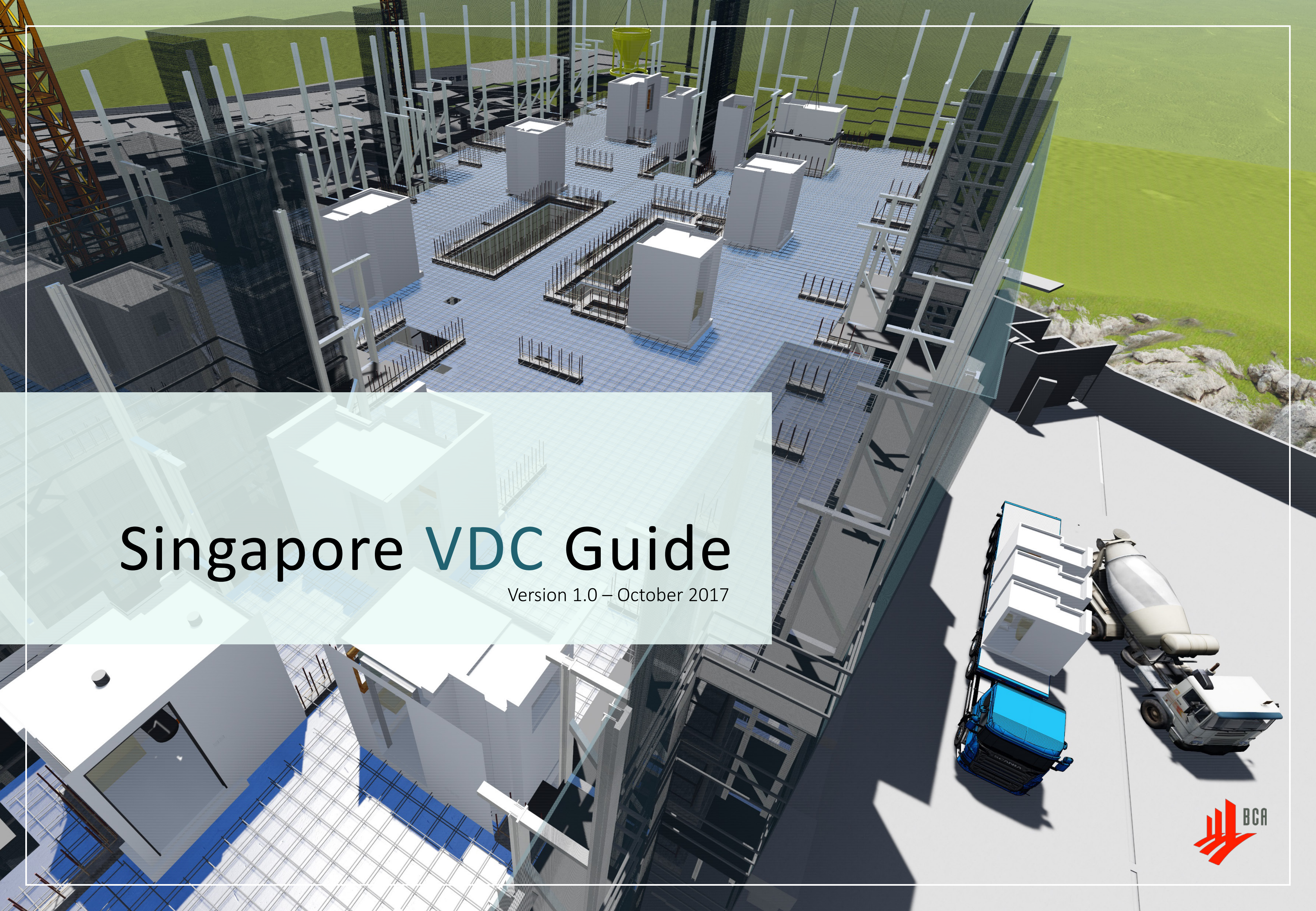
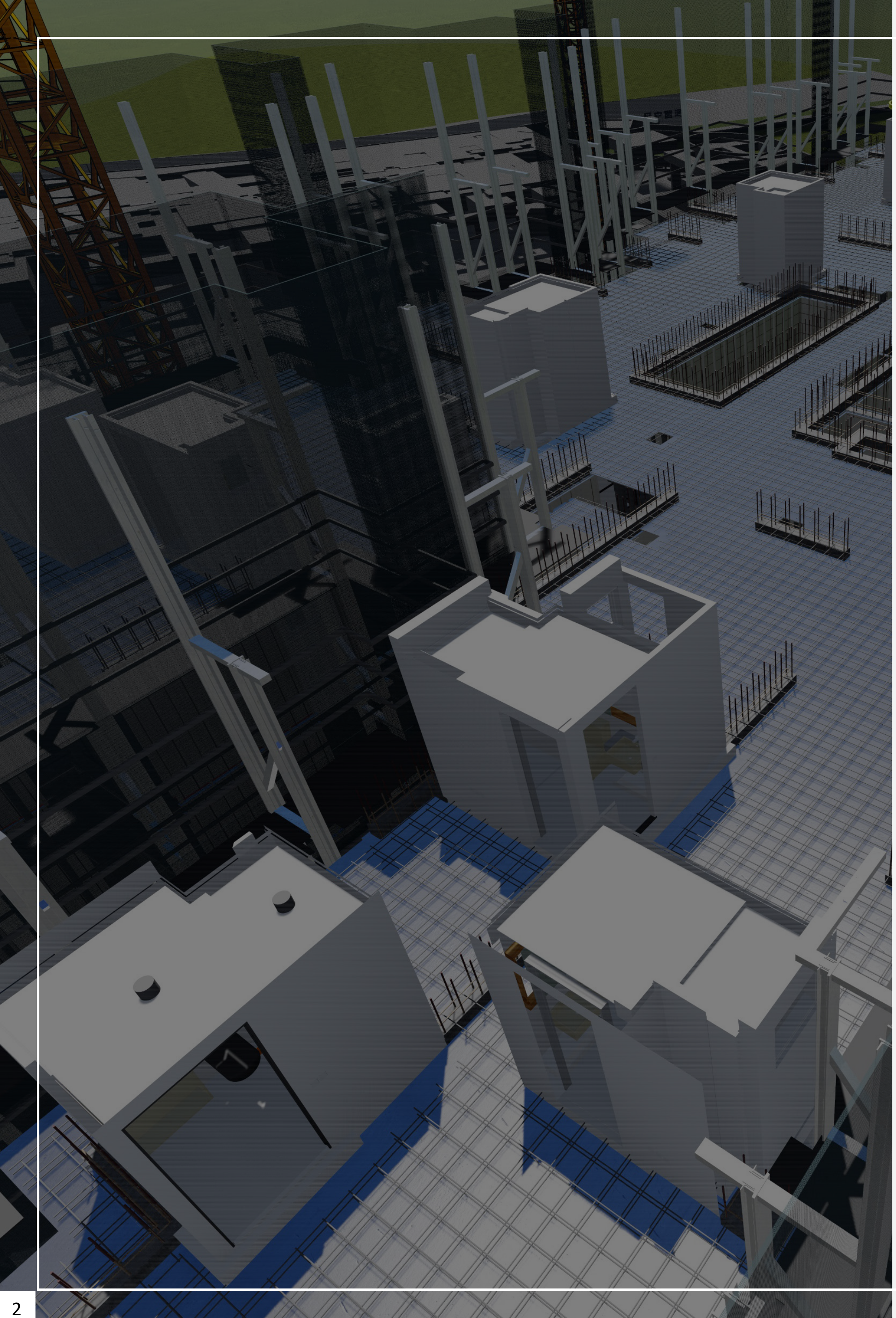


Singapore VDC Guide

Version 1.0 – October 2017

BCA



BCA acknowledges the leadership provided by the BIM Steering Committee in support of the production of the Singapore VDC Guide.

The Singapore VDC Guide has been prepared by the Centre for Construction IT and the VDC Workgroup on behalf of BCA and the BIM Steering Committee.

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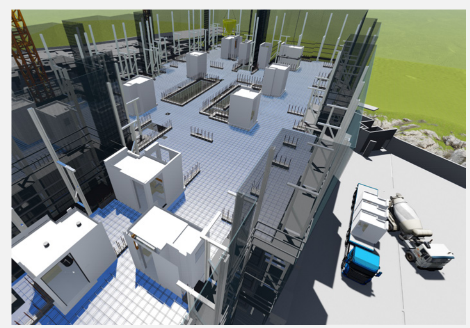
First published October 2017



COVER IMAGE COURTESY OF CHINA CONSTRUCTION (SOUTH PACIFIC) DEVELOPMENT CO PTE LTD

CEO's Message

Dear readers,

Our built environment sector has made good progress in adopting Building Information Modelling (BIM). More firms are embracing this technology and starting to reap benefits, such as having better collaboration among project team members and avoiding abortive works through early identification of design clashes. Some of the measured outcomes of BIM implementation in projects include a 30% reduction in abortive works and up to 80% reduction in change orders.

Many leading firms are also pushing the BIM boundary as they move towards integrating Virtual Design and Construction (VDC) in their building processes.

VDC enables all stakeholders to work collaboratively towards achieving a common goal, requiring everyone to tap on the rich information in BIM to better manage their processes to obtain the desired outcome. To enjoy the full benefits of VDC, we have to make some adjustments to our current work practices, such as involving builders at an early stage.

Produced under the leadership of the BIM Steering Committee, this guide is a result of significant contributions from local and overseas experts in BIM and VDC, drawn largely from actual implemented projects in the local environment. The outcome – a comprehensive set of VDC implementation guidelines for projects in Singapore. This guide also highlights key activities where VDC is most impactful and beneficial. The areas covered include specifying requirements for design model to contractor for further development and the framework for intensive collaboration period where a project team can resolve conflict speedily.

With the launch of the Singapore VDC Guide, we hope that more practitioners can acquire the necessary knowledge to implement VDC in their projects. With each challenge resolved, workflows transformed, and objectives met, we will be able to move faster as an industry to change the way we build and achieve our productivity targets.

Mr. Hugh Lim

BIM Steering Committee Chairman's Message

Dear readers,

Since 2011, as the industry embarked on our journey to implement the Building Information Modelling (BIM) Road Map, a number of BIM Guides had been introduced progressively for the industry to use. This has been essential for setting up a framework of common practices for the industry.

BIM for regulatory submissions was made mandatory for projects larger than 5,000 m^2 from mid-2015. To date, 17% of all the projects done in Singapore have used BIM at least up to the submission stage, but these projects constitute 92% of the new GFA (gross floor area) that is being built. Many of these projects have continued using BIM in the design and construction stages and have also realised substantial productivity improvements.

We have been giving out BIM Awards for projects and organisations since 2014 and each year the BIM Awards assessment committee has seen big improvements in BIM capabilities. This is encouraging and demonstrates the rising competencies of BIM personnel in Singapore.

This Virtual Design and Construction (VDC) Guide is a collaborative effort by leading practitioners from contractors, architects, and engineers, and incorporates best industry practices. The intention is to share these good practices so that the whole industry can benefit and improve their productivity.

We welcome feedback on this Guide so we can make further improvements.

I would like to express my heartfelt thanks to all the practitioners who have volunteered their time and efforts in producing this Singapore VDC Guide.

Mr. Lee Chuan Seng

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ACKNOWLEDGEMENTS

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- National Centre for Infectious Diseases, Centre For Healthcare Innovation
- Hundred Palms Residences
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ACKNOWLEDGEMENTS

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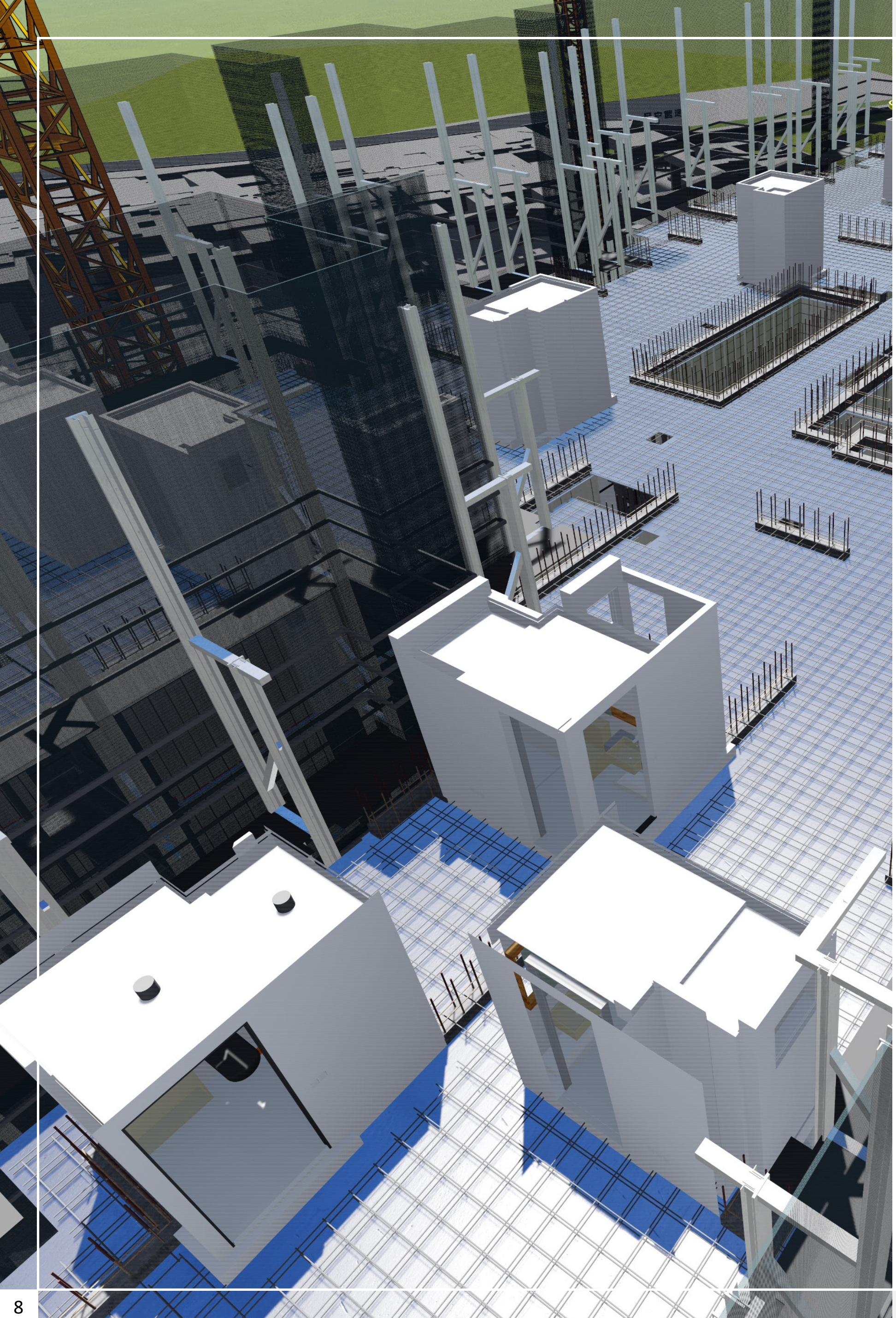


INTRODUCTION

The Singapore VDC Guide is a reference document that provides a set of guidelines for the implementation of VDC in the Singapore context. The document aims to establish the following purposes:

1. To establish a common understanding on the definitions, components, and principles of Virtual Design and Construction
2. To provide a framework to guide VDC Implementation in building projects or for organizational improvement
3. To close some of the key gaps in our current project delivery practices to facilitate industry transformation

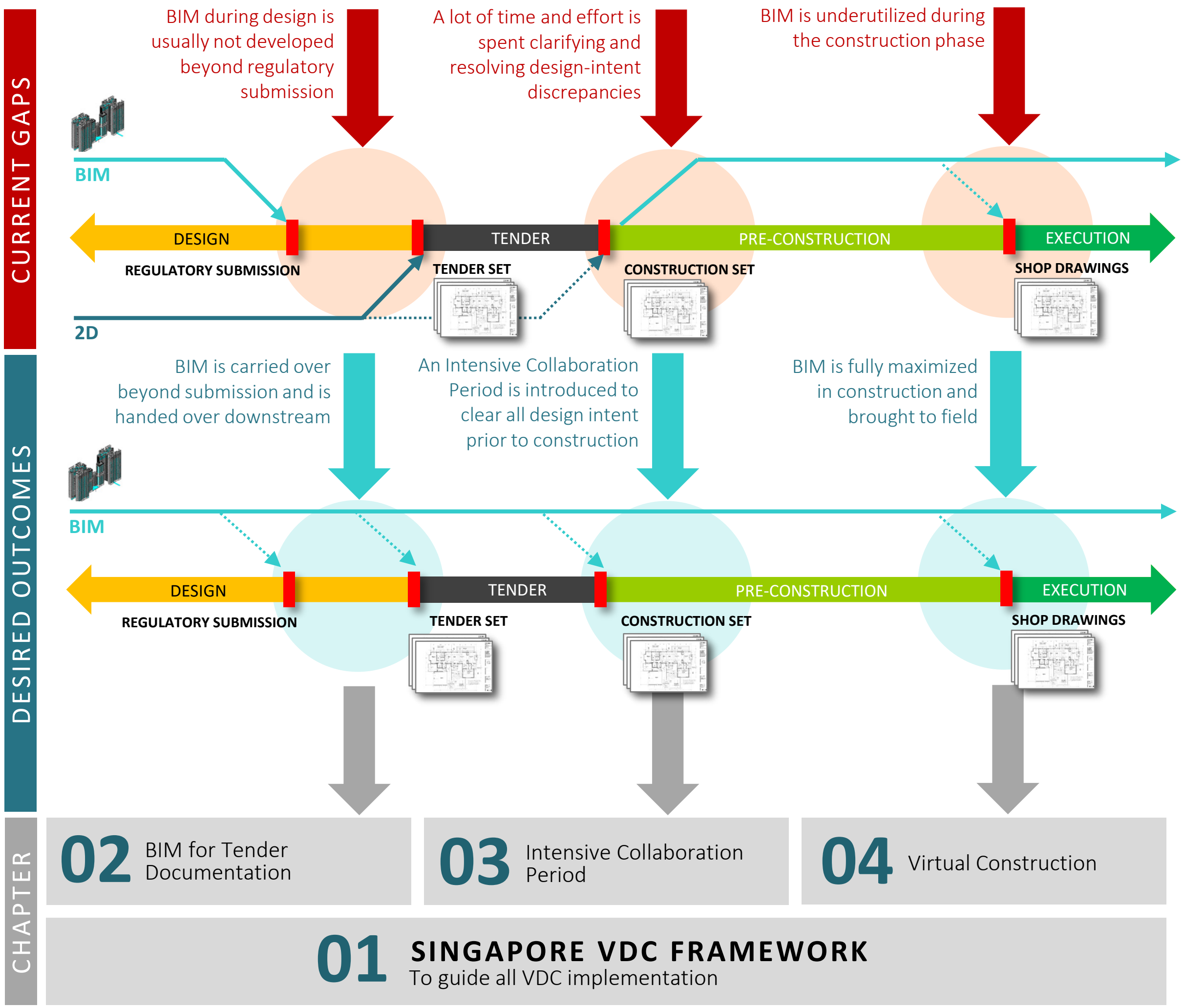
Who should read this guide?

The intended target audience are all stakeholders in the Singapore building and construction industry, including:

CLIENTS	Developers Owners Project Managers
CONSULTANTS	Architectural consultants Engineering consultants Specialist consultants Quantity Surveyors
MAIN CONTRACTOR	
SUBCONTRACTORS	Fabricators Specialist contractors Land surveyors Suppliers

How to read this guide?

