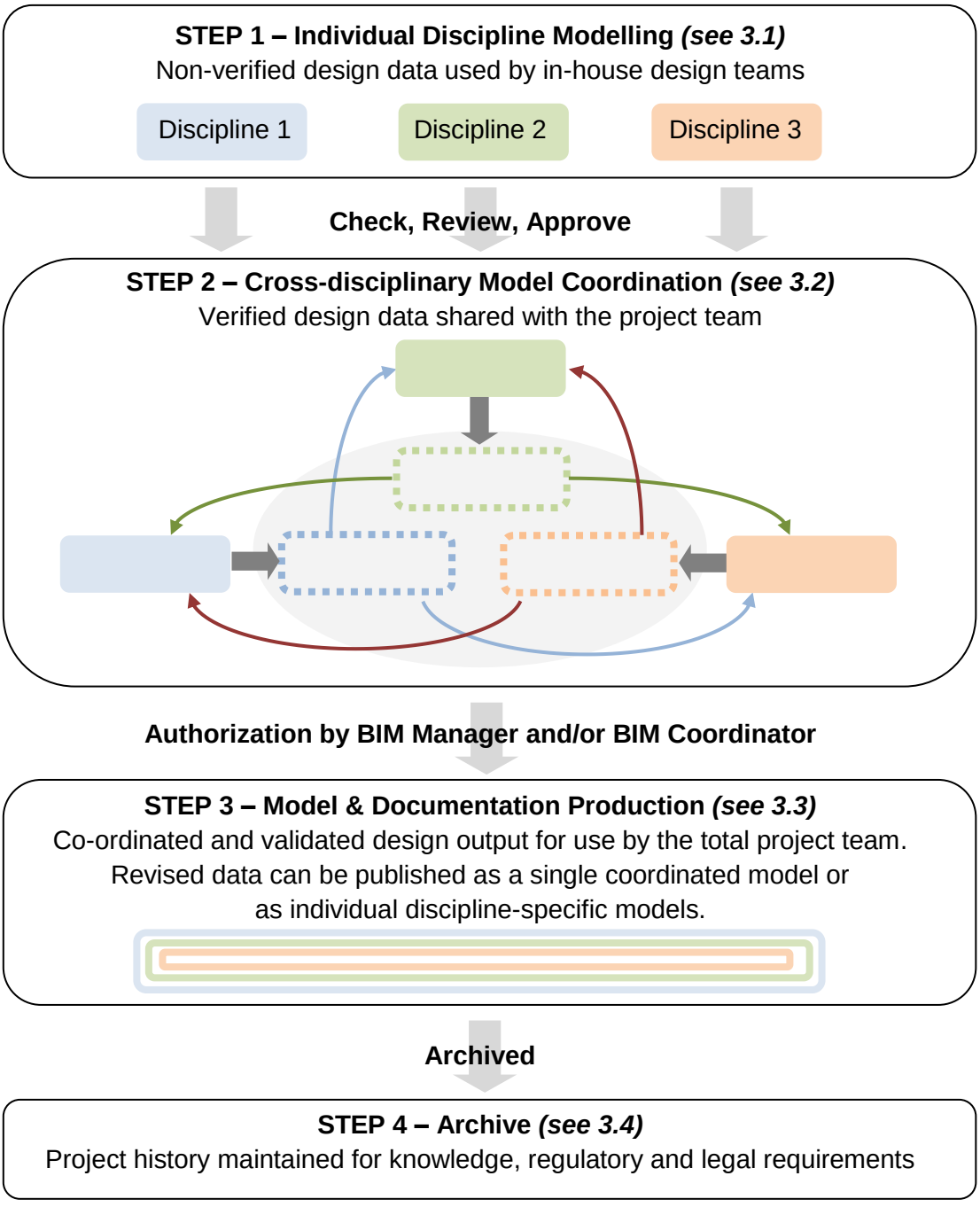
As the efforts required for additional services also depend on the project requirements and resources, it is recommended that additional fees are negotiated among the parties involved.

3. BIM Modelling and Collaboration Procedures

This chapter defines *"**how**"* BIM is to be **created** and **shared** throughout the project.

A typical BIM process can be defined through a BIM modelling workflow, which is essential for efficient data sharing during the process of project collaboration. The following diagram describes a Common Data Environment (CDE) approach which allows information to be shared between all project members through 4 modelling stages of a BIM project:

Note: The following 4 modelling steps in a BIM modelling workflow are not to be confused with the 6 project stages. (i.e. from Conceptual Design to FM). Certain modelling steps may be repeated or omitted in different project stages, depending on the specific deliverables of each project stage.



3.1 Individual Discipline Modelling

At this stage each design discipline will create its model according to the agreed deliverables as stated in the BIM Execution Plan. The model data is stored in and worked on, by the modelling team of each respective design discipline and has not yet been checked and verified for use outside of the team.

To ensure modelling quality, Model Authors should set up and follow a minimum standard of modelling requirements during BIM project implementation.

3.1.1 Modelling Guidelines for BIM Elements

A set of modelling guidelines for key BIM elements at different stages of a project can be found in Appendix B of this document. The modelling guidelines are grouped by Architectural, Structural and MEP disciplines in this version of the document. In general, each element will be modelled according to its size, shape, location, orientation and quantity. At the early stages of the project, element properties are more generic and approximate, but become more specific and increases in accuracy as the project progresses.

3.1.2 Modelling Guidelines for Regulatory Submission

For BIM e-submission to regulatory agencies, additional modelling guidelines and templates for Architectural, Structural and MEP disciplines can be downloaded at http://www.corenet.gov.sg/integrated_submission /bim/BIMe_submission.htm

3.1.3 Model Orientation and Site Configuration

The origin point for the project should be clearly defined and drawn in the real orientation or spatial coordinate system and with reference to Singapore Standard Datum (>100M), rather than project reference level at zero ground.

3.1.4 Model Division and Structure

Depending on the size of the building and / or the phasing for the project, it may be necessary to divide the model into separate building, zones and levels. This should be agreed and documented as early as possible.

3.1.5 Revision Management

The model will evolve rapidly during the project stages. Changes should be tracked and catalogued, especially when the model creation task is divided into a few smaller packages and handled by different people.

There are various software mechanisms to assist BIM users to manage and monitor design changes. BIM users should work with their respective BIM vendor to familiarise themselves with the use of these software mechanisms so that design changes can be managed more effectively. The BIM coordinator for each discipline could play the role of maintaining a register to record the latest information incorporated in the model.

3.2 Cross-disciplinary Model Coordination

Project members should share their models with other project members at regular intervals for reference when they are developing their own single-discipline model. At certain milestones, models from different disciplines should be subject to various coordination processes, allowing involved parties to resolve potential conflicts upfront and avoid costly abortive works and delays at the construction stage.

It is recommended for the project team to map out a high level coordination flow, as seen in Table 5 below, which shows the interactions between the Employer and project members.

Table 5: Example of a BIM Project Collaboration Map

	Employer	Architect	Consulting Engineers	Contractor / Quantity Surveyor
Conceptual Design	Provide requirements related to form, function, cost and schedule	Begin design intent model with massing concepts and site considerations	Provide feedback on initial building performance goals and requirements	Provide feedback on initial building cost, schedule, and constructability∗
Schematic / Preliminary Design	Provide design review and to further refine design requirements	Refine Design Model with new input from Employer, Consulting Engineers, and Construction Manager.	Provide schematic modelling, analysis and system iterations as Design Model continues to develop	Provide design review and continued feedback on cost, schedule, and constructability ∗
Detailed Design	Design reviews. Final approval of project design and metrics	Continue to refine Design Model. Introduce consultants models and perform model coordination	Create Discipline specific Design Models and Analyses	Create Construction Model for simulation, coordination, estimates, and schedule ∗
		Finalize Design Model, Tender Documents and Specifications, Regulatory Code Compliance	Finalize Discipline specific Design Models, Tender Documents and Specifications, Code Compliance	Enhance Construction Model and perform final estimate & construction schedule, Manage bid process,
Construction	Monitor construction and give input to construction changes and issue	Respond to construction RFI's, Perform contract administration, update Design Model with changes	Respond to construction RFI's and update Discipline specific Design Models, field conditions, and commissioning	Manage construction with subcontractors and suppliers, inform changes to Design Model
As-Built		Verify As-built model	Verify As-built model	Prepare As-built model
Facility Management	Engage Architect and Facilities Group for handing over	Coordinate information exchange through model to Facilities Group	Prepare handover documentation	

∗ Applicable to Design & Build projects only, where the Main Contractor is appointed at the Conceptual Design stage

Prior to sharing, the data should be checked, approved and validated as “fit for coordination”. The project team could leverage on the available software solutions to perform the coordination effectively. A common (software) platform is recommended, to reduce possibilities of data loss or errors when sharing different models. Issues that arose from the coordination should be documented and followed up.

Discrepancies discovered during the coordination process should be recorded, managed, and communicated to relevant model owners through coordination reports, including any specific location of interferences and suggested resolutions.

It is recommended that a revised version of the model should be frozen and signed-off after the issues identified during the coordination exercise have been resolved. A digital signature can be considered to effect the protection.

3.2.1 Points To Note

Successful BIM coordination requires careful planning and a clear understanding of different types of coordination process i.e. design coordination, clash detection or space validation.

In early coordination processes, entire models can be run against other models to determine the scope of interference, i.e. objects, elements and selection criteria, for future testing. However, it is important to recognize that not all conflicts detected are problems. Certain conflicts may have been intentional during the modelling process for the sake of simplifying the modelling process. Proper search sets and clash rules should be set up before running the respective coordination processes, to:

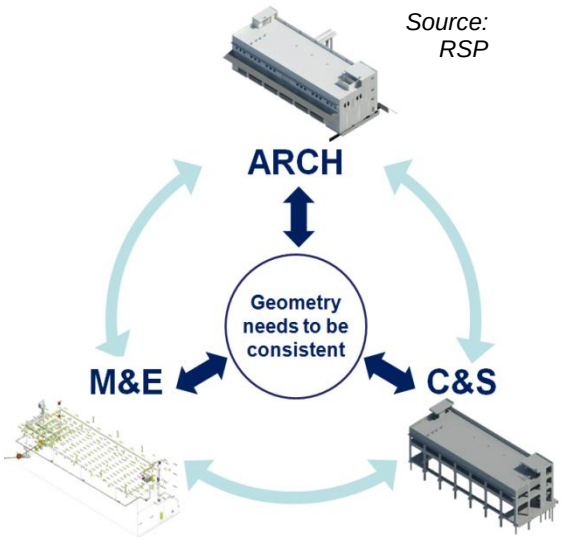
- Reduce time and resources spent on detecting false positives.
- Hide elements that are unnecessary in the coordination process, for example, known issues that are to be resolved in later project stages; elements that do not impact the cost when changed on site, etc
- Group particular elements for a specific type of coordination process, such as forming groups between a ceiling search set and an MEP model only during a clash analysis

Clash results need to be judged in the context of the elements being analysed, and the type of clash detection software being used. For example, one issue that may occur are duplicate instances of the same clash – for example, a pipe hitting steel could represent 20 clashes when in reality it is only one single issue.

<u>Responsibilities during the coordination process</u>

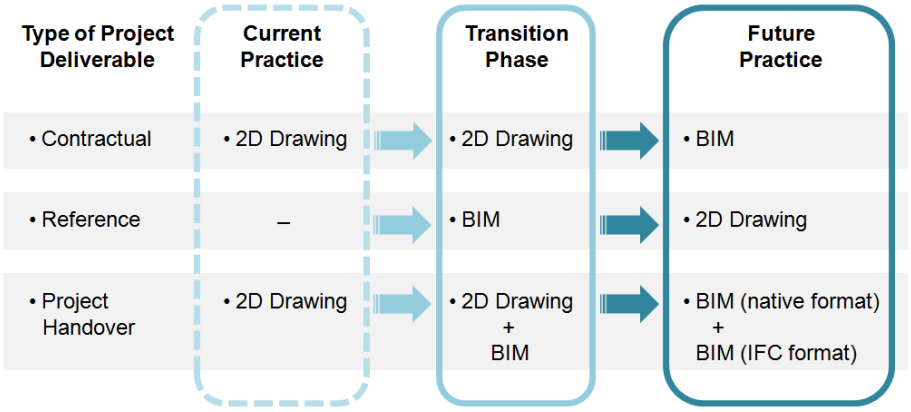
1. Each party **<u>owns</u>** their discipline-specific model
2. During the analysis, their models are linked into a native modelling software or compilation analysis software, depending on the type of analysis used
3. To resolve clash conflicts, each party carries out agreed changes on their own discipline-specific model
4. Liabilities of each discipline-specific model remain the same, before and after the analysis.

Source: RSP



3.3 Model & Documentation Production

When Version 1 of this guide was released in May 2012, the local construction industry is at the "Transition Phase" from the use of 2D drawings to BIM models. In the event of conflict between the contract documents and BIM model, the contract documents shall take precedence over the model.



The changing status of 2D drawings and BIM from current to future practice

3.3.1 Publishing 2D Drawings

Before the industry is ready to accept BIM as part of the contractual documents, there is a need for project members to agree on the standard for 2D drawings that form part of the contract documents. 2D drawings include plans, sections, elevations, details and RFIs, etc.

It is recommended to generate 2D drawings directly from the BIM model, to ensure there are no discrepancies as much as possible. 2D drawings/ details not produced from the BIM models should be clearly labelled.

While the respective disciplines will maintain their own drawing list, drawing numbering and sheet naming systems, the team could determine a common naming convention of views, legends, schedules, sheets and links that could provide a common reference to the corresponding 2D design drawings, tender drawings, working drawings and as-built drawings.

3.3.2 BIM Exchange Formats

Collaboration parties shall agree on the BIM exchange protocol and submittal format (proprietary or open standard) in the BIM Execution Plan.

To ensure the life-cycle use of building information, information supporting common industry deliverables shall be provided in existing open standards, where available. For those contract deliverables whose open standard formats have not yet been finalised, the deliverable shall be provided in a mutually agreed format which allows the re-use of building information outside the context of the proprietary BIM software. The format could be any of the prevailing open standards, such as IFC, where available. (See page 4 for IFC definition) The formats used should be specified in the BIM Execution Plan.

3.4 Archive

All output data from BIM models, including published, superseded and 'as-built' data, should be archived in the project folder.

Additionally, at key milestones of the project stages, a complete version of the BIM data and associated deliverables should be copied into an archive location and stored as a record that should not be altered for any reason. It is recommended that the BIM archive consists of two sets of files. The first should be a collection of individual BIM models and associated deliverables as received from the respective Model Authors. The second set of files should consist of the aggregate of those individual BIM models in a format suitable for archiving and viewing.

3.5 Data Security & Saving

A data security protocol should be established to prevent any possible data corruption, virus "infections," and data misuse or deliberate damage by project team members, other employees or outside sources. Adequate user access right should be established to prevent data loss or damage during file exchange, maintenance, and archiving. BIM project data residing on network servers should be subjected to regular back-ups.

3.6 Quality Assurance and Quality Control

The BIM Manager should establish a quality assurance plan for the BIM models, to ensure appropriate checks on information and data accuracy.

The respective BIM coordinator of each discipline should also establish a quality control procedure to ensure that the discipline model is accurate and correct according to the modelling guidelines.

Each project member should be responsible for performing quality control checks of their design, dataset and model properties before submitting their deliverables.

The following should be considered when determining a quality assurance plan:

- Modelling Guidelines
    - Ensure that the model is created based on the modelling guidelines and CAD standards
- Dataset Validation
    - Ensure that the dataset are populated with correct data.
- Interference Check
    - Detect any clashes between two building components using a Clash Detection software
- Validation of BIM data to be used for Cross-Disciplinary Model Coordination
    - All drawing sheets and extraneous views should be removed from the BIM
    - Each model file should be checked, purged and compressed;

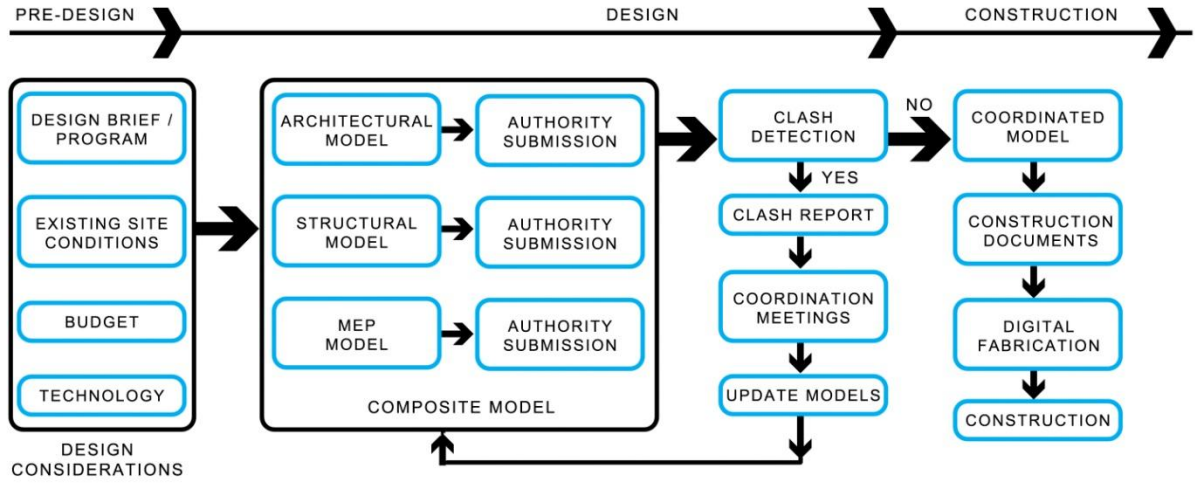
- File format and naming conventions conform to project Data Exchange protocols.
- Data segregation conforms to the agreed methods in BIM Execution Plan
- Model files are up-to-date, containing all users' local modifications
- Model files are detached from central file
- Any linked reference files have been removed and any other associated data required to load the model file is made available
- Model is correctly assembled through visual inspection
- Any changes since the last issue are communicated to the project team.

More details on Quality Assurance can be found in Appendix B (Page 33).

3.7 Workflow of Design-Build Projects

The Design-Build project delivery method allows for a single model that is developed to produce the construction documents and fabrication of the building systems.

- Establish a BIM execution plan prior to modelling;
- In schematic design, designers, in collaboration with subcontractors, will create BIM models to meet predefined project requirements.
- Integrate the BIM models into a composite model that will be used for coordination and clash detection.
- Interferences will be resolved interactively during coordination meetings;
- Once all conflicts have been resolved, construction documents can be produced
- The Design-Build team will hold installation planning meetings where the coordinated model will be used for review and field installation.
- Allows for accurate digital fabrication of key components off site to be items such as structural steel, precast components, prefabricated units (e.g. facade units, prefabricated toilets).



3.8 Workflow of Design-Bid-Build Projects

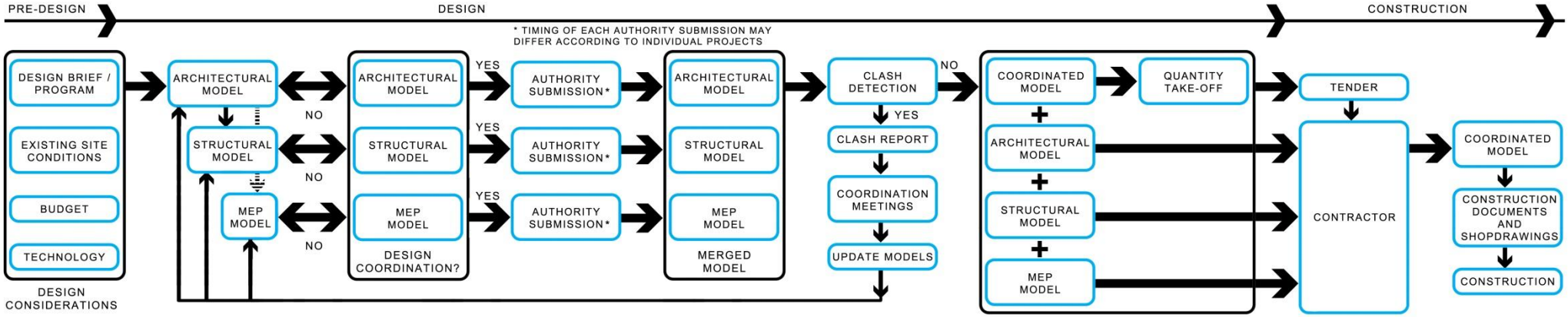
The traditional Design-Bid-Build project delivery method divides the BIM process into two models - a design model and a construction model. The consultants generate the design model and tender documents. The Main Contractor generates the construction model for construction purposes.

Pre-Tender Stage

- Establish a BIM execution plan prior to modelling;
- Create architectural and system models by design teams;
- Integrate design models for coordination and clash detection;
- Interferences will be resolved interactively during coordination meetings;
- Once all conflicts have been resolved, design and tender documents can be prepared;

Construction Stage

- Models and/or drawings generated from the models will be released to the main contractor for reference only;
- Main contractor will develop the model further with construction and fabrication details with fully annotated drawings for/by the sub-contractors;



3.9 Two New BIM Roles

To facilitate the BIM processes, two possible new profiles known as BIM Manager for Project, and BIM Coordinators for Consultants and Contractors have been identified in Table 6 below. **These new roles can be undertaken by existing members in the project team**, such as CAD managers, project managers, consultants, contractors, etc.

Besides ensuring that BIM objectives are achieved, the BIM Manager should also ensure that all parties work collaboratively to resolve conflicts in the most efficient way.

The role of the BIM Manager does not include making decisions about design, engineering and construction solutions for the project, nor organizational processes for each discipline.

Table 6: Overview of Responsibilities for New BIM Roles

Role	Responsibilities in Model Management	BIM Responsibilities
BIM Manager for Project	Coordinate BIM use on project, determine schedule of use, sharing activities, quality control, modelling responsibilities and document in BIM Execution Plan. This role can be played by lead consultant or a BIM specialist appointed by the Employer or project manager	- Oversight - Management execution - Model exchange
BIM Coordinator for each Consultant	Design Execution - Formulate BIM strategy with BIM Manager - Map BIM use for discipline specific design - Determine BIM use for design simulations, analysis, and documentation - Identify analysis tools that are interoperable with BIM	- Coordinate with modellers and designer, as well as project members - Model review - Model exchange
BIM Coordinator for Contractor	Construction - Receives or create BIM for constructability study and field use. - Determine interference checking responsibilities	- Coordinate with design team and sub-contractors - Model user & review - Model exchange

3.9.1 Responsibilities of the BIM Manager

The responsibilities of a BIM Manager can be detailed as, but not limited to, the following:

a. Establish and agree upon a BIM Execution Plan, ensuring on-going compliance and continuous improvement, as well as perform any and all other responsibilities or functions as required in the BIM Execution Plan.
b. Create, delete, modify and maintain adequate user access rights to prevent data loss or damage during file exchange, maintenance, and archiving.

c. Establish protocols for model management such as, but not limited to, the following:
    i. model origin, coordinate systems and unit of measurement;
    ii. model naming;
    iii. processes of releasing authorised and frozen models to project members at an agreed interval;
    iv. facilitating model coordination exercise or meeting (including clash analysis)/ and issue periodic clash detection reports
    v. others which include setting up the following
        - model storage solution
        - model version
        - model access rights
        - model aggregation and make available for viewing
d. Collect incoming models, coordinate submission and exchange of BIM models, log incoming models, validate that files are complete and usable and in compliance with the applicable protocols and/or the BIM Execution Plan and maintain record copy of each file received.
e. Undertake necessary precautions to ensure there would not be any interoperability issues by addressing or specifying the necessary requirements for BIM including but not limited to hardware, software, licensing, file format and interactive workspace requirements
f. Determine the conventions to be followed for reviewing BIM models and associated deliverables
g. Establish a data security protocol to prevent any possible data corruption, virus "infections," and data misuse or deliberate damage by project team members, other employees or outside sources.
h. BIM project data residing on network servers should be subjected to regular back-ups.
i. Routinely run information system scans to maintain model data security.
j. Install patches to close documented vulnerabilities in the model.
k. If appropriate, establish and maintain encryption-at-rest measures and encryption-during-transmissions measures.
l. Document and report any incident relating to the model (including but not limited to an incident originating outside the model that results in the model being a victim of an attack) and take action to protect the model.
m. Maintain a BIM data archive as described in Chapter 3.4 (Page 21)
n. Ensure a quality assurance plan for the Models as described in Chapter 3.6 (Page 21)
o. Transfer unconditionally to a successor BIM Manager, at such times as directed by the Employer, all tangible and intangible property and information that came into his possession, custody or control in its capacity as BIM Manager.