This guide is structured to address the three main gaps in project delivery as seen in the diagram below. Chapter 1 covers the Singapore VDC framework which guides all VDC implementation, while Chapters 2 to 4 describes VDC implementation for three key phases.



KEY PRINCIPLES TO BEAR IN MIND WHEN READING THIS GUIDE

- **BIM is not VDC**
  BIM is only a component of VDC. In the specific context of VDC, BIM is the information that you need to perform the specific activities in order to meet your goals and objectives.

- **Reaping the full benefits of VDC across the value chain requires an industry process transformation**
  This includes transformations in the way we work, the way we collaborate, the extent to which we share information and the quality of that information, and the way we deliver our projects.

- **VDC is a framework**
  However, waiting for full industry transformation to take place is not necessary to start to see benefits in your own implementation. VDC is a framework that may be applied in any scenario, by any project team, or any organization to meet targeted goals and to improve performance.

01

SINGAPORE VDC FRAMEWORK

Define Virtual Design and Construction in the Singapore context as well as the principles of all key components of VDC as integrated into the Singapore VDC Framework. This framework shall serve the guiding reference for all VDC project or organizational implementation.

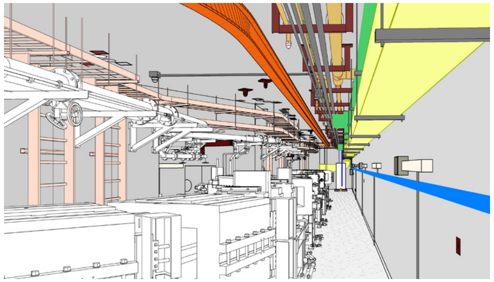
1.1 BIM

1.2 Ecosystem

1.3 Process Optimization

What is VDC?

Virtual Design and Construction or VDC is the management of **BIM** models as well as **people** and **processes** in order to achieve explicit project or organizational **goals** and to improve **performance**.



In essence, VDC is to

"Build Twice"

first **Virtual,** and then **Real**

Building twice enables a project team to fully simulate design and construction in a virtual environment first prior to actual execution on site.

Model what is to be built → DESIGN / CONSTRUCTION COORDINATION

Rehearse what is to be built → CONSTRUCTION COORDINATION / VIRTUAL PLANNING

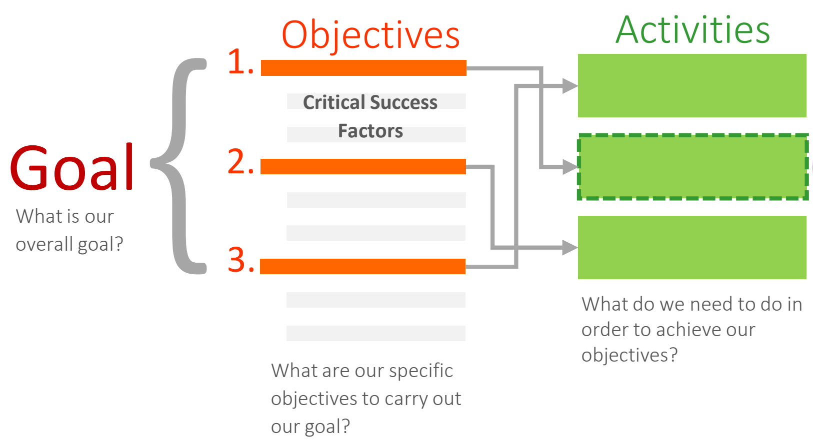
Build what was modelled and rehearsed → VIRTUAL PLANNING / EXECUTION

DESIGN — CONSTRUCTION COORDINATION — VIRTUAL PLANNING — EXECUTION

This framework requires all stakeholders to commit to work collaboratively towards achieving a common set of goals, through systematically modelling what is to be built, rehearsing what is to be built, and building what was modelled and rehearsed, and through constantly measuring and narrowing deviations between what was built (real) and what was modelled and rehearsed (virtual).

Singapore VDC Framework

All of the components of VDC are integrated in a framework as illustrated below:



1 GOAL

A goal is an overall desired result from all VDC efforts. It may be a project goal that is agreed upon in consensus with all stakeholders, or it can be an organizational goal to improve a company's business processes.

2 OBJECTIVES

Objectives are more specific points of focus in order to carry out a goal. These aspects of focus help a project or organizational team concentrate their efforts and identify specific activities to be accomplished in alignment with their desired results.

EXAMPLE:

To reduce time, cost, and manpower

Reduce time

- Maximize opportunities for prefabrication
- Optimize construction sequence
- Optimize activity sequence

} CRITICAL SUCCESS FACTORS

Reduce cost

- Design optimization and value engineering
- Eliminate abortive reworks
- Accuracy of procurement quantities

Reduce manpower

- Maximize opportunities for prefabrication
- Eliminate on-site options
- Optimize detailed construction labour activities

GUIDING QUESTIONS:

- *What do we want to achieve for this project?*
- *What do we want to achieve as an organization?*
- *What are each project member's goals, and how can we align them?*

GUIDING QUESTIONS:

- *How can we achieve each component of our goal?*
- *What specific aspects of our processes should we focus on?*
- *What problems or challenges have we encountered in the past that we want to resolve through this project?*
- *What makes this particular project critical?*

3 ACTIVITIES

Activities are general tasks that need to be carried out as part of accomplishing Critical Success Factors. Each activity or groups of activity must have a specific target against which performance may be measured.

4 TARGETS & PERFORMANCE MEASUREMENTS

Targets are the specific desired outcomes of each activity or group of activities. Performance measurements can be set for some of these targets to provide a yardstick for performance that can be continuously collected and tracked throughout the project.

EXAMPLE:

ACTIVITIES

COORDINATION WORKS

TARGETS

- To collaboratively resolve all raised issues as quickly as possible
- To clear all issues at least 3 weeks prior to execution start

PERFORMANCE MEASUREMENTS

- **TIME TAKEN TO SOLVE INCIDENTS**
- **MEETING ATTENDANCE**
- **CAPTURE "PLANNED VS ACTUAL" IN BIM MODELS**

GUIDING QUESTIONS:

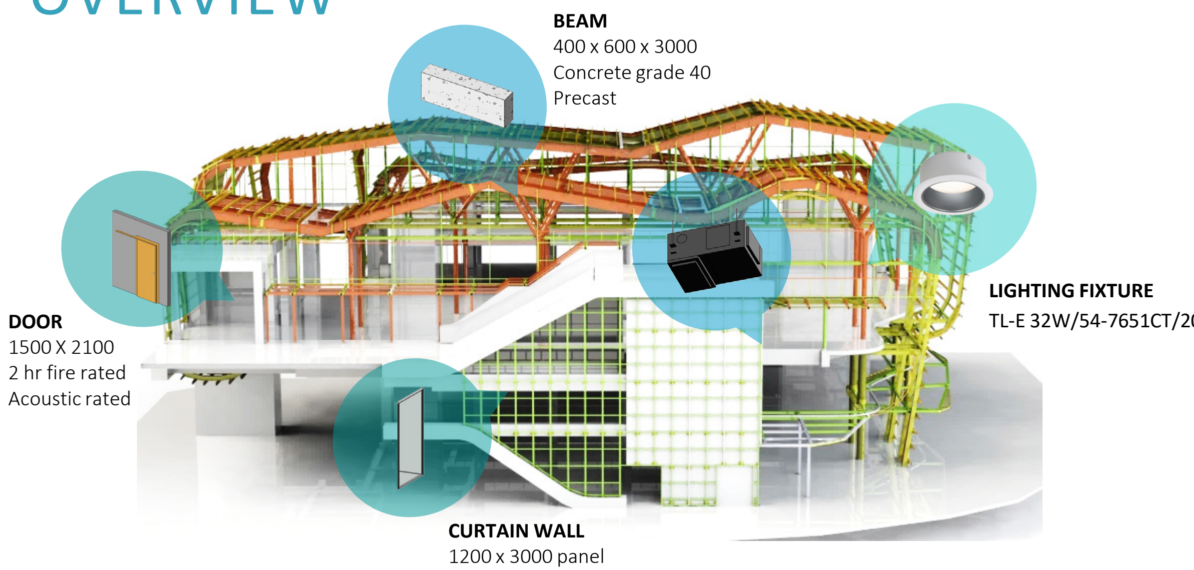
- *What are the key activities that I need to focus on to help me achieve my objectives?*
- *What makes sense to do for this project?*

GUIDING QUESTIONS:

- *What are the meaningful indications of whether I am achieving my goals and objectives?*
- *Where and how do I collect data?*
- *What are my benchmarks?*
- *Are my KPIs aligned with my goals and objectives?*

1.1
BIM

OVERVIEW

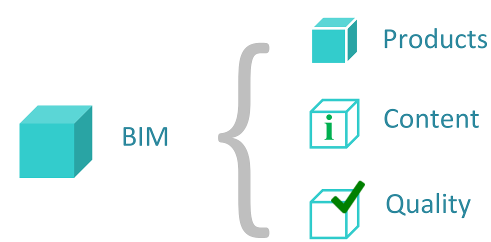


1 BIM AS IN INFORMATION REPOSITORY

BIM shall be approached as a database of all the information that is required to carry out each specific activity as integrated in a virtual model.

Because a project team's goals and objectives are explicit, nothing in the BIM model should be arbitrary. Every model and model element must be developed to be a **reliable** virtual representation of the physical structure, and to the level of geometric and information granularity required to perform all intended activities and analyses.

BIM shall consider products or deliverables, information content, and quality. These following aspects shall be covered in detail in this section.



PRODUCTS

BIM products pertain to the specific BIM models to be produced in alignment with the project objectives and activities, as well as the intended deliverables or model uses.

1 KEY PRINCIPLES

- Know what your objectives and activities are first, before determining the specific models that you would need to produce.
- Determine who the most appropriate author is for each model to be developed.
- Models may have multiple model uses, and it is ideal that the content of which satisfy all model uses.
- Ensure interoperability across all models to be shared.
- Ensure ease of model updates through proper model set-up and management.

2 PRODUCT COMPONENTS

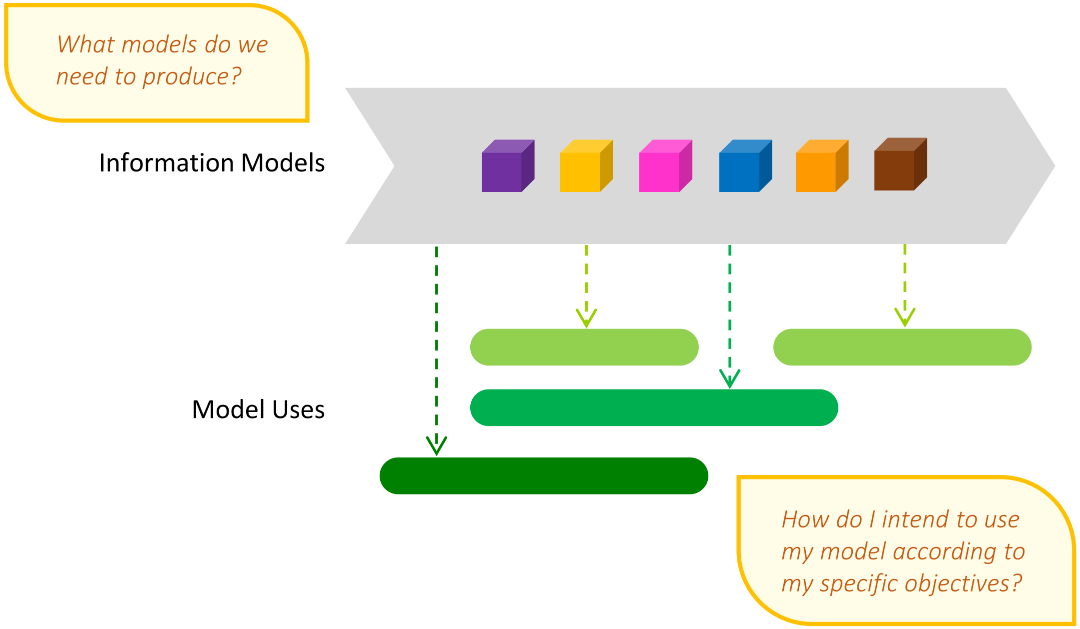
BIM products consist of Information Models and Model Uses [VDC services]

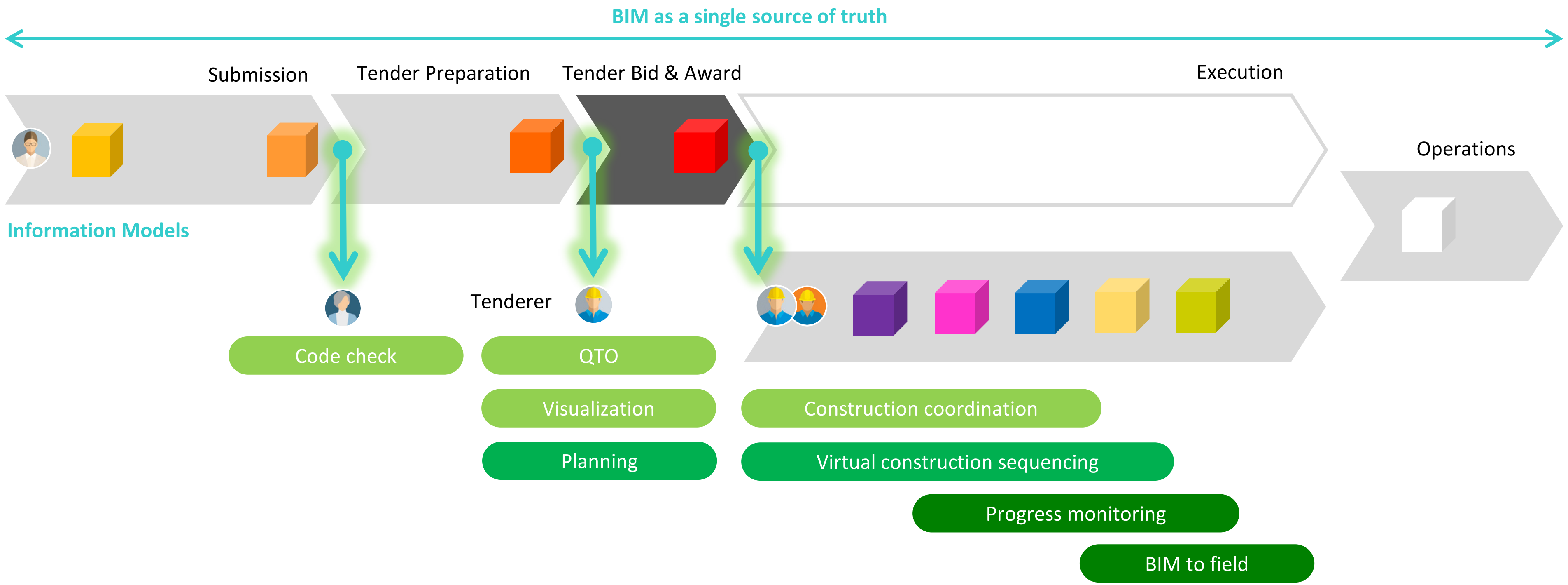
Information Models

Information models form the cornerstone of all VDC efforts as they are the repository of data that are required for all intended uses and analyses. As such, the validity of the data inside information models should be dictated by its suitability for use.

Model Uses [VDC Services]

Model uses drive the data inside each information model and are in turn driven by the specific targets and activities as pre-determined by the project team.





3 MODEL PROGRESSION

To fully maximize the benefits of BIM and VDC in the integration of the entire project life cycle, the model must progress seamlessly from design to construction to operations through the timely incorporation of the required core information and geometric detail as dictated by the specific activities and deliverables at every stage.

This entails a process transformation at certain key junctures wherein:

1. The regulatory submission model must transition for use in tender preparation.
2. The design-intent model must be handed over downstream to be further developed to be fit for construction.
3. Model progression and timeliness of activities must align with the master schedule and targeted milestones.

Design Models

The design intent model progresses from schematic design all the way to construction as-built. Design models capture and convey the projects design requirements for the purpose of visualization, analysis, integration of disciplines, communication, and record.

E-Submission Model

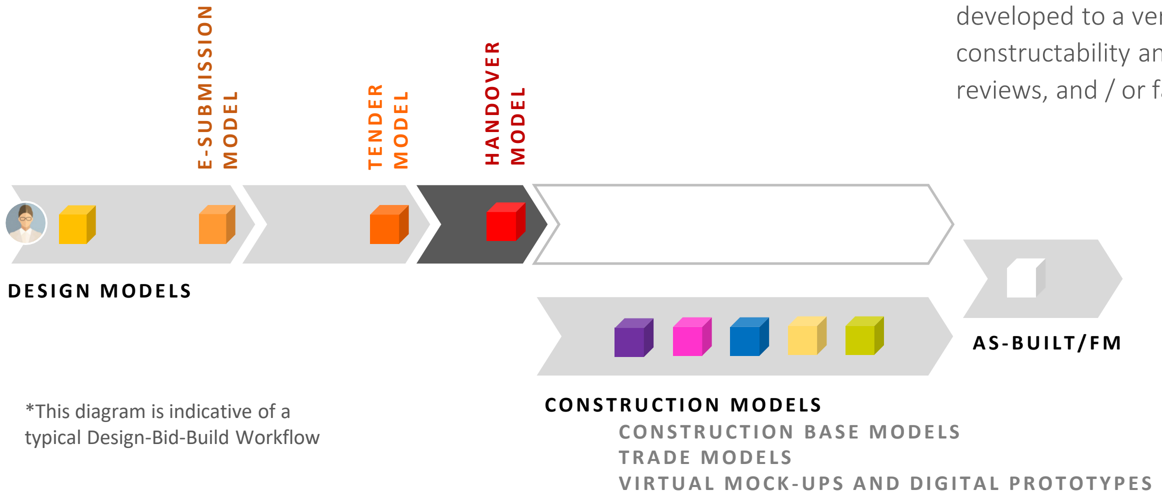
A model that complies with all of the requirements for e-submission and is submitted to respective regulatory agencies. See Codes of Practice for BIM E-Submission.

Tender Model

A design intent model that is fit for use for bidders during the tender period.

Handover Model

A design intent model that is handed over to the awarded contractor for their visual reference and further development.



*This diagram is indicative of a typical Design-Bid-Build Workflow

Construction Models

Depending on the availability of a handover mode, construction models are either developed from scratch or are expanded from a design intent model. Construction models must be fit for the specific activities, analyses and services to fully exploit the benefits of BIM and VDC during the construction stage.

Construction Base Model

Construction base models are the main architectural and C&S models that are handled by the main contractor and used as base or reference for the various trade models.

Trade Models

Trade models are usually developed by the subcontractor or specialist contractor of that specific trade, and integrates the fabrication details and domain knowledge into the model.

Virtual Mock-Ups and Digital Prototypes

These are models of isolated areas in the project that have been developed to a very high level of detail and accuracy for the purpose of constructability and sequencing analysis, visualization and virtual reviews, and / or fabrication.

Model Set-Up

The model must be set up in a way that facilitates ease in model update and ease in downstream use.

Model Setup Considerations:

- Project complexity
- Design intent typicality
- Location-based planning
- Scope of work

Interoperability

Collaboration in a BIM environment requires model and software interoperability for a seamless exchange of data between participants of a project.

Interoperability should ensure that the data created by each party translates correctly in terms of both geometric and non-geometric attributes for accurate reference by all users of each model.

5 MODEL USES [VDC SERVICES]

An information model may be fully exploited to perform a number of value-added VDC services but only if it contains the appropriate information to fulfill each type of service.

These model uses and digital analyses may be classified according to the various dimensions of BIM.