References

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- Brad Hardin, BIM and Construction Management: Proven Tools, Methods, and Workflows (2009)
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- ConsensusDOCS LLC, ConsensusDOCS 301, Building Information Modeling (BIM) Addendum (2008)
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- Pennsylvania State University, Building Information Modeling Execution Planning Guide (2010)
- San Diego Community College District BIM Standards for Architects, Engineers & Contractors (2010)
- State of Ohio BIM Protocol (2010)
- US VA BIM Guide v1.0 (2010)
- US' VA BIM Object / Element Matrix (2010)

Appendix A – Typical BIM Elements by Discipline

(i) Architectural BIM Elements

	Element
Site Model	Site infrastructure within site boundary (roads, pavements, car park spaces, access and parking arrangements and surrounding land use)
	Street fire hydrant (only indication of locations necessary)
	Surface drainage (only indication of locations necessary)
	External drainage & underground drainage
	Hard landscaped areas within site boundary
	Planter boxes including sub-soil drainage systems
	Massing of adjacent buildings relevant to project
Rooms / Spaces	Room spaces, corridors, other spaces, plant and equipment rooms (including designated use)
Walls and Curtain Walls	Interior / Exterior walls / Non-structural walls / Blockwork walls (*Including finishes to identify if tiled / painted / plastered)*
	Studs∗ and individual layers of drywall
	Curtain wall with mullions and transoms with true profile and window glazing units including shading devices
Doors, Windows and Louvers	Interior / Exterior doors
	Interior / Exterior windows
	Louvers
	Ironmongery (handles, locks∗, hinges∗ etc) *Typically in component family*
Basic structure	Beams (based on location and size indicated by the Structural Engineer)
	Columns (based on location and size indicated by the Structural Engineer)
Roofs	Roofs with overall thickness (including finishes & insulation)
Ceilings	Ceilings (without support sub-frames) including module arrangement, material choices and finishes.
	Hangars and sub-frames for ceilings∗
Floors	Horizontal floors
	Sloped floors and ramps
	Floor finishes details including tiling, carpet, screed only
Vertical Circulation	Steps & stairs including risers, threads and railings including headroom clearance requirements
	Elevator shafts (without fit-out installations by lift contractor)
	Escalators & moving walkways, not including motorized equipments inside.
	Access ladders and catwalks
Architectural Specialties and Casework	Precast / GRC / Fibreglass facades
	Fixed Building Maintenance Units in their overall bulk form

Schedules	Schedules allowing information to be extracted from elements
Fixtures and Equipment ∗ (with input from interior designers, specialist sub-contractors, etc)	Loose furniture including desks and computer workstations, casework (carpentry), including upper and lower cabinets
	Appliances such as in kitchen equipment
	Toilet fixtures, plumbing faucets

∗ these elements may cause BIM models to become too big and unmanageable.

(ii) Structural BIM Elements

Element
Foundations including piles, pile caps, tie / ground beams & footings
Diaphragm walls & retaining walls
Beams
Columns
Walls
Slabs, including slab on grade and floating slab, recesses, curbs, pads and major penetrations
Other types of transfer structure not mentioned above
Stairs (steps, risers, threads, landings): all framing members and openings
Shafts and Pits (and openings)
Precast & Prestressed concrete systems: all primary and secondary elements
Temporary structures and platforms
Concrete reinforcement details (Rebar), imbeds and cast-ins ∗
Steel frame structures including bracing systems ∗
Base plates, bolts, clip angles, fixings, etc. ∗
Connection details of structural steel members ∗

∗ these elements may cause BIM models to become too big and unmanageable.

(iii) Civil BIM Elements

	Element
Digital Terrain Model ❄	3D surface based on topography that shows site conditions and building locations and utilities connections Include existing walkways, roads, curbs, ramps and parking lots etc
Geology Report ❄	Soil investigation report (A BIM Model is not required)

Utilities Model	All points of connection for existing and new utilities within site boundary
Rainwater & storm water pipe work	Includes outlets, surface channels, slot channels and manholes
Underground Public Utilities	For drainage only
Others	Drains, canals, crossings, retaining walls, and underground harvesting tanks

❄ Data of existing conditions to be provided by surveyors and geotechnical engineers

(iv) ACMV BIM Elements

	Element
ACMV Equipment	Air Handling unit
	Chiller unit
	Variable refrigerant unit
	Cooling Tower
	Split-type indoor & outdoor air conditioning units
	Exhaust or extract air fans
	Fresh air fans
	Other fans such as jet fans
	Heat Exchanges for projects with District Cooling
ACMV Distribution	Exhaust air ducts (excluding hangars)
	Fresh air ducts (excluding hangars)
	Supply air ducts (excluding hangars)
	Return air ducts (excluding hangars)
	Transfer air ducts (excluding hangars)
	Diffusers, air-boots, air grilles, air filters, registers
	Fire dampers, motorized dampers, volume control dampers, CO_2 sensors, CO sensors
Mechanical Piping	Chilled water supply pipes including connections, fittings & valves
	Chilled water return pipes including connections, fittings & valves
	Condensate drain pipes including connections, fittings & valves
Others	Switch boards, control, BMS & DDC panels, BMS control & monitoring modules
	Fan Coil unit
	Engineering Smoke Extract System (e.g. smoke curtains, ductless fans)

(v) Plumbing and Sanitary BIM Elements

General
Pipe supports and brackets ∗
Pumps
Control panels, monitoring and control sensors
Plumbing BIM Elements only
Fresh water piping, fittings, valves including hot & cold water pipe work with all plumbing equipment, sinks
Water meters
Storage, water holding tanks, pressure vessels
Underground Public Utilities for water supply
Underground Public Utilities for drainage
Grey water systems
Pool filtration equipment
Sanitary BIM Elements only
Foul drainage, kitchen waste pipe work including floor drains, open trapped gullies, sealed trapped gullies and clean outs, vents and manholes
Grease and sand traps
Sump and sewage pits

∗ these elements may cause BIM models to become too big and unmanageable.

(vi) Fire Protection BIM Elements

Element
System piping, droppers, fittings, valves and sprinkler heads, sprinkler inlets, sprinkler control valve set, subsidiary valves, flow switches
Pipe supports and brackets ∗
Fire alarm gongs & break glass unit
Fire sprinkler pumps
Sprinkler tanks
Hydrants and hose reels (location of street fire hydrant determined by architects)
Gas piping for suppression systems
Heat or smoke detectors, control panels, monitoring and control sensors, pump panels, check meter positions
Fire extinguishers
Fire shutters & hoods above
Smoke Curtains

∗ these elements may cause BIM models to become too big and unmanageable.

(vii) Electrical BIM Elements

Element
Cable trays, trunking & cable containment, Electrical risers, conduit, Busduct, power feeds,
Outlets, panels, wall switches, circuiting to devices, security devices, card access and “plug moulds” (socket points)
HV & LV switch boards, switchgear, MCCB boards, MCB boards
Transformers
Light fittings & fixtures & housings for light fixtures
Conduit associated with access, data communication, security systems and electrical equipment
Telecom equipment and computer racks
Generators and exhaust flues including acoustic treatments
Diesel tanks & fuel pipes
Security system including CCTV camera, smart card system, door monitoring system
Car park control system, barrier gates
Equipment and associated installations maintained by public utility companies (Including manholes / drawpits for the Power Grid)
Earthing and lighting protection system
Lifts, PA systems, BMS equipments including display panels (e.g. power consumption display)

∗ these elements may cause BIM models to become too big and unmanageable.

Appendix B – BIM Modelling Guidelines

The following guidelines recommend how BIM elements should be modelled in different disciplines at different project stages. It does not state who is the Model Author required to model the BIM elements. Modelling guidelines for Facility Management will be addressed in the future version of the Guide.

(i) Overview
(ii) Quality Assurance
(iii) Architectural BIM Modelling Guidelines
(iv) Structural BIM Modelling Guidelines
(v) MEP BIM Modelling Guidelines
a. ACMV b. Plumbing and Sanitary c. Fire Protection d. Electrical

(i) Overview

Disciplines / Stages	Architectural Design	Structural Design	MEP Design	Intended Use
Conceptual	Topo, Massing, Site Elements, Site Boundary, Levels, Location, Orientation	*(optional)*	*(optional)*	Site planning, Location of the building(s) on the site, Starting situation for renovation project, Investigation, Visualization, Design options, Investment analysis, Preliminary energy simulation, Alternate spatial designs, Scope management, Investment calculation, Energy simulation, Finalised spatial requirements for structures and MEP systems, Visualisation
Preliminary Design	Building elements with nominal dimensions and details	Load-bearing structures, Proposed structural system & basic structure	MEP Schematics	Definition of building elements, Comparison of building element and structural alternatives, Management of quantity information, Preliminary dimensioning of structures, MEP Analysis, Visualisation
Detailed Design	Building elements with actual dimensions and details	Frame structures, Joints, Foundations, Joining to foundations, Penetrations & Reservations Connections	Service areas of MEP systems, Central units, Ducts, Pipe work, Terminal devices, Switchboards, Cable routes, Lighting fixtures, Penetrations & Reservations	Dimensioning of structures to the precision required for tenders, Definition of MEP systems, Quantity take-off, Penetration & Reservation design, Energy simulation, Visualisation. Combined Services Design
Construction	Model used to extract construction information	Model used to extract construction information	Model used to extract construction information	Detailed Design Information for construction, Prefabricated element design, Production planning
As-Built	Updated detail model as per actual site conditions	Updated detail model as per actual site conditions	Updated detail model as per actual site conditions	Information to be handed over for FM (maintenance & repairs; space & occupancy management)

(ii) Quality Assurance

Architectural Detailed Design BIM	**Structural Detailed Design BIM**	**MEP Detailed Design BIM**	**Merged model at Preliminary Design, Detailed Design, Construction and As-Built stages**
- BIM in agreed version	- BIM in agreed version	- BIM in agreed version	- All agreed models available
- BIM includes defined stories	- BIM includes defined stories	- BIM includes defined stories	- Models represent the same design version
- Building elements & spaces modelled separately in each story	- Building elements defined separately in each story	- Components defined separately in each story	- Models are located in the correct coordinate system
- BIM includes required building elements	- BIM includes required building elements	- BIM includes required components	- No conflicts between vertical shafts and MEP systems
- Building elements modelled using correct objects	- Building elements modelled using correct objects	- Components modelled using correct objects	- No conflicts between horizontal reservations and MEP
- Building elements include types	- Building element types are as agreed	- Components belong to a correct system	- No conflicts between suspended ceilings and MEP
- No excess building elements	- No excess building elements	- System colours are defined systematically	- Penetrations of columns OK
- No overlapping or doubled building elements	- No overlapping or doubled building elements	- System colours are defined systematically	- Penetrations of beams OK
- No significant clashes between objects	- No significant clashes between objects	- No excess components	- Penetrations of slabs OK
- No conflicts between structures in architectural and structural BIM	- No conflicts between structures in architectural and structural BIM	- No overlapping or doubled components	
- BIM includes GFA spaces objects	- No conflicts between penetrations in architectural and structural BIM	- No significant clashes between components	
- Space areas match space program	- Columns and beams converge	- No clashes between MEP disciplines	
- BIM includes spatial reservations for MEP	- MEP penetrations & reservations included in structures	- No clashes between M&E and electrical BIM	
- Space height defined (including suspended ceilings)		- Components fit into their spatial reservations	
- Shape and size of spaces matches with walls		- No clashes between M&E, architectural and structural BIM	
- Spaces do not overlap			
- All spaces have unique IDs			

(iii) Architectural BIM Modelling Guidelines

General Architectural Guidelines:

1) Architectural modelling is carried out in the following stages: Conceptual, Preliminary Design, Detailed Design, Construction and As-Built. The types of models produced at each stage depend on the BIM deliverables required.
2) If the design has precast or prefab design then those elements can be placed as Objects.
3) The building elements must be created using the correct tools (Wall tool, Slab tool, etc.). If the features of BIM authoring tool are not sufficient for modelling the element, the required building elements must be created using other appropriate objects. In that case, define the "Type" of the element correctly.
4) 2D can be used to complement the BIM model when the elements are smaller than the agreed size, e.g. Elements smaller than 100mm do not need to be modelled.
5) 2D standard details can be used to complement the BIM model.
6) Building Elements must be modelled separately for each storey.
7) Required Parameters: Type, Material, ID, Size. Type is required for the Quantity Take-off.
8) If more than one tool is used to model certain elements then the elements should be grouped and identified correctly by "Type", e.g. Slabs and Beams can be used to model the Road. The elements must be grouped as one and define the "Type" as a "Road"
9) Structural elements should be modelled based on the information (e.g. Size) from Structural Engineers. The alternative is to link or work in a shared model with the Structural Engineers.

Stages	Elements	Modelling Guidelines	Remarks
Conceptual	Topo (Existing Site)	Existing site's contour and location should be modelled based on the land surveyor's information (spot levels, northing and easting). Renovation Projects (A&A): If the existing buildings were not in BIM, then 2D drawings of the existing building can be used to complement the BIM model.	Follow BIM e-Submission guidelines for the content and colour code of existing/proposed site.
	Topo (Proposed Site)	Proposed site's cuts and fills of earth should be shown with a proposed site Element	
	Massing (Buildings)	Shape, Location and Orientation of building in site should be modelled using massing element. Name/identify the Mass element clearly, e.g. BLK 1, PODIUM etc. Site elements like Trees, Boundary, Roads, IC, etc can be drawn in 2D.	Output: Concept model that shows site arrangements and building geometries to share with the project members.
Preliminary Design Note: Conceptual model is further developed into Preliminary Design	General Requirement	If the actual dimension is not available then model using the nominal dimension or expected dimension. Examples - Door opening modelled without considering the fittings. - Walls modelled without considering the different layers thickness.	Output: Authorities submission (URA). Refer to BCA BIM e-Submission requirement and Guidelines. Use BIM e-Submission Template.

model (Massing of the selected design should be converted to real building elements like Wall, Slab, Door, Window, etc...)		Note: Since the designers has the libraries and templates with element settings, they can model the actual size	Output: Model for co-ordination with Engineers.
	Wall	Model all the Walls (Brick, Dry wall, Glass, Concrete, wood, etc...) from Finish Floor Level to soffit of Slab/Beam above. When the Wall spans across different heights, if the BIM authoring tool permits model as a single Wall with varying height then model as one Wall. Alternative is to model as multiple Walls. Distinguish the internal and external Walls by "Type" parameter.	
	Slab / Floor	Top of Slab = Finished Floor Level When there is a slope in the Slab or the Slab has a special shape and the BIM authoring tool does not have the functionality to create such Slabs, then create the slab geometry using other tools and define the 'Type' as a "slab".	
	Door	Place the Door object with nominal dimensions and parameters required for Preliminary Design.	
	Window	Place the Window object with nominal dimensions and parameters required for Preliminary Design.	
	Column	Model the Columns on the desired locations from Structural Floor Level to Structural Floor Level for the Preliminary Design co-ordination with Structural Engineer. Columns must be modelled by their outer dimensions, taking into consideration the thickness of the finish and structure. Create objects for Columns with special shapes and cross sections.	
	Roof	Model using the Roof or Slab object and define the "Type" as Roof. The supporting structures can be modelled with general objects or beams.	
	Others	If there is a need to model more elements than what is specified in the Preliminary Design based on the project, refer to the Detailed Design stage. Model those elements with the information available at this stage.	
	Space group (Zone or Space or Room object)	Note: Similar to individual space/room object Examples - Apartment, Fire Compartment, Departments, GFA Boundary, etc Follow BIM e-Submission guidelines for the details required for the Agencies requirement and display them accordingly in the plans	
	Individual Space (Space or Room object)	Space height = floor height from FFL to the soffit of slab above or the suspended ceiling above. One space may belong to more than one space groups. Area/Volume will be automatically calculated from the space geometry. Follow BIM e-Submission guidelines for the details required by the Agency and display them accordingly in the plans.	

		Give a unique ID that can be used to locate the correct space when there is a need. Name the space based on the function of the room, e.g. Office, Lobby, etc... Follow the BIM e-Submission guidelines for various agencies requirement on the space requirements. Category can be used to group the spaces like Commercial, Residential, etc...	
Detailed Design Note: Preliminary Design model is further developed into Detailed Design model	General Requirement	Model all the elements using the actual/accurate dimension and correct materials.	Output: Authorities submission. Refer to BCA BIM e-Submission requirement and Guidelines. Use BIM e-Submission Template. Output: Model for co-ordination with Engineers. Output: Tender Documents
	Wall	Update the Walls created in the preliminary design with the parameters required for Detail Design, e.g. Add different Layer thickness, Fire Rating, etc…	
	Load-bearing wall	Load bearing walls includes Core Walls/Shear Walls. Similar to Wall except if the Walls are between Floors then model from Structural Floor Level to Structural Floor Level of Slab below.	
	Slab / Floor	Update the Slabs created in the Preliminary Design with the parameters required for Detailed Design, e.g. Add different Layer thickness, Fire Rating, etc…	
	Door	Update the Doors placed in the Preliminary Design with the parameters required for Detailed Design, e.g. Fitting information. It is good to identify the functional difference (Types) , e.g. "Fire Door"	
	Window / Louver	Update the Windows placed in the preliminary design with the parameters required for Detailed Design, e.g. Fitting information.	
	Column	Update the Columns created in the Preliminary Design based on the Location and Size information from the Structural Engineer.	
	Beam	Model the Beams based on the Location and Size information from the Structural Engineer. Create objects for Beams with special shapes and cross sections.	
	Staircase / Step / Ramp	Create objects for Staircases, Steps and Ramps with special shapes when it is not available in the BIM authoring tool. If required then the Landings and Stair Platforms can be modelled as Slabs. In that case define their "Type" accordingly.	
	Curtain Wall	Model the Curtain Wall to the full height and not necessary to break it storey by storey. Most BIM Authoring tools enable users to insert Doors and Windows into parts of the Curtain Wall.	
	Balcony	Model using either as an Objects or use Walls, Floors, Beams and Railings. Check the specific elements for their modelling guideline.	
	Canopy		
	Roof	Update the Roofs created in the preliminary design with the parameters required for Detailed Design. Eg. Add different Layer thickness, etc…	
	Skylight	Model using objects and define the "Type" accordingly.	
	Hatch		
	Furniture		

	Balustrade / Railings		
	Project-specific objects		
	Suspended ceiling	If the BIM authoring tool do not have a ceiling tool then modelled using a slab tool or object, and define the "Type" as a Ceiling.	
	Space	Refer to Preliminary Design	
	Civil defence shelter, Service platforms, Structures of passageways, Service ducts, Others	Model using Wall, Floor, Column, Roof, Opening, Objects, Door, Space etc. Check the specific elements for their modelling guideline.	
Construction Note: Work together with the contractors and sub contractors to develop the Detailed Design model into Construction model	Refer to Detailed Design model	Model the portions of the buildings that are affected as a result of updates from the Detailed Design models by the other disciplines and variations/RFIs in the design.	Output: Construction model.
As-Built	Refer to Construction model	When the building is complete, the consultant should check the Detailed Design to correspond with the final implementation (As-Built) based on the information from the Contractor.	Output: Model that can be used for space management, building maintenance and modifications made during occupancy by the FM / Employer.

(iv) Structural BIM Modelling Guidelines

General Structural Guidelines:

1) The structural consultant produces both an analysis model and a physical model (Structural BIM) with actual member size and position. The model will be used for documentation. These documents cover the Structural BIM only.
2) Structural modelling is carried out in the following stages: Conceptual, Preliminary, Detail, Construction and As-Built. The types of models produced at each stage depend on the BIM deliverables required.
3) If the design has precast or prefab design. The part can be designed and modelled by a specialist and incorporated/linked into the model for reference.
4) Structural BIM covers all load-bearing concrete, wood and steel structures, as well as non-load-bearing concrete structures. The basic building elements used are Wall, Slab, Beam, Column and Lattice. The building elements must be created using the correct tools (Wall tool, Slab tool, etc.). If the features of BIM authoring tool are not sufficient for modelling the element, the required building elements must be created using other appropriate objects. In that case, define the "Type" of the element correctly.
5) The model can be phased and divided for various ST submissions as per the project planning/individual firm's practice.

6) Rebar and Joint details can be done in Detailed Design Stage based on the capability of the BIM authoring tool.
7) 2D or 2D standard details can be used to complement the BIM model when the elements are smaller than the agreed size, e.g. Elements Smaller than 100mm do not need to be modelled.
8) 2D can be used for loading plans.
9) 2D can be used for the column schedule when the BIM authoring tool has limitations. The shape and cutting of each column should be included in the schedule.
10) Building Elements must be modelled separately for each storey
11) Required Parameters: Type, Material, ID, Size. Type is required for the Quantity Take-off.
12) If more than one tool is used to model certain elements then the elements should be grouped and identified correctly by "Type". Eg. Individual beams can be used to model the roof truss the elements must be grouped as one and define the "Type" as a "Truss"

Stages	Elements	Modelling Guidelines	Remarks
Conceptual	Existing Buildings (As-Built Condition) for Addition & Alternations.	The Structural Consultants expertise may required when assessing and modelling existing structures, in particular the load-bearing structural system. The scope of Structural BIM model will be agreed upon on a project-specific basis. If the existing Buildings were not in BIM then 2D drawings of existing building can be used to complement the BIM model.	Output: Structural Model of Existing Building or portions thereof.
	New Buildings	The Structural Consultants expertise may be required in special cases in the assessment of the alternatives massing model from Architect and propose framing systems. Structural BIM model is optional at this stage.	Output: Structural concept alternatives.
Preliminary Design Note: Preliminary Design model will be based on Architectural Conceptual Design model. It will be developed further based on the co-ordination during Preliminary Design stage.	General Requirement	Model the elements using the nominal dimension or expected dimension based on precision available at Preliminary Design stage. Model the elements that are critical and required for Preliminary Design co-ordination (based on projects requirement) Connections/Joints and Members can be detailed in the Detail Design stage or Construction stage, depending on the project delivery (traditional or D&B).	Input: Geotechnical information/model, Architectural Conceptual Design Model for intended use (for load assumptions) and geometry of the building (to determine the framing system) Note: The location of load bearing elements and the elevation of the floor will be based on the info from the Architect. Output: ST submission. Refer to BCA's BIM e-Submission requirement and Guidelines. Use BIM e-Submission