3D	Involves **spatial** Information, **geometric** and **material information of objects**: clash detection & coordination, fabrication, visualization	▪ Experience simulations ▪ Systems coordination and clash detection ▪ Virtual reviews ▪ Site utilization studies ▪ BIM driven fabrication ▪ Existing 3D data for conservation
4D	3D plus time: VDC services involving **temporal or time-based** analyses such as sequencing, scheduling schedule, progress tracking	▪ Progress tracking & monitoring ▪ Project phasing simulations ▪ Construction or installation sequence simulation ▪ Project phasing simulations ▪ Visual validation for payment approval
5D	3D plus **cost**: VDC services involving **cost** and resource such as cost planning and estimates, progress billing, resource planning. etc.	▪ Value engineering and what-if scenarios ▪ Quantity extraction to support detailed cost estimates
6D	3D plus **operation and management data** suitable for use by facility managers such as maintenance manuals, specifications, warranties, etc.	▪ Life Cycle BIM strategies ▪ BIM embedded Q&M manuals ▪ BIM maintenance & technical support

Dimensions of BIM

CONTENT

This pertains to the dataset inside of each Information Model as determined by the specific requirements of the intended Model Uses in terms of completeness of modelled objects, modelling technique, and core information.

1 KEY PRINCIPLES

- Different objects and different areas within the same model may require different levels of details
- Do not model more than the required granularity to meet your objective
- Ensure that the required core information is complete and correct
- Modeling techniques for objects may differ depending on your intended BIM usage.
- Embed the information that you need to extract later on

2 CONTENT COMPONENTS

BIM content pertain to Completeness of Modelled Objects, Modelling Technique, and Core Information that is fit for its intended use/uses.

Completeness of Modelled Objects

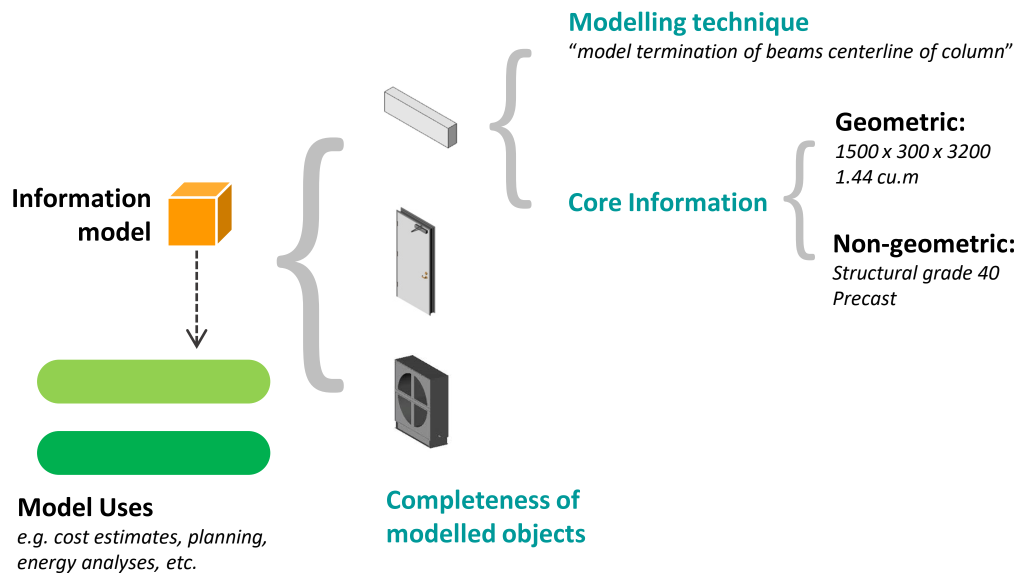
The model must be complete with all the objects that are required for its intended uses.

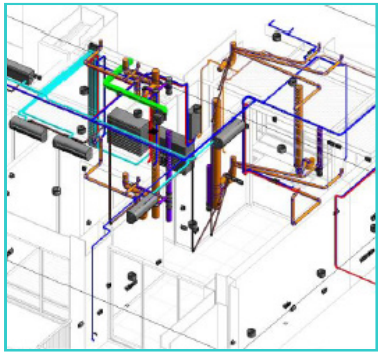
Modelling Technique

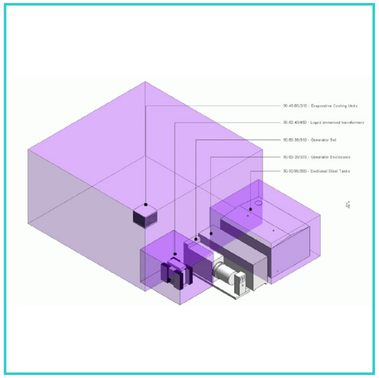
Modelling technique refers to the way in which the object is created.

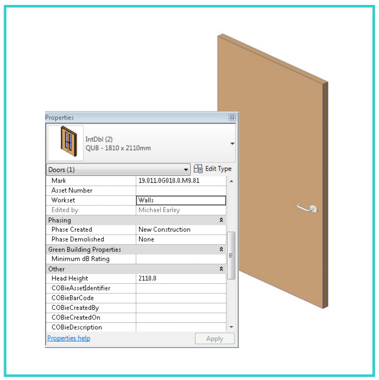
Core Information

Core information refers to both geometric and non-geometric attributes. Core information must be correct and complete to be suitable for model use.









3 KEY CONSIDERATIONS

Completeness of Modelled Objects

- Objects that are below a certain size (e.g. below 50mm) may still need to be modelled if required for coordination, fabrication, or spatial reservation (e.g. conduits).
- Other objects that are typically part of an exclusion list (e.g. hangers) may also be required in isolated areas or cases.

Modelling Technique

- Modelling for quantity takeoff or scheduling may require a specific technique to obtain the correct unit of measurement and more reliable quantities.
- Objects may be modelled so as to serve a specific model use (e.g. building maintenance clearance boxes into equipment to aid in clearance checks).
- Do no over model if only the overall size is required for coordination (e.g. equipment, temporary facilities and structures)

Core Information

- Information may be indicative in early phases, but must be replaced by actual data as information from suppliers and subcontractors come in
- Core Information must be provided by the right stakeholder at the right time.

4 DESIGN OBJECT LIBRARIES (DOL)

Design Object Libraries are repositories of model objects that have already been developed ready for use with certain core information already pre-defined.

Design Object Libraries may be created as part of a company's BIM resources, and is also available industry-wide, with contributors from manufacturers, designers, etc.

Developing and making use of these libraries contributes towards modeling efficiency and reliability of core information.

5 2D-3D INTEGRATION

In cases where details are needed for information but not crucial for geometric coordination, the model may be supplemented by 2D standard details where required.

In all cases, 2D drawings must be consistent with the final approved or coordinated model

2D drawings extracted from 3D models must be done so with no error or loss of data from translation.

QUALITY

BIM quality checks are necessary in order to ensure that the models are fit for use, fit for sharing, are workable, and consistent across all models regardless of being authored by various stakeholders. Implementing stringent quality control measures also contribute towards streamlining of processes, as it helps minimize unnecessary work and double handling of information.

1 KEY PRINCIPLES

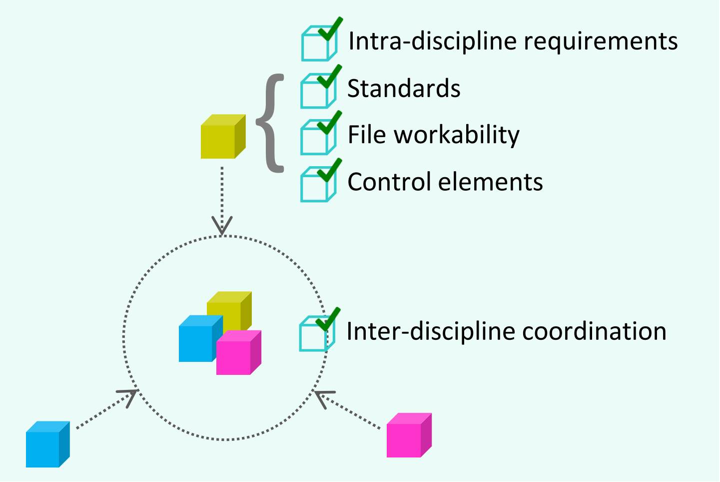
- Each model author is to perform quality checks in their own model prior to model sharing
- Model quality includes content of information that is fit for use
- Models that are handed over to downstream users must ensure that quality is fit for the intended downstream use

2 QUALITY CHECK SCENARIOS

The following diagrams describe the various scenarios in which model quality checks are performed, as well as the types of checks which include, but are not limited to: standards, file workability, control elements, intra-discipline requirements, content, inter-discipline coordination.

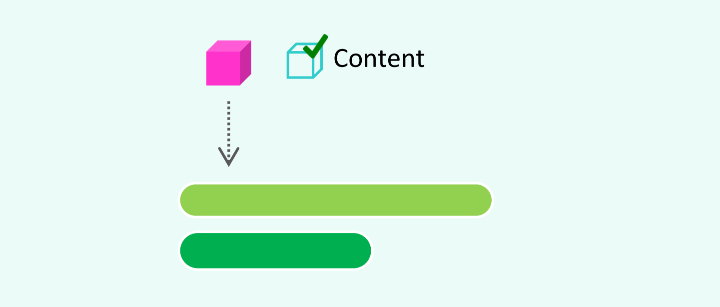
MODEL SHARING & COORDINATION

Check individual model quality prior to sharing for intra-discipline coordination



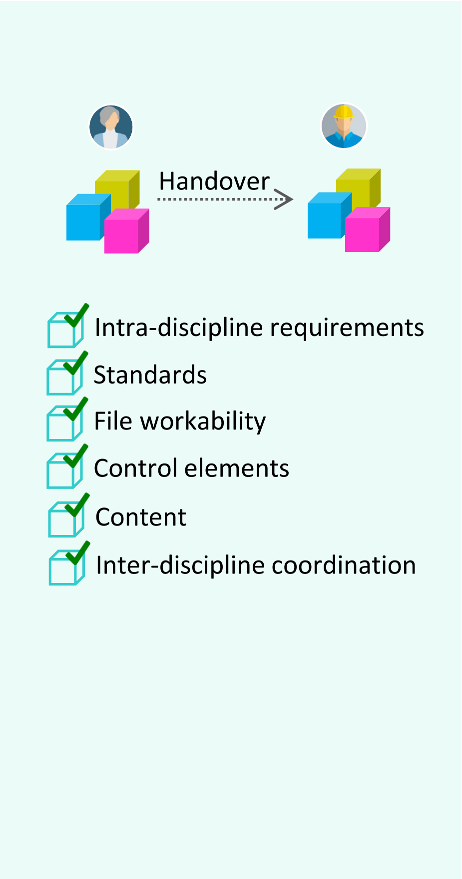
MODEL USE FOR VARIOUS ACTIVITIES

Check suitability of model for intended activities (e.g. QTO, planning, analyses)



HANDOVER AND SUBMISSIONS

Check suitability of model for downstream handover



STANDARDS

Check model conformance with pre-established project standards and guidelines

STANDARDS CHECK
File naming, object naming, and view naming convention
Templates, line weights, etc.
Browser organization
System colours

CONTENT

Check suitability of model information for its intended use

CONTENT CHECK
Completeness of modelled objects
Correct modelling technique
Complete and correct core information
Drawings, schedules, and views from BIM model

CONTROL ELEMENTS

Check alignment and adherence of control elements across all models

CONTROL ELEMENTS CHECK
Origin point
Orientation
Setting out
Grids
Levels

FILE WORKABILITY

Check suitability of model for model sharing

FILE WORKABILITY
Model in agreed format and version
Detached from central file
Model has been purged
Unnecessary link have been removed
Extraneous sheets, views, legends, and schedules removed
Optimized file size

INTRA-DISCIPLINE GENERAL MODEL QUALITY

Check general model quality *within each discipline model*.

INTRA-DISCOPLINE GENERAL MODEL QUALITY CHECK
Modelled using correct objects
No significant overlapping of objects
No duplication of objects
No floating or misplaced objects
Objects are defined by storey*

*May be more suitable during design detailing or construction phase, where defining by storey is required for planning. Also this may not be applicable to building elements such as full height façade, walls, or columns.

INTER-DISCIPLINE COORDINATION

Check coordination *between disciplines.*

INTER-DISCIPLINE COORDINATION CHECK
Geometric hard clashes
Soft or installation and maintenance clearance issues
Alignment and consistency between trades

1.2 ECOSYSTEM

OVERVIEW

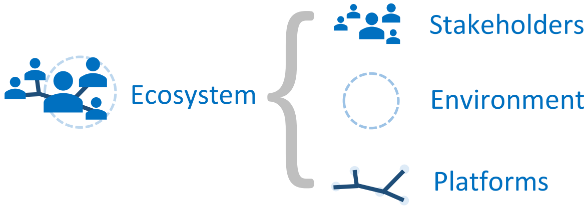
1 ESTABLISHING AN ECOSYSTEM THAT FOSTERS COLLABORATION

All VDC implementations, at any scale, requires the management of people and stakeholders for several reasons:

1. Goal and objective setting requires a project team to be clear and in agreement to what they want or need to work towards.
2. BIM is only as good as the information it contains, and this information needs to be obtained from the right people at the right time, and provided to the right people at the right time.
3. The success to adapting new and better processes requires a willing and consistent **commitment** from all involved stakeholders.

An ecosystem not only involves people but also the environment in which they work, and the platforms of communication and information sharing to aid in their collaboration.

This section shall therefore cover the following: stakeholders, environment, and networks.



STAKEHOLDERS

Stakeholders are all team members who are to be involved in each activity, project phase, or overall VDC implementation. These people may be **project team** stakeholders such as clients, consultants, contractors, or team members within an **organization**, in the case of organizational VDC implementation.

1 KEY PRINCIPLES

- Active commitment of all involved stakeholders and project team members to their roles and responsibilities is crucial in order for the any VDC implementation to work
- In an organizational team setup, VDC is the responsibility of the entire team, and not just one department or person (e.g. BIM manager or BIM department)
- Other organizational team members may need to be trained on how to utilize the BIM models for their own work in order for them to reap benefits to their own work processes and also to improve overall team integration

2 TEAM TYPES

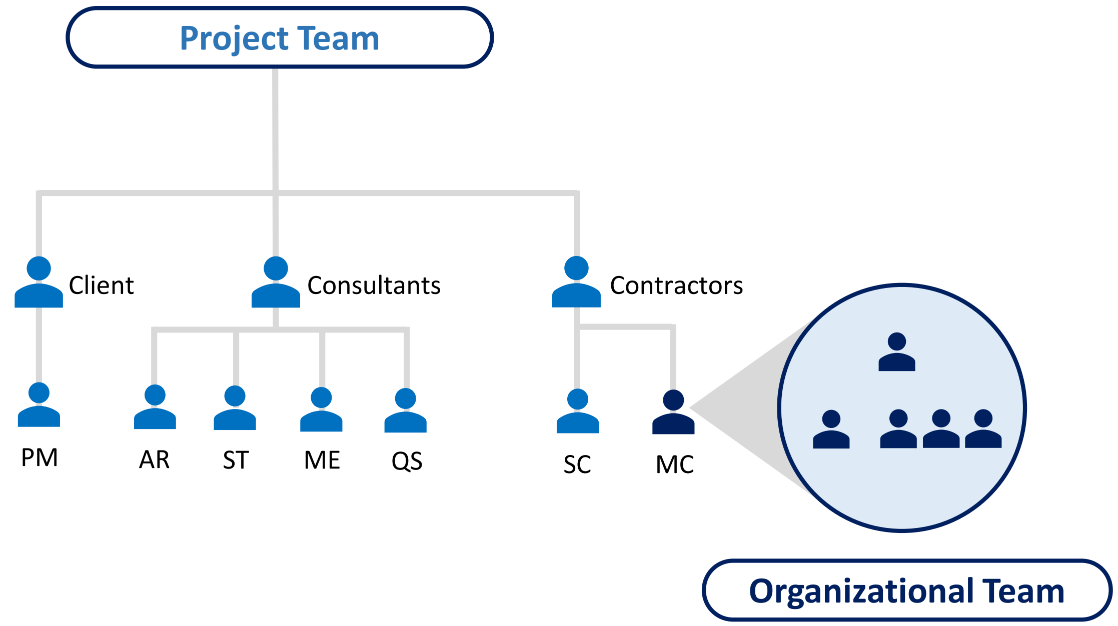
The following describes the two types of team set-ups:

Project Team

Project team stakeholders consist of clients, consultants, contractors, and all other project team members whose participation are required in the VDC process. Each of these stakeholders may have active or passive participation, depending on the level of involvement required of them.

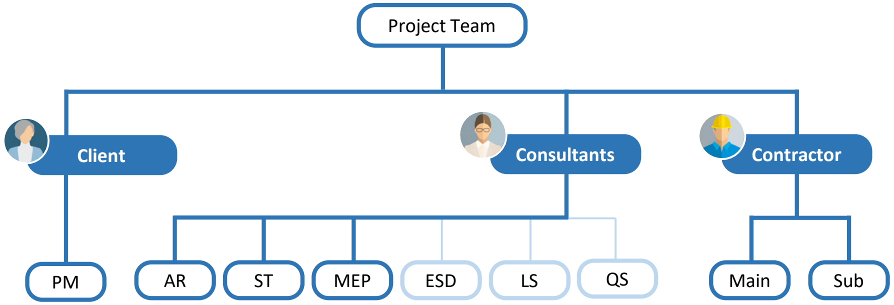
Organizational Team

Organizational team stakeholders consist of the key levels of management, key departments, and/or project team members in a company or organization embarking on VDC.



3 PROJECT TEAM STAKEHOLDERS KEY ROLES

The following describe the general roles of each key stakeholder in a project team. See page 26 for specific roles by phase.



KEY ROLES

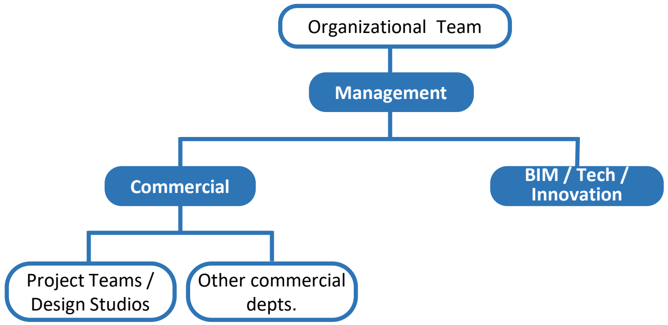
CLIENTS
- Recognize overall benefits of VDC to project and business objectives
- Main driver of VDC among all project stakeholders
- Change management, respective of targeted project timelines and milestones

CONSULTANTS
- Recognize benefits of VDC to individual processes and workflows
- Willingness to cooperate, collaborate, and share information
- Prepare documents and models for submission and handover according to required downstream use

CONTRACTORS
- Manage information and issues from various stakeholders to develop constructible BIM
- Deliver “actual” project as per “virtual”
- Fully utilize model information to maximize BIM in construction & bring BIM to field

4 ORGANIZATIONAL TEAM STAKEHOLDERS KEY ROLES

The following describe the general roles of each key group or member in an organizational team.