			Template. Output: Model for co-ordination with Architects and MEP Engineers
	Piling (Pile Cap and Pile) Diaphragm / Retaining Wall Raft Foundation Pad / Isolated Foundation Strip Foundation	If the BIM authoring tool has relevant objects to represent the foundation elements then place them in the correct level and with the relevant parameter. Alternative is to use Slab, Column and Wall to represent foundation elements. Group them and define the "Type" correctly.	When the design is not confirmed the elements can be modelled as reference to use in the Preliminary Design co-ordination with the Architects and MEP Engineers.
	Slab / Roof Slab	Top of Slab = Structural Floor Level Multiple Slabs need to be placed if the levels, thickness, span direction and material are different. The soffit of the structural slab should be shown. When there is a slope in the Slab or the Slab with a special shape and the BIM authoring tool does not have the functionality to create such Slabs, then create the slab geometry using other tools and define the 'Type' as a "slab".	
	Beam	Top of Beam = As per design (Up stand Beam or Down hang Beam) Create objects for Beams with special shapes and cross sections, e.g. Tapering and haunch.	
	Truss	Model with multiple elements and group them as a truss. Note: Some BIM authoring tools have a function to automate this process.	
	Column	Model from the Structural Floor level to Structural Floor Level of Slab below. Create objects for Columns with special shapes and cross sections.	
	Wall	All Load bearing Walls and concrete Walls (non-load bearing) need to be modelled, e.g. Core Walls, Shear Walls, Retaining Walls, Diaphragm Walls. If the Walls are between floors then model from Structural Floor Level to Structural Floor Level of Slab below else the Walls need to model to the correct levels. When the Wall spans across different heights, if the BIM authoring tool permits model as a single Wall with varying height then model as one Wall. Alternative is to model multiple Walls.	
	Staircase, Step and Ramps	Model only the structure part of the Staircase, Steps and Ramps. Create objects for Staircases, Steps and Ramps with special shapes when it is not available in the BIM authoring tool. If required then the landings and Stair platforms can be modelled as Slabs. In that case define their "Type" accordingly.	
	Opening	Model the structural Opening for the Doors,	

		Windows and Ventilations based on location and size information from the Architects. Model the structural Opening for the MEP elements like Ducts based on the location and size information from the MEP Engineers. Model the Floor openings based on location and Size from the Architects and MEP Engineers.	
	Special Structure Civil defence shelter, Tunnel, Link Way, External structures, Balcony, Canopy, Swimming pool, Temporary structures, Others	Model using Wall, Slab, Column, Beam and Opening or placed as an Object and assign the "Type" accordingly. Check the specific elements for their modelling guideline.	When the design is not confirmed the elements can be modelled as reference to use in the Preliminary Design co-ordination with the Architects and MEP Engineers.
Detailed Design Note: Preliminary Design model is further developed into Detailed Design model	General Requirement	Model all the elements using the actual/accurate dimension. Model all the model elements that are critical and required for the Design co-ordination (based on projects requirement) Detail the Connections/Joints and Members based on the BIM authoring tool's capability. The details can be imported as 2D, which is generated automatically by design tools that can link with BIM authoring tool. Divide the project/building as per various ST's or as per agreed Project Plan. Proceed with the modelling according to the schedule.	Output: ST Submissions. Refer to BCA's BIM e-Submission requirement and Guidelines. Use BIM e-Submission Template. Output: Tender Drawings. Output: Model for co-ordination with Architects and MEP Engineers.
	Refer to Preliminary Design	Develop the Preliminary design with more confirmed parameters like Location, Size and Material. Update the correct Type definition that helps detailed quantity take-off.	The detail can be done only for the agreed portion of the building based on the projects need.
Construction Note: Work together with the contractors and sub contractors to develop the Detailed Design model into Construction model	Refer to Detailed Design model	Model the portions of the buildings that are affected as a result of updates from the Detailed Design models by the other disciplines and variations/RFIs in the design. Deepening of structures should be detailed in shopdrawings, if necessary.	Output: Construction model.
As-Built	Refer to Construction model	When the building is complete, the consultant should check the Detailed Design to correspond with the final implementation (As-Built) based on the information from the Contractor.	Output: Model that can be used for operation, building maintenance and modifications made during occupancy by the FM / Employer.

(v) MEP BIM Modelling Guidelines

a. ACMV

Stages	Elements	Modelling Guidelines	Remarks
Conceptual	System distribution lines	Use line diagrams to show the entire system distribution Include equipment symbols in the line diagrams.	Output: Schematic diagrams
	Space objects	Use box objects to represent spaces required for MEP systems Add names and colours to the space objects.	
Preliminary Design	Zone Objects, Air Handling Unit, Chiller Unit Variable refrigerant flow unit, Cooling tower, Exhaust air ducts, Fresh air ducts, Supply air ducts, Return air ducts, Transfer air ducts, Chilled water supply pipes, Chilled water return pipes, Condensate drain pipes	Zone the spaces that have common design requirements with colour legends on plans. Model each element using the correct BIM generic object Each element should have an approximate size. Show only the main routes of the systems. All ducts and pipes should be connected to the equipments. Fasteners and hangers are not required. In-line accessories, e.g. valves, fire dampers, volume controls and air filters are not required. Use CP83 symbols.	Output: Preliminary Model Shows main distribution into different zones Engineers should verify the space allocated by the Architect.
Detailed Design	Main elements of Preliminary Design Fire dampers, Motorized dampers, Volume control dampers Split-type indoor & outdoor air conditioning units Exhaust or extract air fans Fresh air fans Other fans such as jet fans Diffusers, air-boots, air grilles, air filters, registers Fan Coil unit Switch boards, Control, BMS & DDC panels BMS control & monitoring modules	Use CP83 symbols and colour standards Model each element using object correspond to actual component with actual size, material, type code and performance criteria. Include insulation to reflect actual size for coordination purpose. System routing should be connected with fittings. Unavailable BIM objects that are modelled using different objects should be identified accordingly, e.g. use proper names and colours. Downward slopes of the pipes should be modelled realistically. Required fittings allowances, cross-over spaces and maintenance spaces should be considered. Fasteners and hangers are not necessary. Commercial product libraries can be used to the extent allowed by the modelling	Output: Detailed model for e-Submission and Tender For BIM e-Submission, please also refer to submission guidelines Services should be coordinated with architecture model Proposed position of mechanical components base on calculation or analysis e.g. air terminals, FCU should

		software. Fire rating should be included in the fire damper objects. Pipe Accessories should follow the CP83 symbols in plan views. For design coordination, documents such as coordinated services plans, sections, elevations, etc. should be derived from the model.	be approved by the architect.
Construction	The elements are the same as Detailed Design stage.	Model the portions of the building that need more attention. All changes made by contractor & approved by consultants should be clearly indicated. Objects not found in BIM tool can be represented by a box with proper identification and attributes such as equipment name, capacity, etc. Levels of the elements comprising the system from finish floor line or at the certain reference in the model should be clearly annotated. For construction coordination, documents such as coordinated services plans, sections, elevations, etc. should be derived from the model. Fasteners can be modelled if necessary.	Output: Model with construction details Contractor to develop the detailed Design BIM into Construction BIM.
As-Built	The elements are the same as Construction phase.	When the building is complete, the consultant should check the Detailed Design to correspond with the final implementation (As-Built) based on the information from the Contractor.	Output: Model that can be used for space management, building maintenance and modifications made during occupancy by the FM / Employer.

b. Plumbing & Sanitary

Stages	Elements	Modelling Guidelines	Remarks
Conceptual	System distribution lines	Use line diagrams to show the entire system distribution Include equipment symbols in the line diagrams.	Output: Schematic diagram
	Space objects	Use box objects to represent spaces required for MEP systems Add names and colours to the space objects.	

Preliminary Design	Zone objects, Plumbing equipments Plumbing fixtures Sump and sewage pits Storage, water holding tanks, pressure vessels Water meters chambers Manholes, outlets, surface and slot channels	Zone the spaces that have common design requirements with colour legends on plans. Model each element using the correct BIM generic object Each element should have an approximate size. Show only the main routes of the systems. All main pipes should be connected to the equipments. Fasteners and hangers are not required. In-line accessories e.g. valves, filters, water meters are not required. Use CP83 symbols.	Output: Preliminary Model Shows main distribution into different zones Engineers should verify the space allocated by the Architect.
Detailed Design	Main elements of Preliminary Design Fresh water piping, Fittings, Valves, including hot and cold water pipes Rainwater and storm water pipes Foul drainage and kitchen waste pipe work including Floor drains, Open trapped gullies, Sealed trapped gullies, Clean outs, Vents Control panels, Monitoring and control sensors Underground public utilities for water supply Underground public utilities for drainage	Use CP83 symbols and colour standards Model each element using object correspond to actual component with actual size, material, type code and performance criteria. Include insulation to reflect actual size for coordination purpose. System routing should be connected with fittings. Unavailable BIM objects that are modelled using different objects should be identified accordingly, e.g. use proper names and colours. Downward slopes of the pipes should be modelled realistically. Required fittings allowances, cross-over spaces and maintenance spaces should be considered. Fasteners and hangers are not necessary. Commercial product libraries can be used to the extent allowed by the modelling software. Pipe Accessories should follow the CP83 symbols in plan views. For design coordination, documents such as coordinated services plans, sections, elevations, etc. should be derived from the model.	Output: Detailed model for e-Submission and Tender For BIM e-Submission, please also refer to submission guidelines Services should be coordinated with architecture model
Construction	The elements are the same as Detailed Design stage.	Model the portions of the building that need more attention. All changes made by contractor & approved by consultants should be clearly indicated. Objects not found in BIM tool can be represented by a box with proper	Output: Model with construction details Contractor to develop the detailed Design BIM

		identification and attributes such as equipment name, capacity, etc. Levels of the elements comprising the system from finish floor line or at the certain reference in the model should be clearly annotated. For construction coordination, documents such as coordinated services plans, sections, elevations, etc. should be derived from the model. Fasteners can be modelled if necessary.	into Construction BIM.
As-Built	The elements are the same as Construction phase.	When the building is complete, the consultant should check the Detailed Design to correspond with the final implementation (As-Built) based on the information from the Contractor.	Output: Model that can be used for space management, building maintenance and modifications made during occupancy by the FM / Employer.

c. Fire Protection

Stages	Elements	Modelling Guidelines	Remarks
Conceptual	System distribution lines	Use line diagrams to show the entire system distribution Include equipment symbols in the line diagrams.	Output: Schematic diagrams
	Space objects	Use box objects to represent spaces required for MEP systems Add names and colours to the space objects.	
Preliminary Design	Zone Objects	Zone the spaces that have common design requirements with colour legends on plans.	Output: Preliminary Model Shows main distribution into different zones
Detailed Design	Main elements of Preliminary Design Sprinkler pipework Fire sprinkler pumps Sprinkler heads SIB (Sub-Indicator Board) Sprinkler control valve sets (Main stop valve, Subsidiary valve with indicator,	Use CP83 symbols and colour standards Model each element using object correspond to actual component with actual size, material, type code and performance criteria. Include insulation to reflect actual size for coordination purpose. The types, finish, temperature rating and orifice sizes should be indicated. Unavailable BIM objects that are modelled using different objects should be identified	Output: Detailed model for e-Submission and Tender For BIM e-Submission, please also refer to submission guidelines Services should be

	Alarm valve, Water motor alarm/gong , Test and drain valve, Pressure gauges and Direct read water flow meter.) Hydrants and hose reels, including street fire hydrant system Fire alarm gongs, Break glass unit Fire shutters and hoods above Gas piping for suppression systems Heat or smoke detectors, Control panels, Monitoring and control sensors, Pump panels, Check meter positions Breeching inlet Breeching inlet cabinet Fire extinguishers	accordingly, e.g. use proper names and colours. System routing should be connected with fittings. Required fittings allowances, cross-over spaces and maintenance spaces should be considered. Fasteners and hangers are not necessary. Commercial product libraries can be used to the extent allowed by the modelling software. Pipe Accessories should follow the CP83 symbols in plan views. Size of breeching inlet cabinet For design coordination, documents such as coordinated services plans, sections, elevations, etc. should be derived from the model.	coordinated with architecture model Engineers should verify the space allocated by the Architect.
Construction	The elements are the same as Detailed Design stage.	Model the portions of the building that need more attention. All changes made by contractor & approved by consultants should be clearly indicated. Objects not found in BIM tool can be represented by a box with proper identification and attributes such as equipment name, capacity, etc. Levels of the elements comprising the system from finish floor line or at the certain reference in the model should be clearly annotated. For construction coordination, documents such as coordinated services plans, sections, elevations, etc. should be derived from the model. Fasteners can be modelled if necessary.	Output: Model with construction details Contractor to develop the detailed Design BIM into Construction BIM.
As-Built	The elements are the same as Construction phase.	When the building is complete, the consultant should check the Detailed Design to correspond with the final implementation (As-Built) based on the information from the Contractor.	Output: Model that can be used for space management, building maintenance and modifications made during occupancy by the FM / Employer.

d. Electrical

Stages	Elements	Modelling Guidelines	Remarks
Conceptual	System distribution lines	Use line diagrams to show the entire system distribution Include equipment symbols in the line diagrams.	Output: Schematic diagrams
	Space objects	Use box objects to represent spaces required for MEP systems Add names and colours to the space objects.	
Preliminary Design	Zone Objects, Transformers HV & LV switch boards, Switchgear, MCCB boards, MCB boards Cable trays, Trunking & cable containment Electrical risers Generators and exhaust flues, including acoustic treatments Diesel tanks & fuel pipes Telecom equipment and computer racks	Zone the spaces that have common design requirements with colour legends on plans. Model each element using the correct BIM generic object Each element should have an approximate size. Show only the main routes of the systems. All cable trays, conduits and trunkings should be connected to the equipments. Wires, fasteners and hangers are not required. In-line accessories eg. valves, fire dampers, volume controls and air filters are not required. Use CP83 symbols.	Output: Preliminary Model Shows main distribution into different zones
Detailed Design	Main elements of Preliminary Design Light fittings, Fixtures, Housings for light fixtures Conduit, Busduct, Power feeds Concealed and cast-in-place conduits Outlets, Panels Wall switches, Circuiting to devices, Security devices, Card access, “Plug moulds” (socket points) Conduit associated with access, data communication, security systems and electrical equipment Security system including	Use CP83 symbols and colour standards Model each element using object correspond to actual component with actual size, material, type code and performance criteria. Include insulation to reflect actual size for coordination purpose. System routing should be connected with fittings. Unavailable BIM objects that modelled using different objects should be identified accordingly, eg, use proper names and colours. Required fittings allowances, cross-over spaces and maintenance spaces should be considered. Fasteners and hangers are not necessary. Commercial product libraries can be used to the extent allowed by the modelling software. Electrical devices e.g. switches, power outlets, telephone and TV outlets should	Output: Detailed model for e-Submission and Tender For BIM e-Submission, please also refer to submission guidelines Services should be coordinated with architecture model Engineers should verify the space allocated by the architect

	CCTV camera, smart card system, door monitoring system Car park control system, Barrier gates Equipment and associated installations maintained by public utility companies	follow the CP83 symbols in plan views. For design coordination, documents such as coordinated services plans, sections, elevations, etc. should be derived from the model.	
Construction	The elements are the same as Detailed Design stage.	Model the portions of the building that need more attention. All changes made by contractor & approved by consultants should be clearly indicated. Objects not found in BIM tool can be represented by a box with proper identification and attributes such as equipment name, capacity, etc. Levels of the elements comprising the system from finish floor line or at the certain reference in the model should be clearly annotated. For construction coordination, documents such as coordinated services plans, sections, elevations, etc. should be derived from the model. Fasteners can be modelled if necessary.	Output: Model with construction details Contractor to develop the detailed Design BIM into Construction BIM.
As-Built	The elements are the same as Construction phase.	When the building is complete, the consultant should check the Detailed Design to correspond with the final implementation (As-Built) based on the information from the Contractor.	Output: Model that can be used for space management, building maintenance and modifications made during occupancy by the FM / Employer.

Appendix C – BIM Project Execution Plan Template 1

This appendix is adapted from the **"BIM Project Execution Template"** by the Penn State Computer Integrated Construction (CIC) Research Group, which can be downloaded separately from the CIC website at http://bim.psu.edu/Project/resources/

Important: This template example is based on US practices. Users are expected to interpret content appropriately and customize for local practices, where necessary.

Section A: BIM Project Execution Plan Overview

To successfully implement Building Information Modeling (BIM) on a project, the project team has developed this detailed BIM Project Execution Plan. The BIM Project Execution Plan defines uses for BIM on the project (e.g. design authoring, cost estimating, and design coordination), along with a detailed design of the process for executing BIM throughout the project lifecycle.

[INSERT ADDITIONAL INFORMATION HERE IF APPLICABLE. FOR EXAMPLE: BIM MISSION STATEMENT. This is the location to provide additional BIM overview information. Additional detailed information can be included as an attachment to this document.

Please note: Instructions and examples to assist with the completion of this guide are currently in grey. The text can and should be modified to suit the needs of the organization filling out the template. If modified, the format of the text should be changed to match the rest of the document. This can be completed, in most cases, by selecting the normal style in the template styles.

Section B: Project Information

This section defines basic project reference information and determined project milestones.

1. Project Owner: _____
2. Project Name: _____
3. Project Location and Address: _____
4. Contract Type / Delivery Method: _____
5. Brief Project Description: _____
6. Additional Project Description: _____
7. Project Numbers: _____
8. Project Schedule / Stages / Milestones: _____

Include BIM milestones, pre-design activities, major design reviews, stakeholder reviews, and any other major events which occur during the project lifecycle.

Section C: Key Project Contacts

List of lead BIM contacts for each organization on the project. Additional contacts can be included later in the document.

Section D: Project Goals / BIM Uses

Describe how the BIM Model and Facility Data are leveraged to maximize project value (e.g. design alternatives, life-cycle analysis, scheduling, estimating, material selection, pre-fabrication opportunities, site placement, etc.) Reference www.engr.psu.edu/bim/download for BIM Goal & Use Analysis Worksheet.

1. Major BIM Goals / Objectives: _____
2. BIM Use Analysis Worksheet: Attachment 1
Reference www.engr.psu.edu/bim/download for BIM Goal & Use Analysis Worksheet. Attach BIM Use analysis Worksheet as Attachment 1.
3. BIM Uses: _____
See BIM Project Execution Planning Guide at www.engr.psu.edu/BIM/BIM_Uses for Use descriptions.

Section E: Organizational Roles / Staffing

Determine the project's BIM Roles / Responsibilities and BIM Use Staffing.

1. BIM Roles and Responsibilities: _____
Describe BIM roles and responsibilities such as BIM Managers, Project Managers, Draftspersons, etc.
2. BIM Use Staffing: _____
For each BIM Use selected, identify the team within the organization(s) who will staff and perform that Use and estimate the personal time required.

Section F: BIM Process Design

Provide process maps for each BIM Use selected in section D: Project Goals / BIM Objectives. These process maps provide a detailed plan for execution of each BIM Use. They also define the specific Information Exchanges for each activity, building the foundation for the entire execution plan.

1. Level One Process Overview Map: Attachment 2
2. List of Level Two – Detailed BIM Use Process Map(s): Attachment 3

Section G: BIM Information Exchanges

Model elements by discipline, level of detail, and any specific attributes important to the project are documented using information exchange worksheets.

1. List of Information Exchange Worksheet(s): Attachment 4
2. Model Definition Worksheet: Attachment 5

Section H: BIM and Facility Data Requirements

The section should include the owners' BIM requirements. It is important that the owner's requirements for BIM be considered so that they can be incorporated into the project's BIM process.

Section I: Collaboration Procedures

1. Collaboration Strategy: _____
Describe how the project team will collaborate. Include items such as communication methods, document management and transfer, and record storage, etc.
2. Meeting Procedures: _____
3. Model Delivery Schedule of Information Exchange for Submission and Approval:
_____
Document the information exchanges and file transfers that will occur on the project.
4. Interactive Workspace: _____
The project team should consider the physical environment it will need throughout the lifecycle of the project to accommodate the necessary collaboration, communication, and reviews that will improve the BIM Plan decision making process. Include any additional information about workspaces on the project.
5. Electronic Communication Procedures: _____
Resolve document management issues and define a procedure for each issue: Permissions / Access, File Locations, FTP Site Location(s), File Transfer Protocol, File / Folder Maintenance, etc.

Section J: Quality Control

1. Overall Strategy for Quality Control: _____
Describe the strategy to control the quality of the model.
2. Quality Control Checks: _____
Perform checks to assure quality.
3. Model Accuracy and Tolerances: _____
Models should include all appropriate dimensioning as needed for design intent, analysis, and construction. Level of detail and included model elements are provided in the Information Exchange Worksheet (Section J).

Section K: Technological Infrastructure Needs

1. Software: _____
List software used to deliver BIM.
2. Computer: _____
Understand hardware specification becomes valuable once information begins to be shared between

several disciplines or organizations. It also becomes valuable to ensure that the downstream hardware is not less powerful than the hardware used to create the information. In order to ensure that this does not happen, choose the hardware that is in the highest demand and most appropriate for the majority of BIM Uses.

3. Modeling Content and Reference Information: _____

Identify items such as families, workspaces, and databases.

Section L: Model Structure

1. File Naming Structure: _____

Determine and list the structure for model file names.

2. Model Structure: _____

Describe the measurement system (Imperial or Metric) and coordinate system (geo-referenced) used.

3. BIM and CAD Standards: _____

Identify items such as the BIM and CAD standards, content reference information, and the version of IFC, etc.

Section M: Project Deliverables

In this section, list the BIM deliverables for the project and the format in which the information will be delivered.

Section N: Delivery Strategy / Contract

1. Delivery and Contracting Strategy for the Project: _____

What additional measures need to be taken to successfully use BIM with the selected delivery method and contract type?

2. Team Selection Procedure: _____

How will you select future team members in regards to the above delivery strategy and contract type?

3. BIM Contracting Procedure: _____

How should BIM be written into the future contracts? (If documents / contracts are developed, please attach as attachment 6)

Section O: Attachments

1. _____
2. _____

Appendix D – BIM Project Execution Plan Template 2

This appendix is adapted from the **"BIM Project Execution Template"** by Indiana University, which can be downloaded separately from the Indiana University BIM Standards website at http://www.indiana.edu/~uao/IU%20BIM%20Execution%20Plan%20Template.doc

Important: This template example is based on US practices. Users are expected to interpret content appropriately and customize for local practices, where necessary.

1. Overview

The intent of this BIM Execution Plan is to provide a framework that will let the owner, architect, engineers, and construction manager deploy building information modelling (BIM) technology and best practices on this project faster and more cost-effectively. This plan delineates roles and responsibilities of each party, the detail and scope of information to be shared, relevant business processes and supporting software.

All text that is grey is for illustrative purposes only and should not be construed as a formalized response to this execution plan.

2. Project Initiation

This section defines the Core Collaboration Team, the project objectives, project stages, and overall communication plan throughout the project's stages.