KEY ROLES

MANAGEMENT
- Recognize overall benefits of VDC to corporate objectifies
- Main driver of VDC in entire organization
- Set corporate vision and goals to move towards in VDC implementation

COMMERCIAL
- Recognize benefits of VDC to individual processes and workflows
- Cooperate in integrating BIM and VDC in project or departmental functions where feasible
- Carry out VDC corporate directives in a project and technical level

CENTRALIZED BIM TEAM [or R&D & Technological Innovation Support]
- Provide technical and skills support to commercial groups
- (see page 27 on Centralized BIM Team Functions)

** Smaller companies may have a BIM/VDC Lead instead of a dedicated group*

5 ROLES AND RESPONSIBILITIES OF PROJECT TEAM STAKEHOLDERS BY PHASE

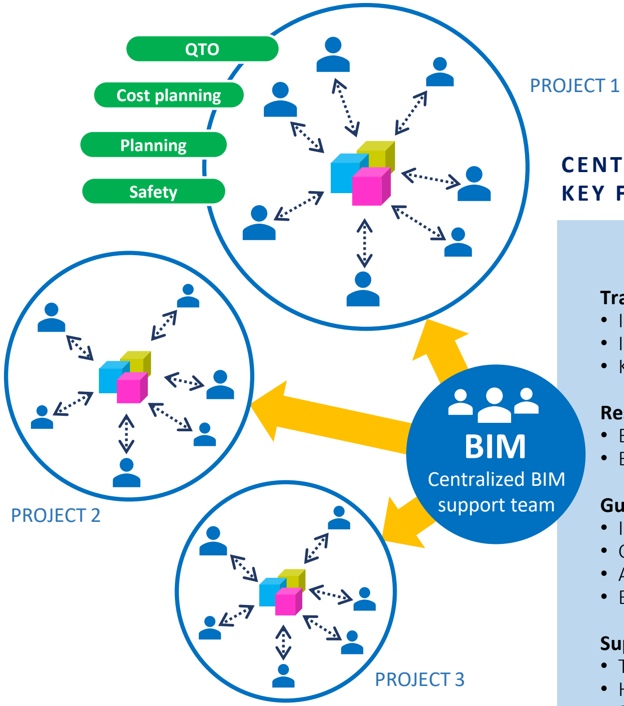
	BRIEF	DESIGN	HANDOVER/ TENDER	CONSTRUCTION
CLIENTS Developers Owners Owner PM	• VDC specifications for design consultants		• VDC specifications for contractors & sub contractors • Stipulate release of Tender Model	• Stipulate Handover Model • Early on-board of NSC
CONSULTANTS AR consultants Engg consultants Specialist consultants		• Coordinate design-intent • Regulatory E-submission requirements	• Develop Tender Model from E-submission model	• Active participation during ICP & PCP • Timely approvals, confirmation, and information as needed
MAIN CONTRACTOR			• Utilize Tender Model for BIM-based tender estimates, planning, & tender presentations	• Lead ICP & PCP • Fully maximize BIM & VDC to meet project goals & objectives and bring BIM to Field • Digital commissioning
SUBCONTRACTOR Fabricators Specialist contractors Suppliers				• Timely model development, updates, and information • Install/fabricate as per final approved model
QUANTITY SURVEYOR		• Preliminary cost estimates	• Provide input on Tender Model organization & information • Tender analysis • Tender award	• Evaluation of progress claims • Assessment of VOs

*Assuming DBB contract

6 ORGANIZATIONAL TEAM EMPOWERMENT

A good organizational set-up enables each project team or each studio to utilize VDC to meet their own specific objectives and to carry out company goals and directives at the project level.

This entails building up capacity of each project team through the support of a centralized BIM / VDC department or committee.



CENTRALIZED BIM KEY FUNCTIONS

Training
- In house training
- Individual training plans
- Knowledge sharing

Resources
- BIM content libraries
- BIM Templates

Guidelines
- Implementation guidelines
- Corporate standards
- Audit checklists
- BIM modelling guides

Support
- Technical support
- Handholding
- Set-up

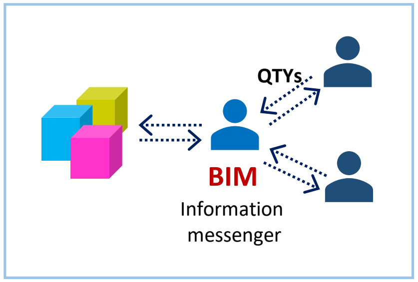
Research and Innovation
- Technological solutions

7 TRANSFORMATION OF ROLES & INTEGRATION OF DOMAIN KNOWLEDGE

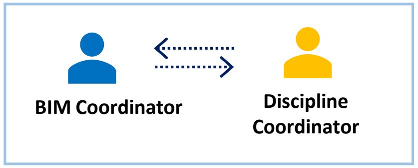
In the current practice, BIM and VDC is not yet as integrated into all relevant workflows and functions in the organization. This is understandable in the earlier phases of adoption during which an organization may still be gaining traction in their BIM technological and skills development.

However, to fully maximize and assimilate the benefits of BIM and VDC to best advantage, the whole organization must be willing to undergo necessary restructuring and integrations of roles and workflows. This transformation can be done in stages as part of a corporate BIM/VDC roadmap.

CURRENT PRACTICE

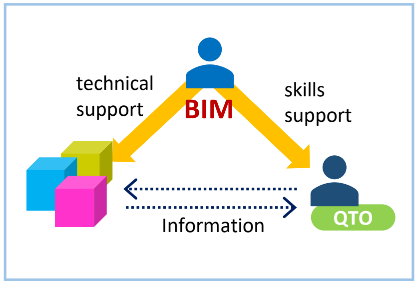


BIM coordinator serves as an information go-between to extract information from the model as required by other project team members

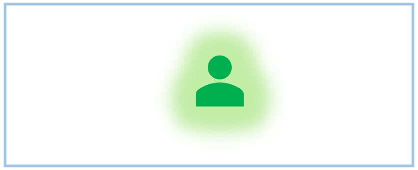


“BIM” is a separate entity and role from designer or coordinator resulting in a domain knowledge gap.

FUTURE PRACTICE



Centralized BIM team provides skills and technical support to aid project team members in utilizing the data in the BIM model for their specific work



One entity combines both BIM and design/technical knowledge and utilizes BIM to perform design or coordination functions.

ENVIRONMENT

Environment pertains to the the physical facilities needed to aid in collaboration.

Enabling stakeholders to cooperate and work with each other to realize common end goals requires creating an environment that fosters collaboration, ease of communication, and data and knowledge sharing.

1 KEY PRINCIPLES

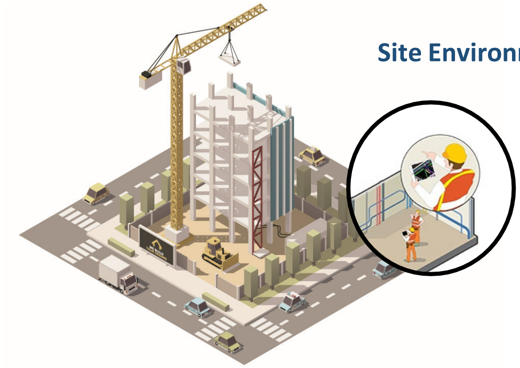
- Collaboration can happen, whether physically co-located or not
- In production work (i.e. model or design development), co-location is preferable, but the key to achieving same results is open communication, shared working platforms, clarity of deliverables, and efficiency of processes. (*see Chapter 3 on Intensive Collaboration Process)*
- However, certain tasks such as coordination, planning, and problem solving requires the physical presence of decision makers and key stakeholders to work towards resolution.

2 ENVIRONMENT TYPES IN DESIGN AND CONSTRUCTION

Whether in a construction site or in a design firm office, there are different types of environments where people come together to work on a project. These may include meeting rooms, design studios, site offices, etc. Nearly all projects would already have these spaces, but the key is to equip them with the necessary provisions or facilities to enable easier collaboration, better visualization, and/or more efficient production or issue resolution. Annex A2 captures best practices of each environment type.

Meeting Rooms

Site Environment



Production areas / "Big Rooms"/ Studios / Offices

Virtual or Cloud-Based Setup

ANNEX A2: Environment & Facility Types and Best Practices

PLATFORMS

These including data sharing platforms (Common Data Environments), collaboration platforms, project management platforms, and all other tools to share information between teams and stakeholders and improve collaboration.

1 KEY PRINCIPLES

- Create a Common Data Environment to establish a single source of information for all project data, (including model data) thereby avoiding duplication and mistakes.
- Shared project information include any type of information whether created in a BIM environment or in a conventional data format.
- The Common Data Environment may include a number of different information environments.

2 TYPES OF PLATFORMS

The following are various types of networks, tools, and platforms

Common Data Environment (CDE)

An online place for collecting, managing and sharing information amongst a team working on a project. A CDE could take many forms, depending on the size or type of project you are working on. It could be a project server, an extranet, or a cloud-based system.

Collaboration Tools & Platforms

Includes, but is not limit to, coordination and collaboration platforms, issue management platforms, design review platforms, etc. Most collaboration tools integrate common data and model sharing.

Construction and Field Management Tools Platforms

Includes, but is not limit to, field management tools, quality and defects management platforms, mobile maps and predictive analytics for field, mobile progress monitoring. These tools may also integrate common data sharing, but model integration depends on the type and function of the platform. The main benefit of these types of platforms is to increase productivity on reporting and documentation, and improve communication between BIM to field, or trailer to field, and vice versa.

1.3

PROCESS OPTIMIZATION

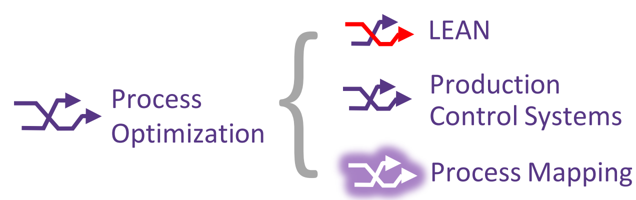
OVERVIEW

1 MAPPING, “LEANING” AND REFINING PROCESSES

A project team shall endeavor to further improve their current state processes beyond mere digitalization of information and the use of technology.

Processes in the AEC industry pertain not only to construction planning and scheduling but all processes involved from project conceptualization to handover, from broader high level design phase workflows which includes interdisciplinary information integration and handoffs, to more detailed process flows for specific activities such as PPVC manufacturing and structural floor cycle times.

Optimizing processes involves making the process visible, learning to see what creates wastes, what creates value, and how to constantly check, refine, and improve.



LEAN

LEAN is a journey that endeavors to maximize value through eliminating wastes and improving flow. There are many LEAN tools available for various applications, and this guide will cover some of them, specifically tools that help in planning and process improvement.

1 KEY PRINCIPLES

- Value can be measured by client requirement and the relevant cost, time, and quality to meet that requirement.
- Wastes comes in many forms, apart from physical wastes on site. To implement LEAN is to learn how to see wastes in all processes.
- All the steps in the process must flow smoothly without delays, bottlenecks, constraints, or interruptions
- Implement a “make ready” process or “pull”
- Strive for continuous improvement

2 LEAN CONSTRUCTION PRINCIPLES

The following are the relevant LEAN principles that are applicable in design and construction. Further details of each principle, as well as other LEAN tools and applications may be found in the ANNEX section.

RELEVANT LEAN PRINCIPLES

CREATE VALUE

- Verify and validate value
- Ensure client requirements have been captured comprehensively
- Ensure requirements flow down

ELIMINATE WASTE

Types of waste:

- Defects
- Overproduction
- Waiting
- Non-utilized resources
- Transportation
- Inventory
- Motion
- Extra-processing

IMPROVE FLOW

- Reduce variability
- Reduce cycle times
- Reduce batch sizes (strive for single piece of flow]
- Increase flexibility
- Select an appropriate production control approach
- Standardize
- Use visual management
- Design the production system for flow and value

ANNEX A3: Types of Wastes in Knowledge-Based Work
ANNEX A4: Suitable Lean Tools for the AEC Industry

PRODUCTION CONTROL SYSTEMS

This pertains to the application of the principles of operations management to the delivery and production of a construction project. There are several production control systems available, including the Last Planner® System, and Location-Based Management Systems. Key concepts of these systems may be applied to improve production control of any project.

1 KEY PRINCIPLES

- Align key activities (such as coordination, shop drawing production and approval, etc.) to the master schedule (see Chapter 4 on creating a VDC schedule)
- Go by "location" according the master schedule
- Implement a "pull" or make ready approach as opposed to conventional "push" scheduling
- Implement "look ahead" to identify and remove potential constraints before you encounter them on site
- Document reasons for variance in order to learn from them
- Involve the people who will do the work when planning

2 KEY CONCEPTS OF LAST PLANNER® SYSTEM AND LOCATION BASED MANAGEMENT SYSTEM

Adopting leaner production control systems, or even the adaption of key concepts, greatly benefits project delivery in that it provides better overall control and predictability. The following lists some key features of both Last Planner System and Location Based Management Systems, and how both contribute to greater plan reliability. For further details on each, see Annexes below.

LPS

Social
Daily commitment
Reliable promises
Collaborative forum

Plan reliability through:

ACUAL COMMITMENTS

Actual commitments are obtained from crews that they CAN and WILL do the task as per plan.

REMOVAL OF CONSTRAINTS

Through Identifying and removing all possible constraints for each activity, where constraints are anything at all that can prevent that task from happening. (e.g. pending shop drawing approval, site area not ready, insufficient manpower, inspections, etc.)

LBMS

Spatial
Mathematical calculations
Look-ahead forecasting
Structured scheduling solution

Plan reliability through:

ACCURACY OF PLANNED DURATIONS

Accurate planned durations in the master program which are calculated based on: accurate quantities from the model, as determined by location (e.g. the actual locations or zones for casting) multiplied by actual productivity rates of crews.

PREVENTION OF TRADE INTERFERENCE

Consideration of the physical space when planning so that crews can flow smoothly from location to location with uninterrupted work (no starts and stops)

ANNEX A5: Last Planner System
ANNEX A6: Location Based Management System

PROCESS MAPPING

Mapping a process makes it visible. When a workflow is visible, it becomes easier to pinpoint all the various forms of inefficiencies in the current state and work from there towards realizing an ideal state. Process mapping shall be undertaken whenever a team wants to analyze and improve upon any current state workflows.

1 KEY PRINCIPLES

- Mapping processes requires the input of all of the people and stakeholders involved in that process.
- Map the current state first exactly as it is
- The goal of process mapping should be to learn and improve
- "Walk through" the process to identify wastes
- Seek opportunities to further streamline, automate, and improve flow

2 TYPES OF PROCESSES IN DESIGN & CONSTRUCTION

There is a certain hierarchy and level of detail of processes in design and construction that need to be taken into consideration when looking to improve your own project or organizational processes. The following diagram describes this hierarchy as well as some specific examples. Any process, no matter at what granularity, can be further improved and optimized, but a typical first step is to map the current state in order to know specifically where and how to improve. See Annexes for further details of process improvement tools.

INTEGRATED CROSS-FUNCTIONAL PROCESSES

Is an integration of each stakeholders, discipline, or departments own processes and how they tie in together to work towards a specific project milestone. It captures just-in-time information flows from one party to another in order to remove loopbacks or redundancies from inefficient or paralleled processes.

- Cross-disciplinary workflows during the design phase to include all submittals, handoffs, and milestones.
- ERP systems in construction which integrate BIM, cost, scheduling, and other construction functions into one data platform

SINGLE FUNCTION PROCESSES

A series or sequence of tasks to produce a specific deliverable or product. The typical objective of this kind of process is to **reduce cycle time**.

- Intensive Coordination Process
- Floor casting cycle
- PBU manufacturing cycle

PROCESS FLOWS

A usually standardized step by step procedure to produce a specific task

- BIM-based crane capacity planning steps
- BIM to field digital surveying steps

ANNEX A7: Process Mapping Tools
ANNEX A8: Process Streamlining Tips
ANNEX A9: Integrating BIM with Process Mapping
ANNEX C6: Workflows and Best Practices for Virtual Construction Activities

02

BIM FOR TENDER DOCUMENTATION

Define how VDC is used to produce quality design documentation for a Design Bid Build tender release.

2.1 Introduction
2.2 Tender BIM Products
2.3 Tender Information Content
2.4 BIM Quality

Refer to Annex B to learn about discipline-specific information requirements

INTRODUCTION

1 OBJECTIVE

This chapter establishes a common set of standards and guidelines for BIM-based Tender documentation.

This chapter aims to:

- Provide a common understanding and interpretation of the information contained in the Tender Model by different users of the built environment and how this information shall be communicated.
- Provide a more efficient exchange and sharing of information amongst the project team members in a collaborative environment during the Tender Stage.
- To encourage and facilitate the development of Design models beyond regulatory submission.

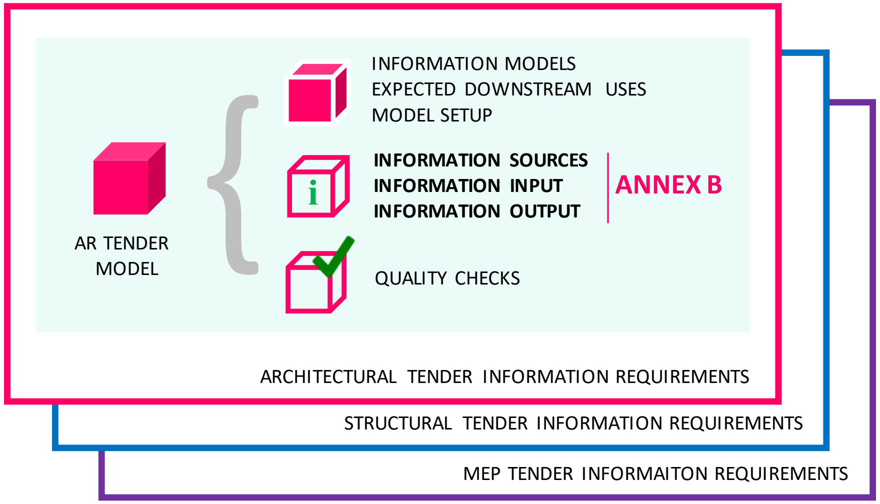
Note: Tender Stage refers to Construction Tender during a typical Design Bid Build project

2 HOW TO USE THIS CHAPTER

This chapter shall serve as a reference both for the model authors who create the Tender Model and also for the model users who will reference to the model for visualization, QTO, costing, and construction analysis during the tender period.

All parties must have the same understanding of what is to be expected from the Tender Model.

Therefore, all of the necessary prerequisites for the model to be used successfully for the purposes of tender are described here, as elaborated in the following sections, and as detailed in ANNEX B.



3 SCOPE

The scope of this chapter covers the TENDER PHASE only, particularly the preparation and release of Tender Documents. It does not include Tender Award and release of the Contract Documents and/or Construction Documents, although the requirements stipulated herein may be used as a basis.

Project Typology

The scope of this chapter covers the RESIDENTIAL TYPOLOGY only, including private and public developments. This includes condominiums, apartments, HDB developments, etc.

Contract Type

The content of the information described in this chapter assumes a DESIGN-BID-BUILD contract.

Tender Packages

The chapter covers information requirements for all 3 Disciplines, focusing on TENDER PACKAGES that are typical to this typology and that usually cover the bulk of the project cost.

These packages or general building element/area categorization are described in the first section of each discipline requirement in Annex B, including exclusions, if any.