A. Project Information

Project Name: _____

Project Number: _____

Project Address: _____

Project Description: _____

B. Core Collaboration Team

Contact Name	Role / Title	Company	Email	Phone

C. Project Goals and Objectives

Project Goal	Objective	Achieved if	Project Timeframe

D. Collaborative Process Mapping (Coordination Plan)

	Project Stakeholders Involved				
	Owner	Architect	Consulting Engineers	Construction Manager	Commissioning Agent
Conceptualization / Program of Requirements					
Criteria Design / Schematic Design					

E. Project Stages / Milestones

Project Stage / Milestone	Estimated Start Date	Estimated Completion Date	Project Stakeholders Involved
Detailed Design / Design Development			
Implementation Documents / Construction Documents			

3. Modeling Plan

Advance planning around which models will need to be created during the different stages of the project, who will be responsible for updating models and distributing them, and predetermining the content and format of models as much as possible will help your project run more efficiently and cost-effectively during every stage.

A. Model Managers

Each party – such as the owner, architect, contractor, or sub-consultants – that is responsible for contributing modelling content should assign a model manager to the project. The model manager from each party has a number of responsibilities. They include, but are not limited to:

- Transferring modelling content from one party to another
- Validating the level of detail and controls as defined for each project stage
- _____
- _____

Stakeholder Company Name	Model Manager Name	Email	Phone

B. Planned Models

In the table below, outline the models that will be created for the project. List the model name, model content, project stage when the model will be delivered, the model's authoring company, and the model authoring tool that will be used. For models that will not be used or created in your project, just leave the row blank, and add rows for model types you anticipate needing that are not already listed.

Model Name	Model Content	Project Stage	Authoring Company	Authoring Tool
Architectural Model	Architectural objects, code information	Conceptualization / Program of Requirements Stage		Autodesk Revit Architecture

C. Model Components

As an aid to usability during later stages of your project, specify what the content, level of detail, and file naming structure of your models should look like.

1. File Naming Structure

   Determine and list the structure for model file names.

File names for models should be formatted as:	
Architectural Model	ARCH -
Civil Model	CIVIL -

2. Precision and Dimensioning

   Models should include all appropriate dimensioning as needed for design intent, and construction. With the exception of the exclusions listed below, the model will be considered accurate and complete. In the table below, enter which items' placement will not be considered entirely accurate and should not be relied on for placement or assembly.

Items that will not be considered accurate for dimensioning or placement
MEP --
Construction --

3. Modeling Object Properties

   The level of property information in the modelling objects and assemblies depends on the types of analysis that will be performed on the model. See the following 4. A. (Analysis Models) for the types of analysis that will be performed.

4. Modeling Level of Detail

   Specify the level of detail in your models below. The level of detail can be defined by exclusions and / or by object size.

   i. Exclusions: List the objects that will be excluded from the model in the table below.

Items that will be excluded from the Model
Architectural --
MEP --

   ii. Size: Any object smaller than [TBD] will not be included in the model.

5. Detailed Modeling Plan
   - i. Conceptualization / Program of Requirements Stage
     - Objective : _____
     - Model Roles : _____
     - Responsibilities : _____
   - ii. Criteria Design / Schematic Design Stage
   - iii. Detailed Design / Design Development Stage
   - iv. Implementation Documents / Construction Documents Stage
   - v. Agency Coordination / Bidding Stage
   - vi. Construction
   - vii. Facility Management

4. Analysis Plan

By listing and specifying what types of analysis your project will likely require at the beginning of your project, you can ensure that your key models will include the relevant information, making the analysis easier and more efficient.

A. Analysis Models

Your project's scope of work may require performing certain kinds of analysis, such as the ones listed below, based on existing or specially created model(s). In most cases the quality of the analysis depends on the quality of the original model that the analysis is derived from. Therefore the project team member performing the analysis should clearly communicate the analysis requirements to the original model authoring team member.

i. Quantity Takeoff Analysis
ii. Scheduling Analysis
iii. Visualization Analysis
iv. Energy Analysis
v. Structural Analysis

B. Detailed Analysis Plan

For each type of analysis that may be performed for your project, list the models used for the analysis, which company will perform the analysis, the file format required for the analysis, the estimated project stage, and the analysis tool that will be used. If there are other special instructions associated with the analysis, mark the Special Instructions column and list the details in the Special Instructions table in the next section.

Analysis	Analysis Tool	Model	Authoring Company	Authoring Tool
Quantity Takeoff		All Models		.rvt

C. Clash Detection Process

Clash detection analysis is done to check for interferences between the designs of one or many models. To reduce change orders during construction, clash detection should be performed early and continue throughout the design process. For clash detection to work properly your project's models need to have a common reference point and they must be compatible with the clash detection tool.

5. Concurrent As-Built Modeling Plan

As-built modelling will be a collaborative effort between the Architect and consultants and the construction team. During the construction process, the design team will incorporate changes triggered by requests for information (RFIs), architect's supplemental instructions (ASIs) and change orders into the Architectural and Consultant models. At specified dates during the construction process, the construction team will provide the design team with necessary changes due to shop drawings, coordination drawings and change orders. As required, the completed form of the construction will also be verified at these specified dates using laser scanning. The design team will then incorporate the changes reported by the construction team into the Architectural and Consultant models. At the end of construction, it will be the updated Architectural and Consultant models that are used for facility management.

A. Construction Capture Schedule

Event	Date	Parties involved
Construction Capture 1		Construction team, Design team, [Laser Scanning]

6. Collaboration Plan

Creating a collaboration plan early on – including defining permissions and file structures – will help team members efficiently communicate, share, and retrieve information throughout the project. It lets you get the most out of your collaborative project management system, saving time and increasing your ROI.

A. Document Management

A Collaborative Project Management system will have to be researched and agreed upon prior to start of project. The requirements of the Collaborative Project Management system are;

- Be web-based or web-enabled – so all relevant, authorized project team members can remotely access it.
- Accommodate different permissions profiles for different project team members.
- _____
- _____

B. Document Management Solution

A document management solution will be provided by the owner. The document management solution that will be used is called [TBD]. The architect will setup the site and set up all permissions for the site. The architect will lead a training session for the entire project team on how to use the site. The site will be maintained from the signing of this document until the occupation of the building.

Appendix E – Sample of the BIM Particular Conditions Version 1.0

The sample of the BIM Particular Conditions Version 1.0 on the following pages may be attached to the Principal Agreement when incorporating the use of BIM into the project, as part of the scope of services under the Principal Agreement.

Please read the Notes below before using the BIM Particular Conditions.

Notes:

A. This document is for use in construction projects where Building Information Modelling (BIM) is used and shall be called the BIM Particular Conditions. All parties in such projects shall incorporate the BIM Particular Conditions as a contract document in their respective agreements for services, supply and/or construction for the project.

B. The BIM Steering Committee (BIMSC) appointed by the Building and Construction Authority (BCA) developed this document. The BIMSC consists of representatives from a wide cross-section of the construction industry. The BIM Particular Conditions was developed by consensus of opinion of the members of the BIMSC.

C. The BIM Particular Conditions can be used for all methods of procurement. However, this document does not cover all issues in the use of BIM; especially those that may be specific to any particular user. The BIMSC therefore encourages users to review and adapt the BIM Particular Conditions for specific use. Users should obtain appropriate professional/legal advice before making any changes to the BIM Particular Conditions.

D. Please refer to the Notes to Users at the end of this document for further information.

PARTICULAR CONDITIONS FOR BUILDING INFORMATION MODELLING

1. DEFINITIONS

1.1. **BIM** means building information modelling and is the process and technology used to create a Model.

1.2. **BIM Guide** means the guide to the use of BIM published by the Building and Construction Authority for the time being in force (the Singapore BIM Guide) or such other guide to the use of BIM as may be expressly provided in the Principal Agreements.

1.3. **BIM Particular Conditions** means these particular conditions for BIM.

1.4. **BIM Execution Plan** means the plan referred to in Clause 4 of this BIM Particular Conditions.

1.5. **BIM Manager** means the person, firm or corporation appointed by the Employer as BIM Manager pursuant to Clause 3 and includes any person, firm or corporation appointed by the Employer to replace an existing BIM Manager.

1.6. **Construction Documents** means all drawings, calculations, computer software programmes, samples, patterns, models and other information of a similar nature prepared by the Designer for the Project but not a Model.

1.7. **Contribution** means the expression, design, data or information that a party to the Project (a) creates or prepares, and (b) incorporates, distributes, transmits, communicates or otherwise shares with other parties to the Project for use in or in connection with a Model for the Project.

1.8. **Designer** refers to the party or parties in the Project who are responsible for the design of the whole or some part of the Project under the relevant Principal Agreement(s).

1.9. **Drawings** means (a) those two-dimensional plans, sketches or other drawings that are contract documents in the Principal Agreement and are created separately from, and are not derived from, a Model and (b) those two-dimensional projections derived from a Model supplemented with independent graphics and annotations specified by the parties to be contract documents in the Principal Agreement.

1.10. **Employer** means the owner of the Project including any government or statutory body.

1.11. **Model** means a digital representation of the physical and functional characteristics of the Project, that is, a three-dimensional representation in electronic format of building elements representing solid objects with true-to-scale spatial relationships and dimensions. A Model may include additional information or data. A Model may be used to describe a **Model Element** (that is, a portion of the Model representing a component, system or assembly within the Project or Project site), a single Model or

multiple Models used in aggregate or in federation. BIM is the process and technology used to create the Model.

1.12. **Final Design Model** means a Model of those aspects of the Project that are (a) to be modelled as specified in the BIM Execution Plan and (b) have reached the stage of completion that would customarily be expressed in two-dimensional construction documents. This shall not include analytical evaluations, preliminary designs, studies, or renderings. A Model prepared by a Designer that has not reached the stage of completion specified in this definition is referred to as a Model.

1.13. **Model Author** means the party responsible for developing the content of a specific Model Element to the level of detail required for a particular phase of the Project. **Model Authors** are identified in the Model Element Table in the BIM Execution Plan.

1.14. **Model User** means any individual or entity authorised to use the Model on the Project, such as for analysis, estimating or scheduling.

1.15. **Principal Agreement** in relation to any party in the Project means the agreement for services, supply and/or construction which that party has entered into for the Project.

1.16. **Project** means the project in which the parties will be carrying out BIM pursuant to their respective Principal Agreements.

2. GENERAL PRINCIPLES

2.1. The parties to a Project shall incorporate the BIM Particular Conditions into all agreements for services, supply and/or construction where at least one party shall be required to be involved in carrying out BIM. This BIM Particular Conditions shall be passed downstream to subconsultants, suppliers and subcontractors, as applicable.

2.2. The BIM Particular Conditions does not change any contractual relationships or shifts any risks of the parties in a Project as provided in the Principal Agreements. In particular:

2.2.1. Nothing in this BIM Particular Conditions shall relieve a Designer from its obligation, nor diminish the role of the Designer, as the person responsible for and in charge of the design of the Project or any part of the Project.

2.2.2. Where under applicable law or in contract, the Employer warrants to any party the adequacy and/or sufficiency of design, nothing in this BIM Particular Conditions shall diminish the extent to which the Employer warrants to any party the adequacy and/or sufficiency of design.

2.2.3. Participation of a contractor or its subcontractors and suppliers in carrying out BIM shall not constitute performance of design services unless in the Project, the contractor or its subcontractors and suppliers had assumed design responsibility under their respective Principal Agreements.

2.2.4. In the event of any inconsistency between a Model and any Drawings, the Drawings shall prevail.

2.3. In the event of any inconsistency between the BIM Particular Conditions and the applicable Principal Agreement, the BIM Particular Conditions shall prevail.

2.4. As regards the Models produced in BIM:

2.4.1. A Final Design Model is not intended to provide the level of detail needed in order to extract precise materials or object quantities, unless the parties agree in the BIM Execution Plan otherwise.

2.4.2. The dimensional tolerances provided in the Principal Agreement shall apply to the dimensions in a Model, unless the parties agree in the BIM Execution Plan otherwise.