KEY PRINCIPLES FOR BIM TENDER DOCUMENTATION

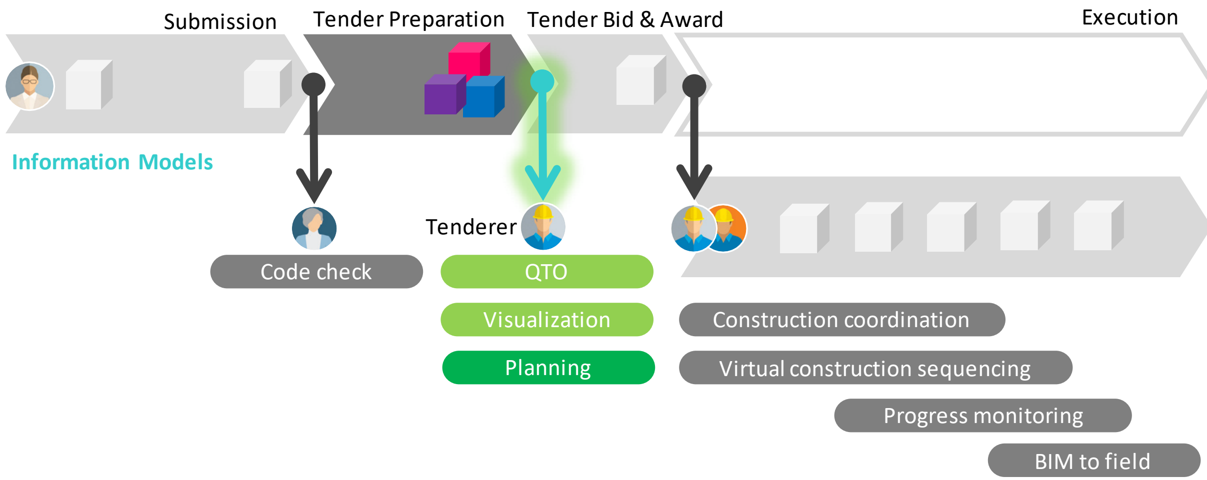
It is important to read this chapter with a good understanding of certain overarching principles that make model handover and communication of information successful in a BIM-based Tender process.

- Drawings and schedules created separately from BIM are a major source of discrepancies and unproductivity. BIM must serve as the single source of truth. To remove discrepancies, drawings, views, and schedules must be derived from the BIM model where possible.
- In a 3D tender workflow, it is important to divert efforts from tedious 2D drawing preparation and annotation to correct and complete information embedment.
- Tender Information must be communication in a method that is efficient yet still useful for tender, as opposed to over-modelling. A rule of thumb is to always consider the unit and method of measurement. There is no need to over-model provided that the required information is available and correct.

PRODUCTS

1 TENDER MODELS

The main deliverable is to produce Tender Models that are fit for bidder's downstream use during the tender period.



Information Models Required:

- Architectural Tender Model
- Structural Tender Model
- MEP Tender Model/s

These models must be of the minimum expected quality and content required for its purpose. The succeeding sections as well as Annex B provides further details of these requirements.

Expected Downstream Uses:

- QTO
- Visualization
- Planning

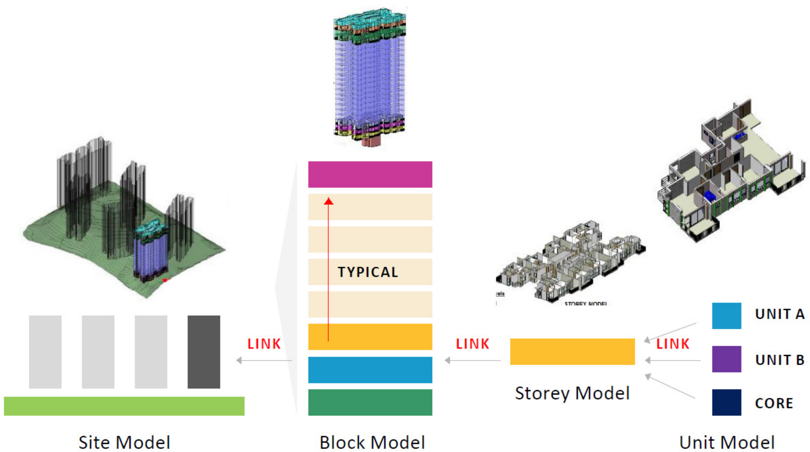
It is up to the bidders as to to what extent they intend to utilize the model for tender, as well as the method or means of data and quantity extraction they choose to employ.

2 MODEL SET-UP

This section describes an example of a typical model set-up for ease of organization and access of information.
Model Set-up shall be described in the BIM Execution Plan at the onset of the project.

Architectural Model Setup

The following diagram shows a sample model and linking structure for the Architectural discipline.

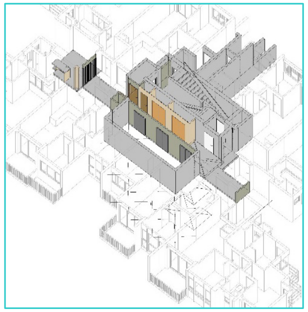


Ideally, each element is modelled in the proper file for better organization. For example, all elements that make up a unit such as all of the floor finishes, windows, ceiling, walls, furniture, etc. inside of the unit shall be modelled in that Unit Model, and not in the Storey Model. This makes it easier to group the quantities and cost by location or by unit.

Storey Model

TYPICAL MODELLED ELEMENTS:

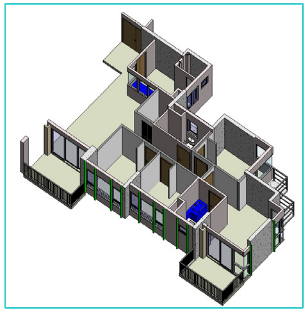
- ✓ FLOOR FINISHES of common areas
- ✓ WALLS of common areas including pipe chases, lift, etc.
- ✓ DOORS of lifts, stair cases, service shafts, etc.
- ✓ WINDOWS of common areas
- ✓ STAIRS
- ✓ RAILINGS of stairs, balconies and AC ledges
- ✓ CEILING of common areas such as corridors
- ✓ ROOMS of common areas including pipe chases, etc.



Unit Model

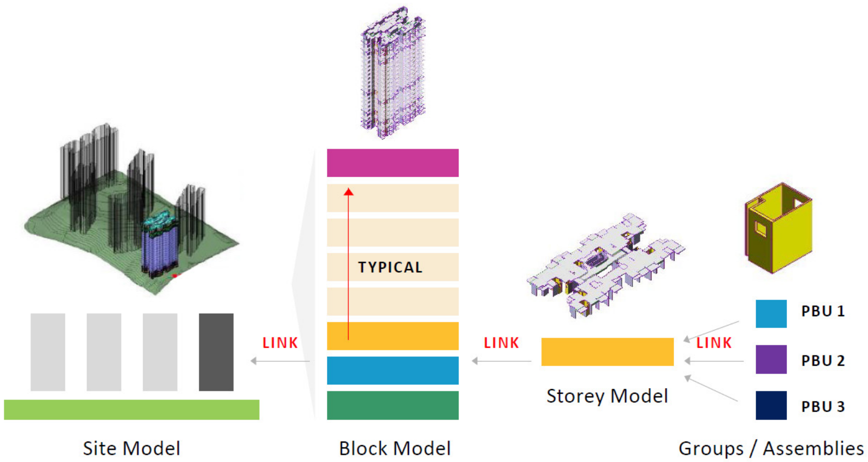
TYPICAL MODELLED ELEMENTS:

- ✓ FLOOR FINISHES of unit
- ✓ WALLS both interior and exterior
- ✓ DOORS of unit and main door
- ✓ WINDOWS of units
- ✓ RAILINGS of balconies and AC ledges
- ✓ CEILING inside unit
- ✓ ROOMS inside unit
- ✓ FIXTURES
- ✓ CABINETRY
- ✓ FURNITURE
- ✓ APPLIANCES



Structural Model Setup

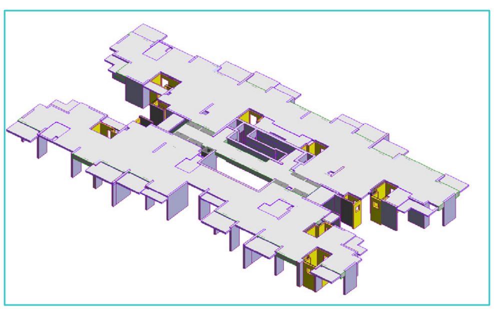
The following diagram shows a sample model and linking structure for the Structural discipline.



Storey Model

TYPICAL MODELLED ELEMENTS:

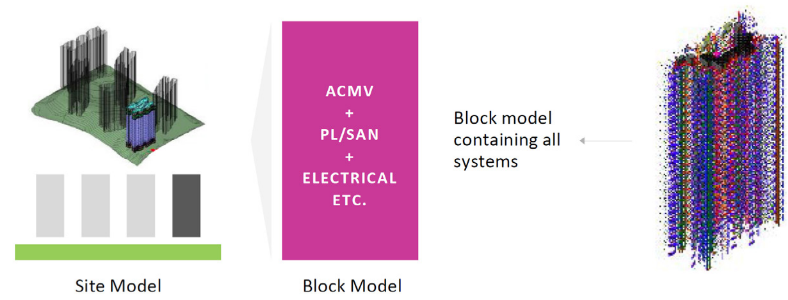
- ✓ COLUMNS
- ✓ SLABS with coordinated openings
- ✓ STRUCTURAL WALLS with coordinated
- ✓ BEAMS
- ✓ PPVC, PBU as Assemblies



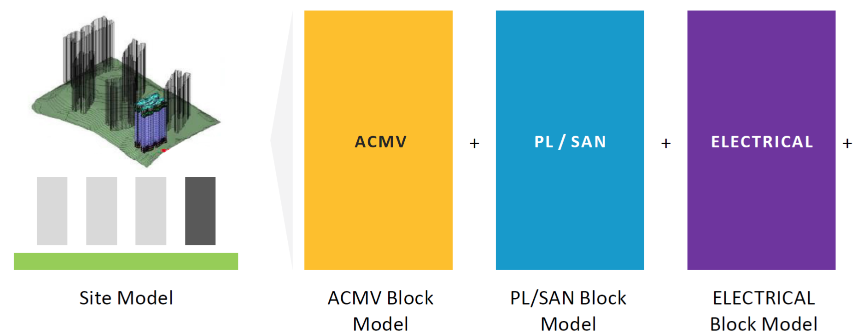
MEP Model Setup

The MEP model may be setup through the following options:

- All systems within one zone/block as one file as illustrated in the following diagram:



- Depending on model size, one system of one zone/block in one file (This makes it easier to handover files to different MEP subcontractors for their further development and use), where each system may be further split up into floors if needed.



CONTENT

1 INFORMATION SOURCES

Not all cost items can be captured in Tender models as modelled elements. For key tender packages such as architectural finishes, there may be multiple or varied sources of the same information, whether they be found in room schedules, modelled elements, or 2D drawings.

The information format remains the prerogative of the design team, but the objective is for that information to be consistent and correct across all sources. For example, rooms must be correctly tagged in the models in order to be identified and read in conjunction with room schedules.

Annex B provides a suggested hierarchy of references for key tender packages.

e.g. information sources for wall finishes

<Room Schedule>

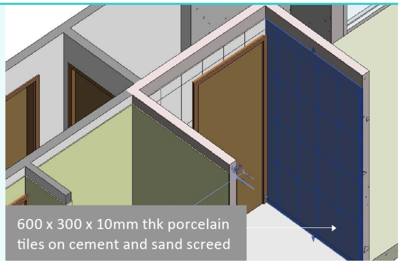
A	B
Name	Wall Finish
BEDROOM 2	
MASTER BATH	600 x 300 x 10mm thick porcelein/ homogenous tiles in polished with approved on cement and sand
MASTER BATH	600 x 300 x 10mm thick porcelein/ homogenous tiles in polished with approved on cement and sand
MASTER BATH	600 x 300 x 10mm thick porcelein/ homogenous tiles in polished with approved on cement and sand
MASTER BATH	600 x 300 x 10mm thick porcelein/ homogenous tiles in polished with approved on cement and sand
MASTER BATH	600 x 300 x 10mm thick porcelein/ homogenous tiles in polished with approved on cement and sand
MASTER BATH	600 x 300 x 10mm thick porcelein/ homogenous tiles in polished with approved on cement and sand
MASTER BATH	600 x 300 x 10mm thick porcelein/ homogenous tiles in polished with approved on cement and sand
MASTER BEDROOM	Skim coat plaster 5mm thick with 3 coats emulsion paint to wall
MASTER BEDROOM	Skim coat plaster 5mm thick with 3 coats emulsion paint to wall
MASTER BEDROOM	Skim coat plaster 5mm thick with 3 coats emulsion paint to wall
MASTER BEDROOM	Skim coat plaster 5mm thick with 3 coats emulsion paint to wall
MASTER BEDROOM	Skim coat plaster 5mm thick with 3 coats emulsion paint to wall
MASTER BEDROOM	Skim coat plaster 5mm thick with 3 coats emulsion paint to wall
MASTER BEDROOM	Skim coat plaster 5mm thick with 3 coats emulsion paint to wall

WALL FINISH

1st Reference:
Wall finish as Core Information inside of Room Data

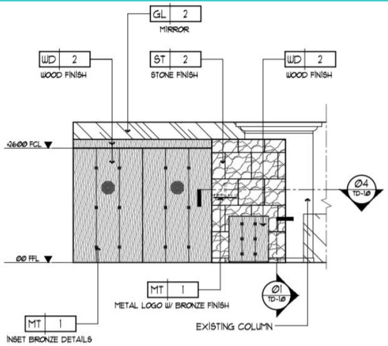
WALL FINISH

2nd Reference:
Wall finish as modelled element, finishes modelled separately from core



WALL FINISH

3rd Reference:
Wall finish found in 2D blow up room details



2 MODEL COMPLETENESS, MODELLING TECHNIQUE, AND CORE INFORMATION [INPUT]

This section describes the expected minimum content of each Tender Model by discipline. Refer to Annex B for complete checklists on Architectural, Structural, and MEP Model Content Requirements.

Model Completeness

Minimum expected modelled elements according to key tender packages and cost items.

Modelling Technique

Minimum modelling requirement to capture critical information required for costing and other purposes during the tender stage.

Core Information

Minimum geometric and non-geometric attributes required for costing and other tender purposes. Note that some of these core information are already prerequisites for e-submission.

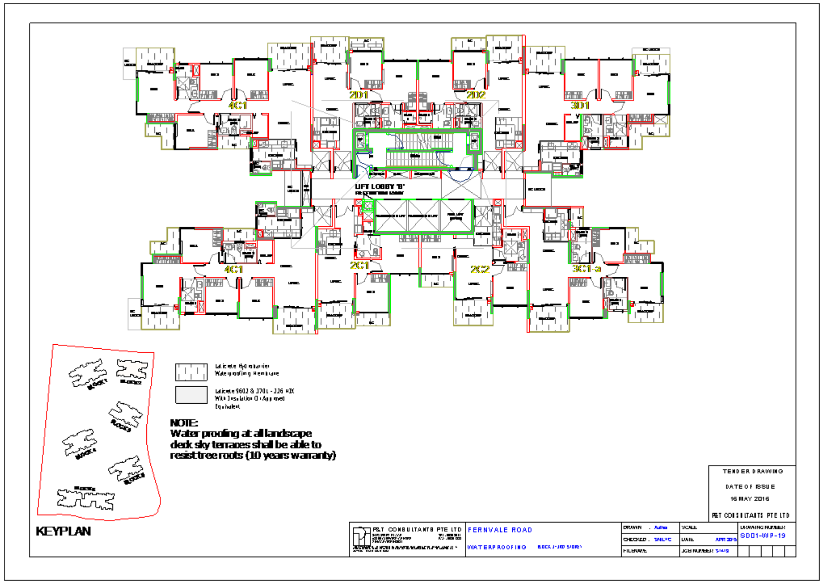
ELEMENT	MODELLING REQUIREMENT	CORE INFORMATION	REMARKS
DOOR	• Define the door type clearly. Ensure that locations and counts are correct per type. • Do not over model. Ensure that overall door size is correct. Door details may refer to 2D typical details. • Door shall be coordinated with structural openings if it is in Structural Wall • Ironmongrey shall be indicated as core information in schedule and do not need to be modelled • Model roller shutter doors to design-intent size, including the box up. • Location shall be with regards to the from room or to room	Name / Type	
		Dimensions	
		Level	
		Door Mark	
		Door Description	
		Location	
		Door Leaf_Type	
		Door Leaf_Thickness	
		Door Leaf_Material	
		Door Leaf_Fire Rating	
		Door Leaf_Finishes	

3 INFORMATION FORMAT REQUIREMENTS [OUTPUT]

Tender Information may be presented through 2D views, 3D views, and schedules. All of these outputs and deliverables, especially if they are critical layout drawings, are to be extracted from the Tender Models to the fullest extent possible, unless indicated otherwise.

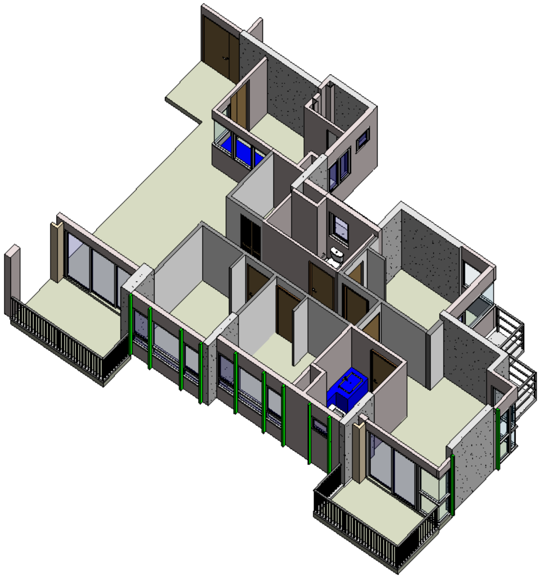
2D Views

Consist of floor plans, layout plans, blow up details, standard details, etc. Annex B provides details on 2D requirements for each disciplines.



3D Views

Consists of overall views and part 3D views by floor or area, for easy visual reference.



Schedules

Schedules must show all required Core Information by element. The main purpose of schedules is for **easy auditing of the completeness and correctness of core information**, and to **facilitate the extraction of the correct unit of measurement**. It remains the Tenderer's responsibility to check and vet the quantities for costing purposes.

Example:

DOOR SCHEDULE													
DOOR MARK	LOCATION	WIDTH	HGHT.	IRON-MONGERY SET	DOOR LEAF					DOOR FRAME			COUNT
					TYPE	MATERIAL	FIRE RATING	FINISHES	ACOUSTIC RATING	TYPE	MATERIAL	FINISHES	
D10	Lift lobby	1000	2100	C	Single leaf timber swing door	Hard-wood	1/2	Laminate Finish		Timber	Hardwood	Veneer	8
D10A	Smoke Stops Lobby	800	2100	B	Single leaf metal swing door	Metal	½	Selected Paint Color		Metal	Metal	Selected Paint Color	2

QUALITY

All tender models must comply with the minimum level of model quality as described in this section, where quality is defined by:

- Standards
- Control elements
- Intra-discipline requirements
- Content
- Intra-discipline coordination
- File Workability

1 STANDARDS

This section describes naming conventions for files, objects, and views.

Naming Conventions

File Naming Conventions

File Naming Conventions shall comply with the requirements as stated in the Code of Practice for BIM e-Submission.

View Naming

View names shall consist of 3 fields in the following format:

		TYPE OF VIEW			VIEW NAME
TENDER	–			–	

Refer to Code of Practice for Building Information Modelling for the **Type of View** Codes and **View Naming** examples.

Object Naming

Object must be properly named since some information required for tender is found the Object Name itself. This particularly holds true for MEP objects such as fixtures, equipment, and accessories.

Refer to Code of Practice for Building Information Modelling for the object naming format.

IMPORTANT NOTE:

The DESCRIPTION of the object must be explicit and well-defined and must contain enough information required to cost that element.

ORGANIZATION (USER DEFINED)	OBJECT CODE	DESCRIPTION
_	_	

NOTES:

- Names shall be composed of only alphanumeric characters without text formatting (e.g. a-z, A-Z, 0-9)
- The naming fields shall use the underscore character (_) as a delimiter and the dash character (-) within phrases
- Information within each field shall be in CamelCase (capitalized first letters to words and no spaces)
- No spaces or other punctuation shall be used.

MEP Colour Standards

MEP Colour Standards shall follow the requirements as stated in the Code of Practice for BIM e-Submission Part 3: MEP.

MEP Sub-Discipline Codes

MEP Sub Disciplines shall follow system codes below:

DISCIPLINE	SUB-DISCIPLINE	ABBREVIATION
PLUMBING	Cold Water supply	CWS
	Hot Water Supply	HWS
	Sanitary	SANITARY
	Rain Water Down Pipe	RWDP
	Hose Reel	HR
	Wet Riser	WR
	Sprinkler System	SPR
	Gas	GAS
ELECTRICAL	Electrical Cable	ECAB
	Telecom	TELECOM
	Cable Tray	CTRAY
	Cable Ladder	CLAD
	Cable Trunking	CTRUNK
	Cable Enclosure	CENCLOSE
MECHANICAL	Fresh Air Duct	FAD
	Supply Air Duct	SAD
	Kitchen Fresh Air Duct	KFAD
	Kitchen Exhaust Air Duct	KEAD
	Exhaust Air Duct	EAD
	Return Air Duct	RAD
	Toilet Exhaust Air Duct	TEAD
	Toilet Return Air Duct	TRAD
	Condensing Water Supply	CWS
	Condensing Water Return	CWR

2 CONTROL ELEMENTS

Key project control elements such as origin points, orientation, boundary setting out, grids and levels must be agreed upon and defined by the project team on the onset of the project.

Origin Points shall be geo-referenced to the Singapore SVY21 coordinate system for Easting and Northing (x, y) and to the Singapore Height Datum for Height or SHD (z). Elevation levels of the model shall be set up based on Singapore Height Datum (SHD) of 0.000m.

Orientation of the site model shall be presented in True North or real-world orientation.

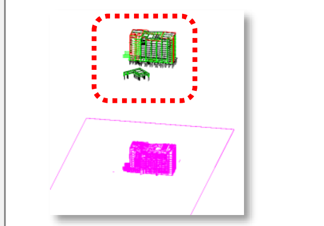
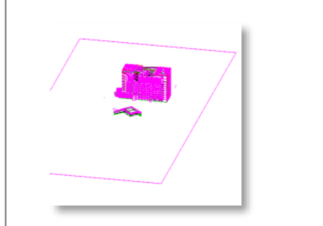
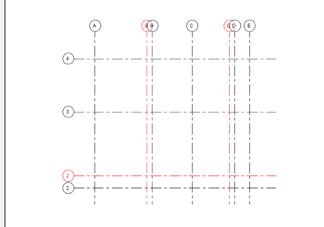
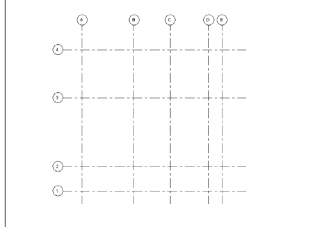
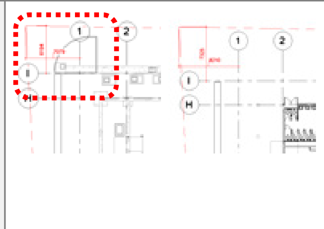
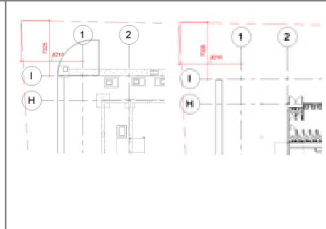
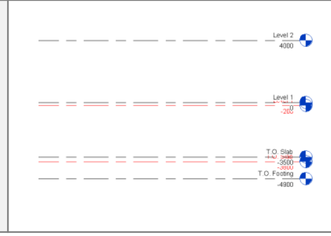
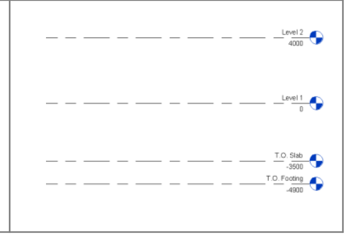
Setting-out of the project shall be based on the known boundary points and boundary lines.

Grids are the planner control elements used to set-out the building elements on site. Grids must be consistent and aligned across all models and across all disciplines.

Levels are the vertical control elements used to set-out the building elements floor by floor. Levels also used in communicating the location of issues during coordination process. Levels must be consistent and aligned across all models and across all disciplines.

Note Structural consultants may opt to have separate structural floor levels from the finish floor levels given in the architectural model. This is may be acceptable so long as the difference in drop from the FFL is logical and consistent and that there is a corresponding structural floor level for every finish floor level.

Sample images:

	INCORRECT	CORRECT
Origin points		
Grids		
Setting Out		
Levels		

3 INTRA-DISCIPLINE REQUIREMENTS

Intra-discipline requirements describe modelling best practices within each discipline model.

Modelling using correct objects

To aid quantity take-off, the correct software object / tool must be used to create building model components. For example, beams shall be modelled using the beam tool, and in no case shall they be modelled using floors or any other object. This also means that objects that have been modelled in place or created as a library object should be categorized correctly. Avoid classifying elements as 'generic objects' if the correct category is available.

Note: If a tool is not available to model specific objects (such as trunking), then another tool may be used as a workaround provided that the elements are named correctly and contain the required Core Information.

No overlapping of objects

Object overlapping result overlapping quantities occupying the same space. Follow the recommended modelling procedure in the following chapters.

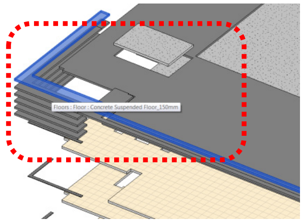
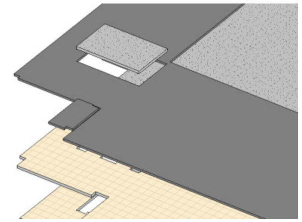
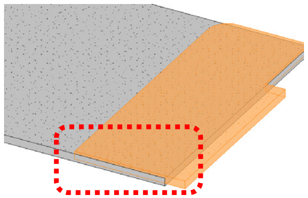
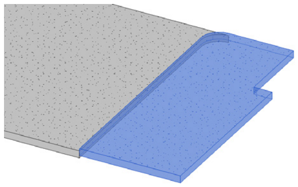
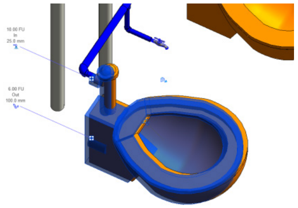
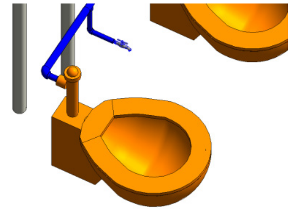
No duplication of objects

Duplicate objects are counted twice, resulting in incorrect quantities. To avoid duplicates, perform interference checks for components that are typically measured by count i.e., lighting fixtures, toilet fixtures, devices, doors, equipment, etc.

No floating of misplaced objects

Floating or misplaced objects are general modelling errors. Floating objects add in additional quantities that are not part of the project scope. Misplaced objects may lead to miscommunication especially if the model were to be used as reference for construction.

Sample images:

	INCORRECT	CORRECT
Modelling using correct objects	 *Baffles modelled as floors*	 *Floor category consists of floors only*
No overlapping of objects		
No duplication of objects		

4 CONTENT

Complete and correct more information

Information is key for BIM models to be utilized for tender, and therefore special attention must be taken to embed sufficient and correct data into each model component for it to be referenced successfully for this purpose.

BIM-extracted drawings and views

As previously highlighted, drawings, schedules, blow-up details, and other views that are non-standard must be taken from the BIM model to avoid inconsistency of the information between views. Only standard details (details that are not unique to the project) may be generated separately from the model. Other specialty packages such as Landscape, Interior Design, Water Feature, etc., may also be generated in 2D CAD provided that the contents therein are sufficiently coordinated and do not contradict with the 3D model.

Model Completeness

The model must be complete and adequate and must contain expected objects for the project scope, especially for the tender packages as indicated in this Chapter.

5 INTER-DISCIPLINE COORDINATION

Inter-discipline coordination requirements refer to the minimum level of model coordination required between disciplines. This following are typical coordination issues that are critical to construction and must be ideally resolved during design stage.

Architectural – Structural Coordination

- Column setting out and alignment between Architectural and Structural models.
- Ceiling to structural framing coordination
- Staircase and ramp coordination

Architectural – MEP Coordination

- Service shaft coordination
- Ceiling to concealed MEP services coordination

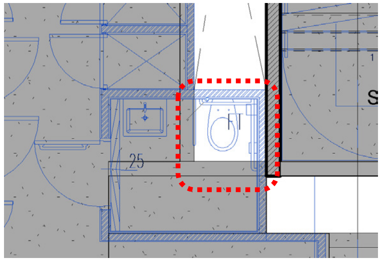
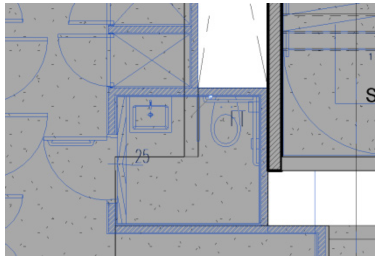
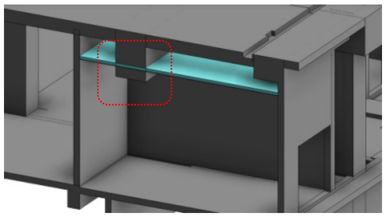
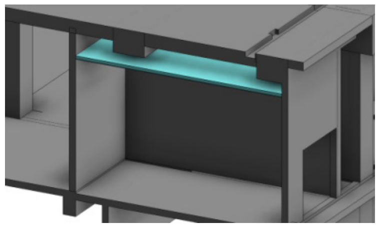
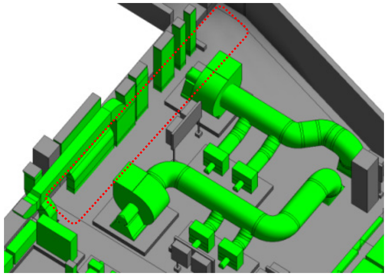
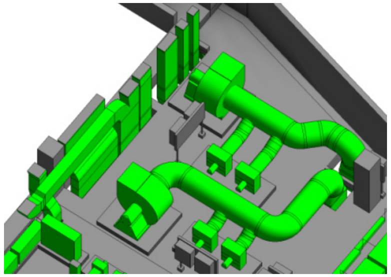
Structural – MEP Coordination

- Critical penetrations especially of large pipes and MEP services into structural framing
- MEP openings into structural walls
- Underground MEP services to structural foundation

AR-ST-MEP

- Toilet setting out, including coordination of tile layout, floor drains, and fixtures
- Façade coordination

Sample images:

	INCORRECT	CORRECT
Column setting out and alignment between Architectural and Structural models	 *Portion of toilet with no slab in structural model; outline of opening not coinciding.*	 *Architectural and structural floor plate coincide.*
Ceiling to structure coordination	 *Beam clashing with ceiling.*	 *No critical clashes to ceiling.*
Critical MEP penetrations to structure	 *Duct risers penetrate into slab.*	 *No critical penetrations to structure.*

TARGETS & PERFORMANCE MEASUREMENTS

The following describes some relevant targets and corresponding KPIs for tender preparation and documentation:

1. **Increased productivity in tender preparation**

   The extra time required to further develop the model for tender documentation may be offset by the savings in manhours from the traditional manual process of preparing schedules, 2D views, and other drawings that may have been produced separately from the BIM model

   - Comparison of man-hours spent for Tender Documentation between traditional process and new process

   __ reduction in manhours or

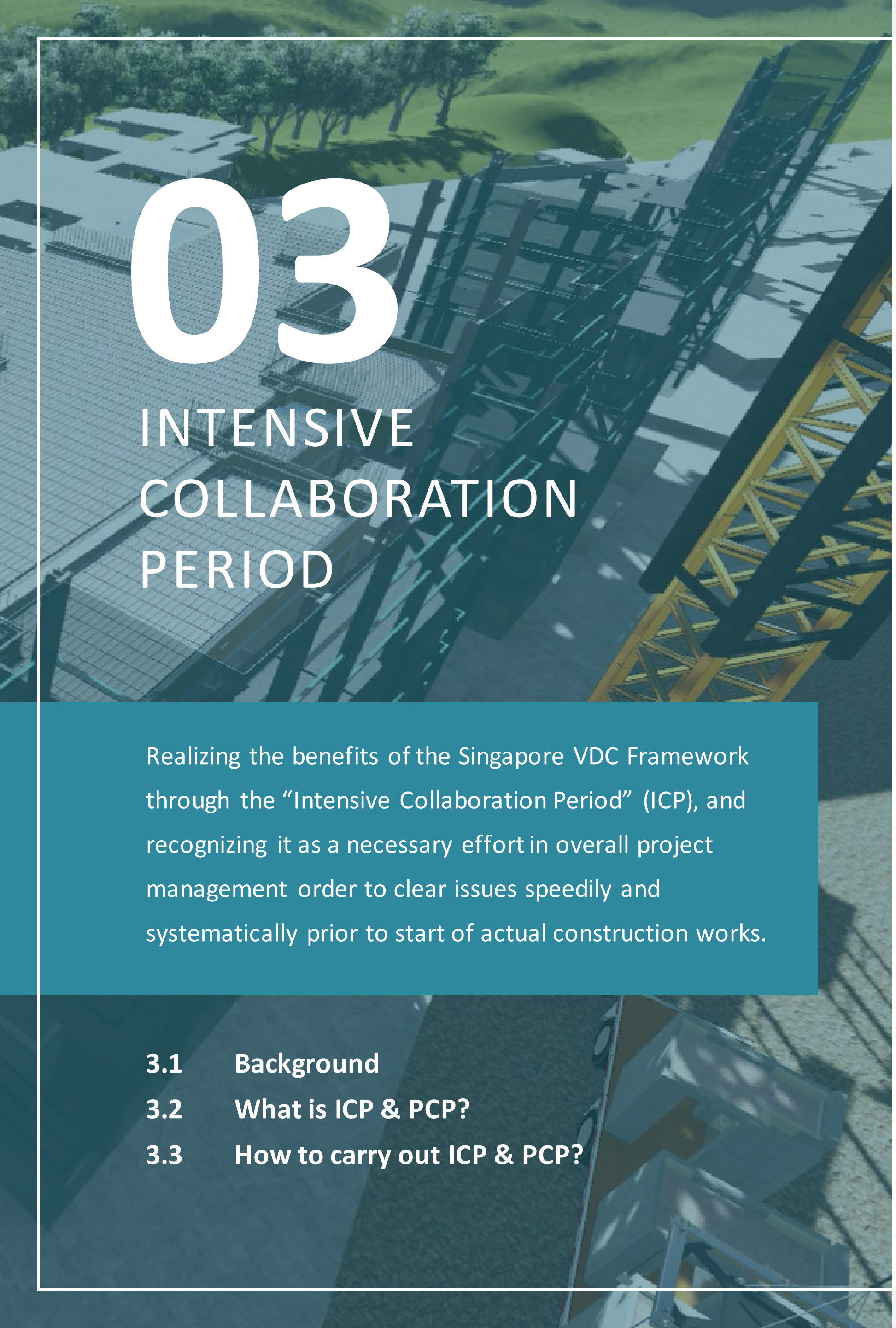
   __% increase in manhour productivity

2. **Reduction of information discrepancies**

   Establishing the model as the single source of truth should result in a marked reduction of discrepancies and inconsistencies that were borne from this same paralleled 2D and 3D workflow and manual annotation and documentation.

   - Comparison between number of tender queries pertaining to information discrepancy especially between multiple sources of the same information

   __ reduction in tender queries



03

INTENSIVE COLLABORATION PERIOD

Realizing the benefits of the Singapore VDC Framework through the “Intensive Collaboration Period” (ICP), and recognizing it as a necessary effort in overall project management order to clear issues speedily and systematically prior to start of actual construction works.

3.1 Background

3.2 What is ICP & PCP?

3.3 How to carry out ICP & PCP?

INTRODUCTION

1 OBJECTIVE

This chapter provides insight on the guiding principles of using the Singapore VDC Framework to carry out “Coordination Works” through a dedicated phase or task called Intensive Collaboration Period. Any other essential task can also utilize similar concepts demonstrated here.

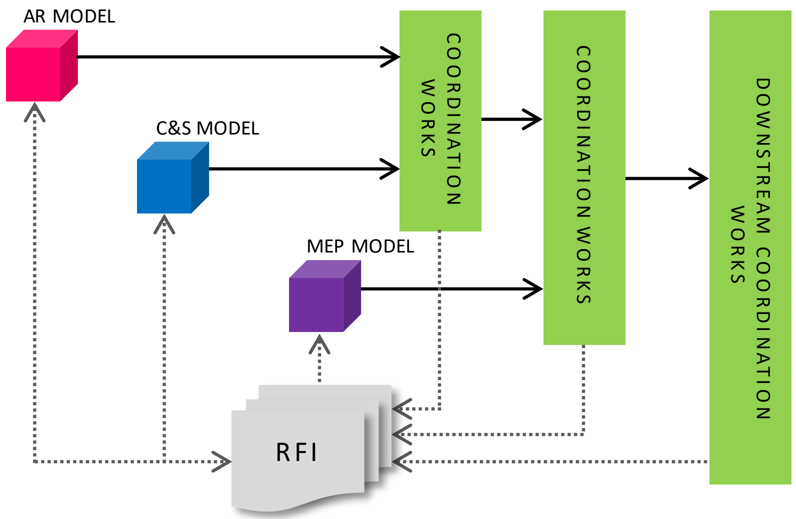
This chapter aims to:

- Define and describe the principles of Intensive Collaboration Period (ICP)
- Illustrate how ICP can be carried out in a typical project implementation
- To demonstrate ICP as task / activity that utilizes the Singapore VDC methodology or framework to carry out coordination works more efficiently

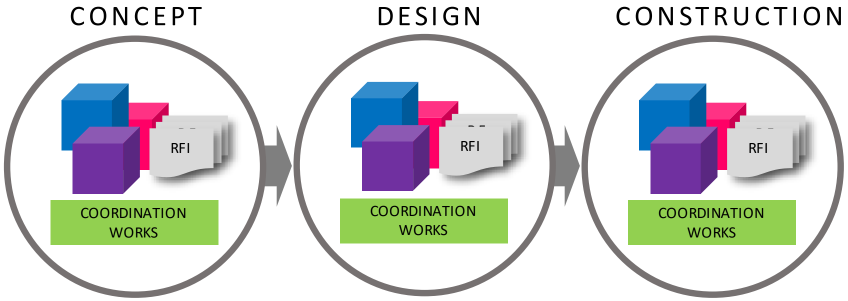
2 BACKGROUND

Typically, BIM users would develop their project BIM model to appreciate the spatial interaction among building elements. For instance, to be able to understand which floor a column would start and end, or how a floor slab will interface with the adjoining beam. In doing so, the project BIM model should provide sufficient clarity to the design intent, so that all stakeholders may have a common understanding of how the project would eventually look like.

Once a specific domain has been developed for the project BIM, stakeholders will then cross reference against each other to ensure consistencies between disciplines, as well as to avoid interference among the design elements.



Any of these inconsistencies are usually raised as "Request for Information (RFI)" to the respective parties for feedback, which could subsequently require changes to the project BIM model. This cycle will go on throughout the duration of the project, as well as throughout different phases of the project; for instance, from Design Phase to Construction Phase and Operational Phase.



While this workflow has helped surface many benefits for all stakeholders during coordination, this virtual resolution has been limited to just maintaining the project BIM content and is not necessarily creating sufficient downstream benefits to the Project Execution stage, especially in the Construction Phase.