2.4.3. If there is a conflict between a Final Design Model and any other Model, the Final Design Model shall prevail.

2.4.4. If any party to the Project becomes aware of a discrepancy between a Model and either another Model or any contract document in the Principal Agreement, that party shall immediately notify all the other parties to the Principal Agreement and the BIM Manager.

3. BIM MANAGEMENT

3.1. The Employer shall appoint one or more BIM Managers for the Project. All compensation and related costs for the BIM Manager shall be paid by the Employer unless otherwise agreed between the parties to the Project. The Employer may appoint any one or more of the parties in a Project as BIM Manager in addition to the duties and obligations of that party under the Principal Agreement.

3.2. The role and responsibility of the BIM Manager shall be as provided in the BIM Guide unless expressly agreed otherwise in the BIM Execution Plan.

4. BIM EXECUTION PLAN

4.1. As soon as practicable and from time to time as required, the BIM Manager shall call all parties to the Project involved in the execution of BIM to meet, confer and use their best efforts to agree upon the terms of or modifications to a BIM Execution Plan.

4.2. The BIM Execution Plan and the Model shall be developed in accordance with the BIM Guide.

4.3. As soon as practicable and from time to time as required, the BIM Manager shall call all parties to the Project involved in the execution of BIM to identify and agree on the Final Design Model.

4.4. The BIM Manager shall schedule and chair all meetings. In the event of any disagreement on the terms or modifications to the BIM Execution Plan, the BIM

Manager's decision shall be final and conclusive. In the event that more than one BIM Manager has been appointed in accordance with Clause 3, then the decision shall be the joint decision of the BIM Managers.

4.5. If under the BIM Execution Plan for the time being in force, any party is required to perform or carry out any work which is beyond its scope of work under the Principal Agreement; such work shall be treated as additional works or variations under the Principal Agreement.

5. RISK ALLOCATION

5.1. Each Model Author's Contribution is intended to be shared with subsequent Model Authors and Model Users throughout the course of the Project.

5.2. In contributing content to the Model, the Model Author does not convey any ownership right in the content provided or in the software used to generate the content. Unless otherwise granted in a separate licence, any subsequent Model Author's and Model User's right to use, modify, or further transmit the Model is specifically limited to the design and construction of the Project, and nothing contained in this BIM Particular Conditions conveys any other right to use the Model for another purpose.

5.3. It is understood that while the content of a specific Model Element may include data that exceeds the required level of detail specified in the BIM Execution Plan, Model Users and subsequent Model Authors may rely on the accuracy and completeness of a Model Element consistent only with the content required for the level of detail identified in the BIM Execution Plan.

5.4. Any use of, or reliance on, a Model Element inconsistent with the level of detail indicated in the BIM Execution Plan by subsequent Model Authors or Model Users shall be at their own sole risk and without liability to the Model Author. Subsequent Model Authors and Model Users shall indemnify and defend the Model Author from and against all claims arising from or related to the subsequent Model Author's or Model User's unauthorised modification to, or use of, the Model Author's content.

5.5. To the extent that any or all Final Design Models are included as contract documents, parties may rely upon the accuracy of information in those Final Design Models (including dimensional accuracy) unless otherwise specified in the BIM Execution Plan.

5.6. The standard of care applicable to each party regarding any Contribution shall be in accordance with the Principal Agreement or if none is specified, in accordance to applicable law.

5.7. Each party shall use its best efforts to minimize the risk of claims and liability arising from the use of or access to its Model or the Final Design Model. Such efforts shall include promptly reporting to the relevant party and the BIM Manager any errors, inconsistencies or omissions it discovers in its Model or the Final Design Model. However, this section shall not relieve any party of liability for any of its Contribution.

5.8. No party involved in creating a Model shall be responsible for costs, expenses, liabilities, or damages which may result from use of its Model beyond the uses stated in the BIM Execution Plan.

6. INTELLECTUAL PROPERTY RIGHTS

6.1. Each party warrants to the other parties to the Principal Agreement that either (a) that party is the owner of all copyrights in all of that party's Contributions, or (b) that party is licensed or otherwise authorised by the holders of copyrights of expression contained in the Contribution to make such Contribution under the terms of this BIM Particular Conditions. Each party agrees to indemnify and hold such other parties harmless against claims of third parties arising out of or relating to, claims or demands relating to infringement or alleged infringement of expression contained in that party's Contribution. Nothing in this BIM Particular Conditions is intended to limit, transfer, or otherwise affect any of the intellectual property rights that a party may have with respect to any Contribution, except for licences or permissions expressly granted by this BIM Particular Conditions or the Principal Agreement.

6.2. Subject to the provisions of Clause 6.1, each party grants to the other party or parties to the Principal Agreement for the sole purpose of the other party or parties carrying out their respective duties and obligations relating to the Project:

6.2.1. A limited, non-exclusive licence to produce, distribute, display, or otherwise use that party's Contribution for purposes of this Project only.

6.2.2. A limited, non-exclusive sub-licence to reproduce, distribute, display, or otherwise use, for the purposes of this Project only, the Contributions of those other parties to the Project who have granted that party an identical licence or sub-licence;

6.2.3. The right to grant an identical sublicence to any other party to the Project with which the licensee has a contract in which this BIM Particular Conditions is incorporated by reference; and

6.2.4. A limited, non-exclusive licence to reproduce, distribute, display, or otherwise use any Model containing such Contributions, or any other Model with which the Model containing such Contributions is federated or otherwise related.

The limited licence granted in this Clause shall include any archival purposes permitted in this BIM Particular Conditions or in the Principal Agreement.

6.3. If a party to a Principal Agreement is the holder of copyrights in the Contribution of another party to the Project or is the grantee of an exclusive licence with respect to such Contribution, then such holder or exclusive licensee hereby grants to the other party or parties to the Principal Agreement the right to grant to other parties to the Project with which that other party has or those parties have a contract in which this BIM Particular Conditions is incorporated, a limited licence in the terms set forth in Clause 6.2.

6.4. The Employer's entitlement to use any Final Design Model after completion of the Project shall be governed by the Principal Agreement(s) between the Employer and the Designer(s).

6.5. Unless otherwise limited herein or by express licence-limiting terms in the Principal Agreement, the non-exclusive licence granted in this BIM Particular Conditions shall remain in effect as permitted by law. In addition, after final completion of the Project, the non-exclusive licence shall be limited to keeping an archival copy of Project-related Contributions.

6.6. In the absence of express language to the contrary in the Principal Agreement or in this BIM Particular Conditions, nothing in this BIM Particular Conditions, and no act by any party in the Project in furtherance of this BIM Particular Conditions, shall be deemed or construed to deprive or dispossess any party in the Project of copyrights or licence rights held by that party in its respective underlying Contribution to any Model. Other parties, persons or entities that provide Contributions to a Model shall not be deemed to be co-authors in the Contributions of other parties to the Project.

Notes to Users:

1. Clause 1.2 defines the BIM Guide as either the Singapore BIM Guide published by BCA or such other guide as may be expressly provided in the Principal Agreements. If the user intends to use any other guide for a project, then it is absolutely critical that this be stated in the Principal Agreements (see next paragraph for a suggestion on how this can be done).

2. For the BIM Particular Conditions to apply in a project, the parties must ensure that the BIM Particular Conditions is incorporated as a contract document in the Principal Agreements. This can be done in a variety of ways. Suggestions for the more common local standard forms of contract are set out below.

   a. REDAS Design and Build Conditions of Contract

      To insert as one of the documents in Appendix 4:

      Particular Conditions For Building Information Modelling ("BIM Particular Conditions") published by the Building and Construction Authority for the time being in force.

      For the purposes of Clause 1.2, if it is intended that another guide for BIM be used, then, to insert as one of the documents in Appendix 4:

      Particular Conditions For Building Information Modelling ("BIM Particular Conditions") published by the Building and Construction Authority for the time being in force. For the purpose of Clause 1.2 of the BIM Particular Conditions, the BIM Guide shall be [name of the guide].

   b. SCAL Conditions of Sub-Contract

      To amend Clause 4 by adding a new Clause 4(j) as follows:

      (j) Schedule 10: Particular Conditions For Building Information Modelling ("BIM Particular Conditions") published by the Building and Construction Authority for the time being in force.

      For the purposes of Clause 1.2, if it is intended that another guide for BIM be used, then, to amend Clause 4 by adding a new Clause 4(j) as follows:

      (j) Schedule 10: Particular Conditions For Building Information Modelling ("BIM Particular Conditions") published by the Building and Construction Authority for the time being in force. For the purpose of Clause 1.2 of the BIM Particular Conditions, the BIM Guide shall be [name of the guide].

   c. SCAL Standard Agreement for Appointment of Consultants

      To insert as one of the documents in Appendix C:

      The Particular Conditions For Building Information Modelling ("BIM Particular Conditions") published by the Building and Construction Authority for the time being in force shall apply for use of building information modelling.

      For the purposes of Clause 1.2, if it is intended that another guide for BIM be used, then, to insert as one of the documents in Part 1 of the Schedule:

      The Particular Conditions For Building Information Modelling ("BIM Particular Conditions") published by the Building and Construction Authority for the time being in force shall apply for use of building information modelling. For the purpose of Clause 1.2 of the BIM Particular Conditions, the BIM Guide shall be [name of the guide].

   d. SIA Contract

      To amend Article 6 of the Articles of Contract by adding a new Article 6(g) as follows:

      (g) Particular Conditions For Building Information Modelling ("BIM Particular Conditions") published by the Building and Construction Authority for the time being in force.

      For the purposes of Clause 1.2, if it is intended that another guide for BIM be used, then, to amend Article 6 by adding a new Article Clause 6(g) as follows:

      (g) Particular Conditions For Building Information Modelling ("BIM Particular Conditions") published by the Building and Construction Authority for the time being in force. For the purpose of Clause 1.2 of the BIM Particular Conditions, the BIM Guide shall be [name of the guide].

   e. SIA Sub-Contract

      To insert as one of the documents in Part I of the Schedule:

      Particular Conditions For Building Information Modelling ("BIM Particular Conditions") published by the Building and Construction Authority for the time being in force.

For the purposes of Clause 1.2, if it is intended that another guide for BIM be used, then, to insert as one of the documents in Part I of the Schedule:

Particular Conditions For Building Information Modelling ("BIM Particular Conditions") published by the Building and Construction Authority for the time being in force. For the purpose of Clause 1.2 of the BIM Particular Conditions, the BIM Guide shall be [name of the guide].

f. SIA Conditions of Appointment (for Architect)

To amend the Conditions of Appointment by adding a new Clause 1.1(11) as follows:

(11) Building Information Modelling

The Particular Conditions For Building Information Modelling ("BIM Particular Conditions") published by the Building and Construction Authority for the time being in force shall apply for use of building information modelling.

For the purposes of Clause 1.2, if it is intended that another guide for BIM be used, then, to amend the Conditions of Appointment by adding a new Clause 1.1(11) as follows:

(11) Building Information Modelling

The Particular Conditions For Building Information Modelling ("BIM Particular Conditions") published by the Building and Construction Authority for the time being in force shall apply for use of building information modelling. For the purpose of Clause 1.2 of the BIM Particular Conditions, the BIM Guide shall be [name of the guide].

g. Association of Consulting Engineers Singapore Agreement

To insert at Clause 1.1.1(i) of the Specific Provisions:

Particular Conditions For Building Information Modelling ("BIM Particular Conditions") published by the Building and Construction Authority for the time being in force.

For the purposes of Clause 1.2, if it is intended that another guide for BIM be used, then, to insert at Clause 1.1.1(i) of the Specific Provisions:

Particular Conditions For Building Information Modelling ("BIM Particular Conditions") published by the Building and Construction Authority for the time being in force. For the purpose of Clause 1.2 of the BIM Particular Conditions, the BIM Guide shall be [name of the guide].