In some instances, this results in a crunch for resources because the construction team captures information on site that is different from what was being coordinated.

Besides the overheads to rectify this information mismatch, it poses chances for delays should the issue requires re-design or regulatory re-approvals. This would then mean that the construction team would have to re-plan their works in order to meet the committed timeline in the construction phase.

3 FOCUS ACTIVITY: COORDINATION WORKS

It therefore seems a method is necessary to enable the quality information created upstream to continue into the downstream functions. And this does not necessarily have to be confined between the phases in the Project Lifecycle, but it must be applicable within the phases as well.

VDC is recognized as such a methodology or framework to realize this objective. But to be successful with this framework, we need to create an activity in our master schedule that will describe the various task that we wanted to carry out, in order to reap the full benefits from VDC implementation. These activities are primarily focused on "Coordination Works", and it can be generalized into 3 main categories:

COORDINATION WORKS

Intra-Discipline Quality Checks

This is where you ensure quality information in the elements of the Project BIM developed. Some examples of these checks you would perform includes no overlapping or duplicates of elements, or no floating items that has no spatial relationship to the surrounding. Extended quality control checks can include "Serviceable Space" where you want to ensure accessible space are not interfered with building elements.

Inter-Discipline Coordination Checks

Typically carried out across discipline or multiple Project BIM content. Some examples of these checks would be to ensure consistent representation of structural columns between the Architectural and Structural Project Models, or that there are no clashes between windows and structural beams.

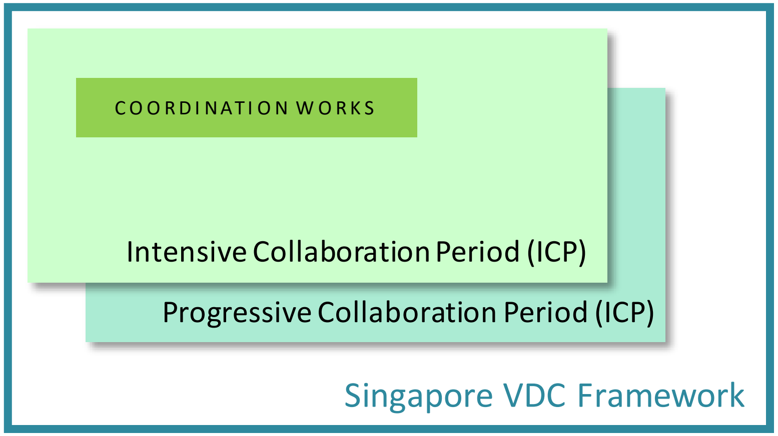
Essential Core information.

Beyond creating geometrical representations of the Project BIM elements, embedding essential core information can help improve downstream activities. For instance, whether a particular column is "Precast" or "Cast-In-Situ", or whether a cable-tray is for electrical works or telecommunication. In any case, it can speed up the understanding of the project in planning and decision making. In today's conventional practices, one would have to clarify with consultants, or base on local knowledge (or assumptions). All these could lead to delays or reworks.

OTHERS

Thus, by understanding the scope of the "Coordination Works", we can now extend the activities by applying the VDC methodology over it, so that the benefits can be extended further into other various implementations for the project.

To avoid challenges in managing the differences in scope of work, we have named this task as **"Intensive Collaboration Period (ICP)"** as opposed to "Coordination Works". Detailed description of ICP will be elaborated upon in the next section.



WHAT IS ICP AND PCP?

Essentially, Intensive Collaboration Period (ICP) and Progressive Collaboration Period (PCP) are activities in the project schedule that incorporates all functionality you would perform in "Coordination Works", but complemented with the VDC framework. The VDC framework provides the foundation and basis for carrying out ICP and PCP. Essential understanding of how to carry out effective ICE sessions, planning and managing processes, as well as creating meaningful and measurable metrics are just some key elements to getting the best results out of this task for your project.

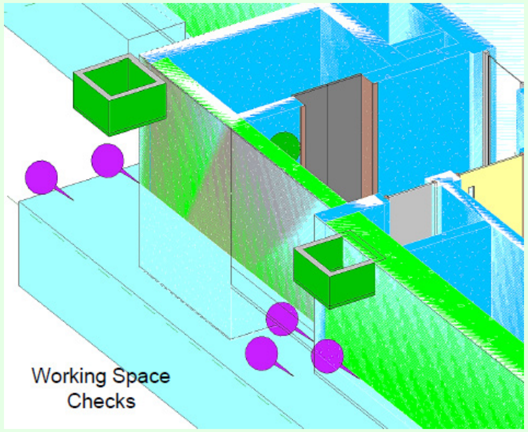
1 KEY PRINCIPLES OF ICP & PCP

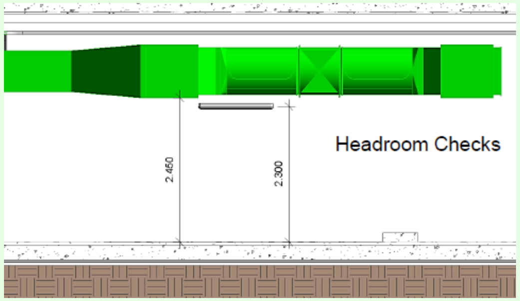
- The ideal coordination set-up is to **physically co-locate** all key stakeholders and **address issues as quickly as possible.**
- But since physical co-location may not be feasible most of the time, a variation is for stakeholders to convene on a **very frequent basis**, especially at the beginning of the project, using ICE to collaboratively resolve any issues resulting from the project BIM coordination and validation.
- For projects that do not have the luxury of a dedicated black-out period after project award, the intensive collaboration period may still occur during site preparatory works or the early stages of construction, since **issues must be systematically addressed by order of priority according to the master schedule critical path**.
- The main difference between ICP and traditional coordination is that issues are raised, resolved, and updated within the BIM model inasmuch as possible during each ICP session.

Coordination Issues Covered

Issues covered during ICP / PCP are not limited to matters raised by consultants, contractor and sub-contractors, and may typically include the following:

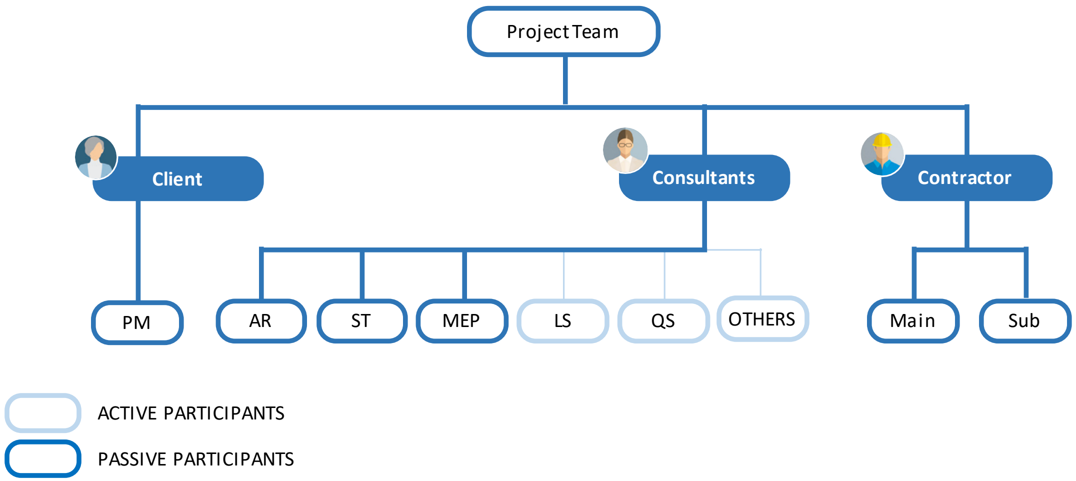
- Modelling issues
- Design-related issues
- Clearance and accessibility checks
- Working space checks
- Resources, processes and methods that will be of concern to any stakeholders, which will requires clarification among the team.
- Depending on the agreed scope of work in the ICP (to be addressed in the BEP), temporary works may be also be covered
- Any other issues surfaced over the course of discussion





CREATING AN ECOSYSTEM FOR EFFECTIVE ICE SESSIONS

- All respective stakeholders must have appropriate representatives for the purpose of solving project issues virtually before approving any actual downstream works. Stakeholders are expected to ensure that the **right representatives** are present for any the decision making (for instance the Design Architect or the Structural Engineer).
- All stakeholders must contribute effectively to address matters raised in the ICP Session.
- Any stakeholder (e.g. Landscape Consultants or Specialist Subcontractors) who may not have their own BIM models are still expected to participate in the ICP/PCP Sessions. This is because any item that has implication to their works (or vice-versa) must be addressed together as a team, so that consistent interpretation is communicated to all members.
- BIM modelers or BIM coordinators are expected to be present to make any changes on the ground, based on the discussion and outcome in the ICP sessions.
- Ideally, all stakeholders use the same (or interoperable) software platforms and they must have reasonably qualified skilled staff to carry out their own scopes of work.
- The ICP/PCP moderator (or whoever is leading the coordination works) will have to be mindful of the targeted incidents to resolve and metrics to track.



ACTIVE VS PASSIVE PARTICIPANTS

Stakeholders involved during ICE sessions in the ICP/PCP phases are either active participants or passive participants, depending on the criticality of their role during their discussions and also according to what phase of the project is being addressed at that point of time in the master schedule. This is why at certain times, roles may change from active to passive or vice versa for certain stakeholders.

Active participants

Active participants hold a primary role in all discussions, as their input is critical. They are usually also present during most of the ICE sessions.

Passive participants

Passive participants may still need to be involved during discussions, in the event that the issues discussed involved or affect their scopes of work or vice versa.

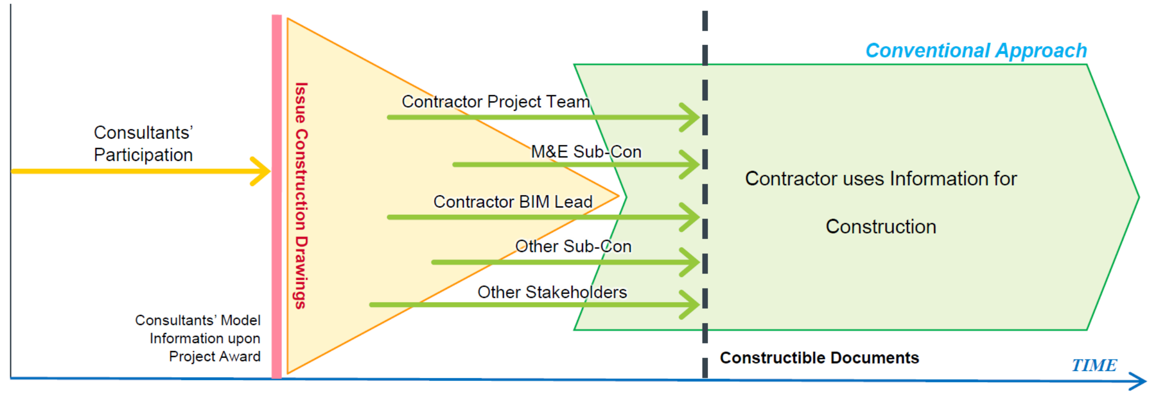
A CHANGE PROCESS

ICP / PCP will eventually result in changes to the way project gets delivered. The "Change Process" is essential to realize overall productivity gain and quality improvement for the Project.

1. The primary concept in ICP / PCP is to **bring forward as much of the coordination work as possible**, early in the cycle so that downstream activities can be realized and executed predictably over the project timeline.
2. It is also to **minimize any redundant and unnecessary work** as much as possible. For instance, effort and time to prepare documentations for constructions works based on non-federated BIM, could be wasted if constant changes were expected out of it. Unfortunately, these changes may not be eliminated 100% , though we can minimize instances as much as we can manage.

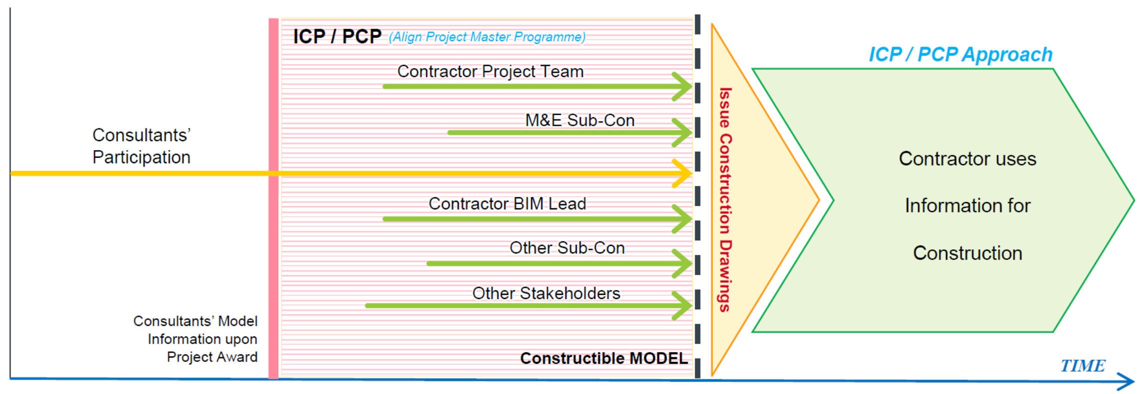
Illustrated here is an example of what the change process means to the project cycle.

CONVENTIONAL APPROACH



In a conventional approach, when a project gets awarded to a builder, many would rush to generate drawings for downstream activities as early as possible. Over the course of these activities, revisions and changes could flow through due to the number of RFIs raised. With more generated and different revisions to different disciplines, coordination work becomes more complex. In some cases, using the wrong set of documentation for construction resulted will result in delays or reworks.

ICP / PCP



With ICP / PCP in place, the system will require a black out period where no drawings are to be generated until all coordination works are virtually assessed and verified good for construction for that particular area. This approach is usually pegged to the master schedule where high priority items are worked on first. In addition to this, metrics can also be compiled to measure effectiveness of the virtual construction against the construction work.

TARGETS & PERFORMANCE MEASUREMENT

The following are examples of metrics that may be used to track project performance during ICP / PCP. These metrics will be monitored frequently during the period to evaluate whether or not the targets were reasonable and also to improve overall performance and productivity.

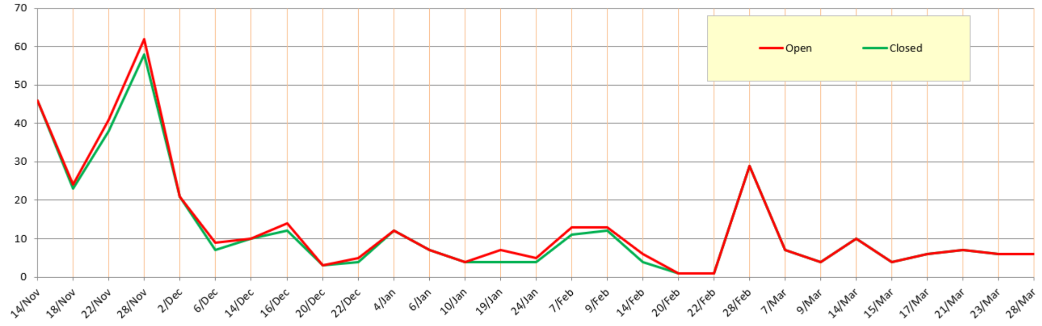
1. **Issue Progress Tracking (open vs closed)**
   The project team sets a target to the number of issues to be resolved in each ICE session, and keep records to the number of open versus closed as metrics.

2. **Issues Turnaround time**
   Where issues remains open, the time taken to closing them is tracked. Should the figure exceeds the targeted turnaround time, necessary actions must take place. The targeted duration can be set according to the issue complexity.

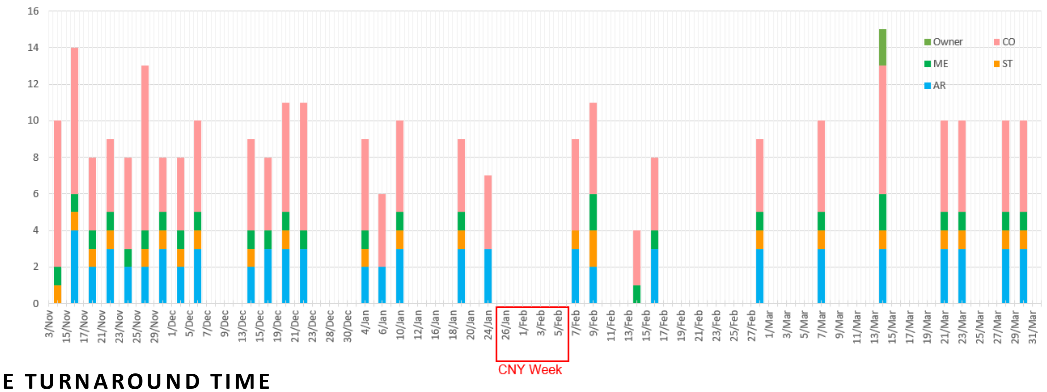
3. **Plan-against-Actual Construction**
   Tracking Planned vs Actual variance in a construction task against a target can help monitor the productivity performance in the project.

4. **ICP / PCP Session Attendance**
   Any essential parties missing in the Session can delay resolution of issues. As such, monitoring this against the expected representatives' presence is important for the project.

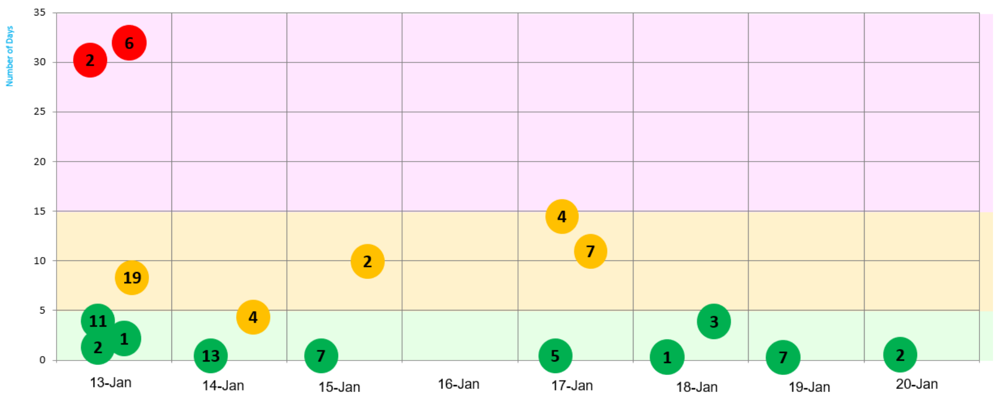
ISSUE PROGRESS TRACKING (OPEN VS CLOSED)



ICP/PCP SESSION ATTENDANCE

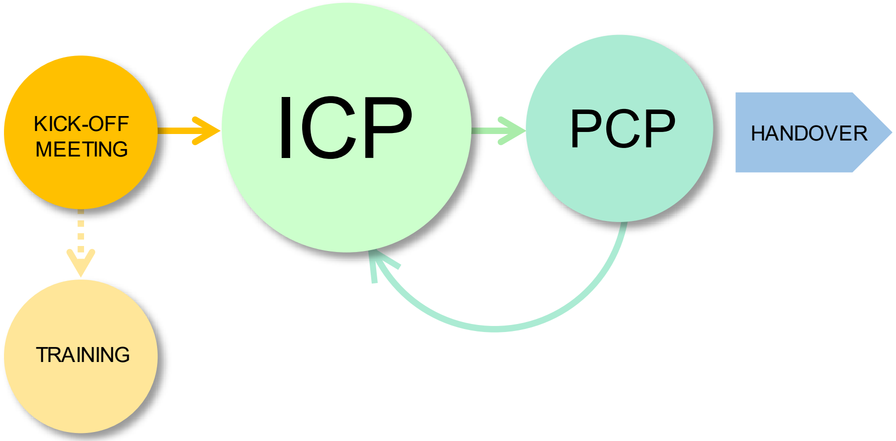


ISSUE TURNAROUND TIME



HOW TO CARRY OUT ICP & PCP?

The following sections describe a use case where ICP & PCP was conducted between Consultants and Contractors during the construction phase. Your process may vary but the principles remain the same.



1 KICK-OFF MEETING

To introduce the approach to all stakeholders, a kick-off meeting was carried out to jump start and set a platform for a common understanding of the project. All members are required to attend including the representatives from the developer so as to provide clarity to the set processes and metrics in the project. Different roles and responsibilities for each team were also articulated to clarify the overall management scope for the project. In this kick-off meeting, salient items discussed are listed below. All these activities are typically completed within the first two weeks upon project initiation.

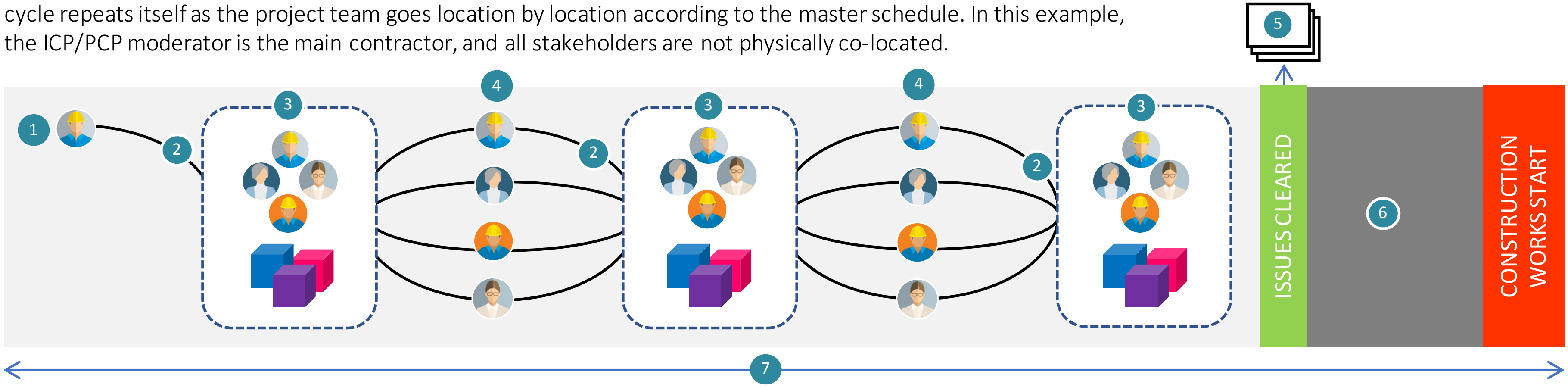
- Goals and Objectives and how the project team shall work towards them
- The importance of each stakeholder's participation during the ICE session, and that all members must aim towards solving issues for the project as quickly as possible. Targets are set and all stakeholders must strive to reach them.
- Schedules and frequencies for Intensive Collaboration Period (ICP) and when to transition into Progressive Collaboration Period (PCP). Venues and infrastructure for these sessions are also discussed.
- Coordination workflows leading to the shop drawings production, any exceptional workflows, and how to manage changes with reference back to the master schedule
- The deliverables out of the ICP / PCP sessions, and the utilization of the project BIM for any other purpose in the project
- Any other concerns by stakeholders

2 TRAINING

Where members are not clear with the VDC-framework or lack understanding on the metrics, a separate training session was carried out for them.

3 AN ICP/PCP "CYCLE"

The following diagram describes a typical ICP/PCP scenario from preparation to start of construction work. This cycle repeats itself as the project team goes location by location according to the master schedule. In this example, the ICP/PCP moderator is the main contractor, and all stakeholders are not physically co-located.



1 Preparation

- In this case, the Contractor takes on the leading role of IPC. Some early preparations by the Contractor involve evaluating requirements, and studying the preliminary models for quality issues.
- The first session is usually used to explain files and structure management for all project models and document repositories. The modelling team are to follow a structured filing system, as well as naming conventions and essential core information entries. If work-sharing mechanisms (or file linking techniques) are used, the dos and don'ts are will be enforced for the benefit to the project members.

2 Prior to each ICE session

- The contractor would generally compile and distribute the set of issues to be discussed to all stakeholders for assessment before the ICE Sessions.

3 ICE Session

- The project team systematically goes through each issue, ideally updating the BIM model as per the discussed resolutions.
- At the end of each session, some time will be allocated for the BIM Coordinator to do a summary on achievements against the **targets** for the day, the **follow up items** to be addressed in the next session, and communicate any **preparation work** essential to the team members.
- All stakeholders will then copy a set of ALL the latest models back with them, to address any back office follow-up works.

4 Model updates

- All respective stakeholders will then have to collect this information back with them for any of the internal operational activities such as validating against their regulatory approved drawings or correspondence with their specialist sub-contractors (to name some examples).

5 Construction documentation

- While the coordination works could lead to early availability of shop drawings, it should not be generated until the site is ready to utilize these documents. This is to avoid creating any drawing versions in between cycles.
- One can apply the "Pull" principle and set a target to generate the shop drawings e.g. 2 weeks before actual construction works, and gradually modify this duration after monitoring for a period of time.

6 Freeze Documentation Period

- Once the shop drawings have generated, it should be read as a period where no changes should be allowed to the model or documents, otherwise revisions will affect the quality of the cycle.

7 Metrics tracking

- Any pre-established metrics must be kept up to date during the ICP phase and not left till the end of the cycle to compile data. Where automation in capturing this data is available, one would need to exploit this option where possible, so as to improve the credibility of the metrics compiled. Only then can this information be used to progress the project forward.
- All these set targets are constantly tracked, monitored and benchmarked internally against actual data so that any necessary adjustments to the targets can be applied where necessary

4 TRANSITIONING FROM ICP TO PCP

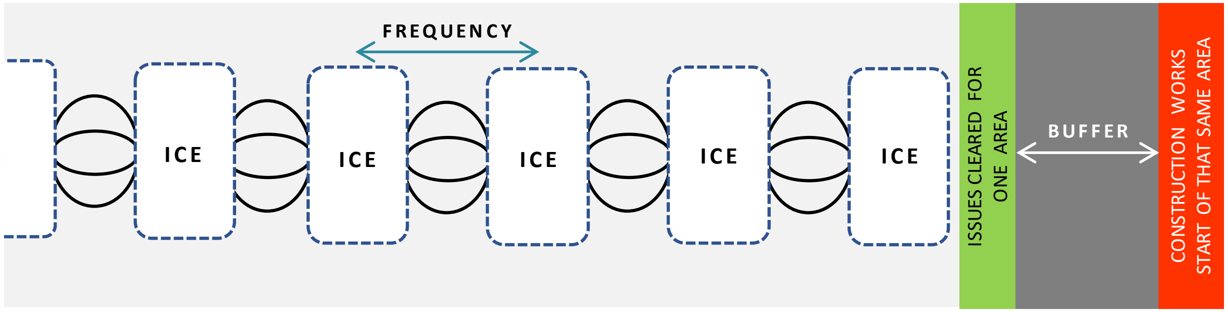
There will reach a time in the project cycle that the ICP phase would have created a good enough buffer between virtual coordination works and actual construction activities (e.g. coordination is now 3 months or 5 floors ahead of actual construction). The lead time of this buffer is subject to the discretion and comfort level of the project team.

At this stage, stakeholders have to collectively come together to decide on a new interval period for ICE session, and it is from here that the **Intensive** Collaboration Period transitions to **Progressive** Collaboration Period (PCP). With regards to the functionality of PCP, all functions during PCP are no different from ICP, although it may not be as critical to update issues in the project model during actual sessions.

INTENSIVE COLLABORATION PERIOD (ICP)

Duration:
The duration for ICP can run anything from **2 months to 6 months** from project award, depending on scale and complexity of the project.

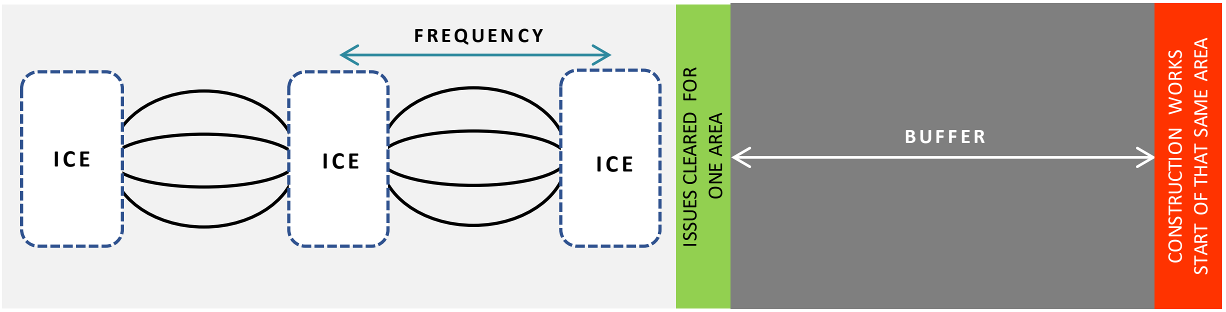
Frequency:
Daily (or highly frequent)



PROGRESSIVE COLLABORATION PERIOD (PCP)

Duration:
From end of ICP to all the way to the end of the project.

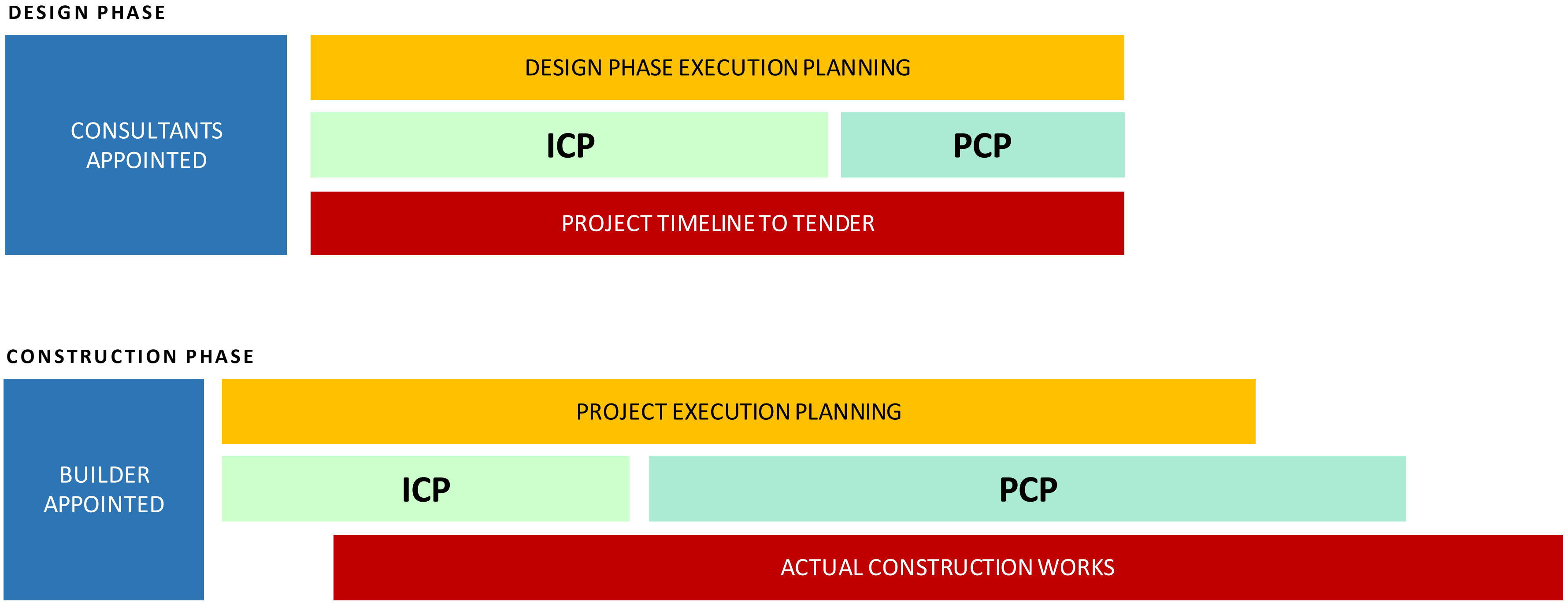
Frequency:
The frequency can now progressively reduce from a daily ICE session to 2 times a week, to once a week, and subsequently stretch to once a month.



5 HOW THE CONCEPT OF ICP/PCP CAN BE APPLIED AT ANY PHASE

Though the use case shown previously is that of construction phase, the concept and principles of ICP/PCP can also be applied during design while working on design coordination in preparation for tender. Some of the principles of conducting ICE sessions can also hold true for any project coordination or process design which involves the input of multiple stakeholders with the intention of arriving at a solution or resolution as speedily as possible.

The diagrams illustrated here are symbolic representation to proportion of time spent in ICP / PCP in during Design and Construction phases in a Design-Bid-Build environment. The eventual composition of time spend for different types of projects is expected to vary.



04

VIRTUAL CONSTRUCTION

Define how to maximize the benefits of VDC to meet the specific goals and objectives of any construction project, as exemplified by four critical use cases typically found in most projects.

4.1 Site Logistics & Utilization

4.2 PBU Installation

4.3 MEP Installation

4.4 Architectural Fit-Out

INTRODUCTION

1 OBJECTIVE

This chapter provides a comprehensive set of guidelines on how to utilize BIM and VDC in the construction stage and bring BIM to Field.

The chapter aims to:

- Establish the key principles of the VDC Framework as specifically applied in construction.
- Provide an overview of the specific objectives and details of the various key Activities in the construction phase.
- Provide a front-to-end walkthrough of the Framework from Goal and Objective setting, identifying key Activities, defining BIM, Ecosystem, Process requirements, and establishing meaningful performance measurements.

2 HOW TO USE THIS GUIDE

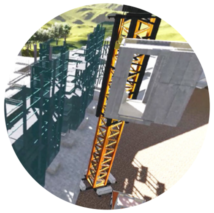
This guide shall serve as a reference for main contractors who take the lead in carrying out VDC during the construction stage, and all other project team stakeholders such as clients, consultants, sub contractors, suppliers, who play key roles in the construction project lifecycle.

All parties must have the same understanding of the principles of VDC in construction and the specific objectives of every activity during this phase. Furthermore, each party must be aware of and fulfill their individual roles responsibilities in all activities where their involvement is required.

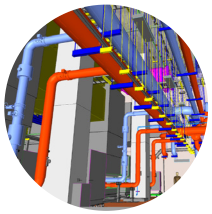
Critical Activities

VDC in Construction is exemplified in this chapter through four Critical Activity use cases. Each critical activity presents its own unique challenges and constraints and their criticality is relevant in most construction projects, though some more than others depending on project typology and project complexity.

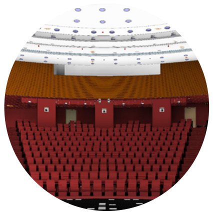
Site Logistics



PBU Installation



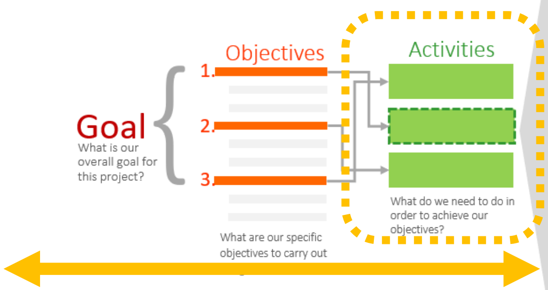
MEP Installation



Architectural Fit-Out

2 *Details of typical activities comprising "Model what is to be built, Rehearse what is to be built, and Build what was modelled and rehearsed" can be found from page 65-69*

1 *The key principles of the entire framework is described in pp 62-63.*



3 *A walkthrough from Goals, Objectives, to Activities and Performance metrics is demonstrated for four Critical Activity use cases from pp 70-92.*

4 *Specific details of BIM, Ecosystem, and Process for each Critical Activity use case is found in ANNEX C.*

3 GENERAL PRINCIPLES

The key principles of every component of the VDC framework as applied in the construction phase is described in this section.

Goal

- A project goal must be agreed upon by all key stakeholders.

Objectives

- When setting objectives, consider of all aspects of construction (e.g. schedule, cost, safety, planning, quality, maintenance, department or stakeholder interfacing and collaboration, etc.) that may be relevant to your goal.

Activities

- Focus on the activities that will help your team achieve your specific objectives. It is not necessary to carry out all activities as described in this chapter for every project

"Model what is to be built"

- Develop construction models to be an accurate and reliable "virtual" representation of what is to be built.

"Rehearse what is to be built"

- Utilize the construction model to analyze and simulate constructability, resource allocation, and safety in order to remove time, space, resource constraints and reduce overall risk during "actual" construction.

"Build what was modelled and rehearsed"

- "What to build" and "how to build" must be communicated to crews, executed correctly both on-site and off-site, and closely monitored in terms of accuracy of physical representation, quality, and adherence to schedule to ensure that "actual" is as per "virtual".

Master Planning

VDC Schedule

Construction modelling & virtual mock-up development

Virtual reviews

Virtual planning & sequencing

Constructability & Safety studies

Quantity takeoff

Construction drawing production

Site briefing

Communication & visualization

Layout & survey

Digital fabrication

Site Control

Quality & defects management

As-built verification

BIM

Products
- The model author of each trade is preferably the installer or fabricator of that trade
- The "construction model" is a live federation of all trade models and base models
- The construction model must ideally serve as a single source of truth for all tasks & activities

Content
- The content of the model is dictated by the activities required downstream
- Model as how it will be built in actual construction
- Do not both over-model or under-model according to what is required to carry out each activity

Quality
- The quality of the model is dictated by its reliability and usability of its content in construction
- The main contractor must set the expected level of quality for all models
- All model authors (subcons, suppliers) must consistently comply with expected model quality

Ecosystem

Stakeholders
- Get the right people (NSCs, subcontractors, suppliers) on board at the right time
- VDC is not just the responsibility of the BIM personnel, but all construction project team members
- Bridge knowledge gaps between the BIM model "virtual" and physical installation "actual"

Environment
- It is ideal to co-locate key trade stakeholders on site for model development and updating
- Create a meeting room environment that supports virtual reviews sessions & instant model update
- Utilize the site environment to communicate and bring BIM to Field

Platforms
- Create a Common Data Environment to enable model sharing & collaboration between stakeholders
- Utilize tools and platforms to bring information direct to site and vice versa
- Ensure the most updated models, drawings, and files are available to all stakeholders

Process Optimization

Lean
- Implement a "make-ready" or "pull" process as referenced from actual execution dates
- Carry out activities location by location according the master schedule
- Strive for integration of departmental processes

ACTIVITIES

1 CREATING A VDC SCHEDULE

The main contractor shall create, maintain, and update a comprehensive schedule of all tasks and activities to be carried out by location in accordance to the master schedule.

Creating and maintaining a VDC schedule is crucial to ensure that all activities are carried out in order of priority in accordance to the schedule of works on site. Identifying all possible issues and constraints and resolving them timely for every location, by location is the key to smooth project operation.

The following describes the series of steps involved in creating a VDC schedule.

ANNEX C1: VDC Schedule Sample

STEP 1
Extract execution dates of each construction activity from the Master Schedule.

STEP 2
Organize schedule chronologically by location and by activity per location according to the master schedule execution dates.

STEP 3
For every location and activity, indicate pull dates with sufficient lead time to perform each task:

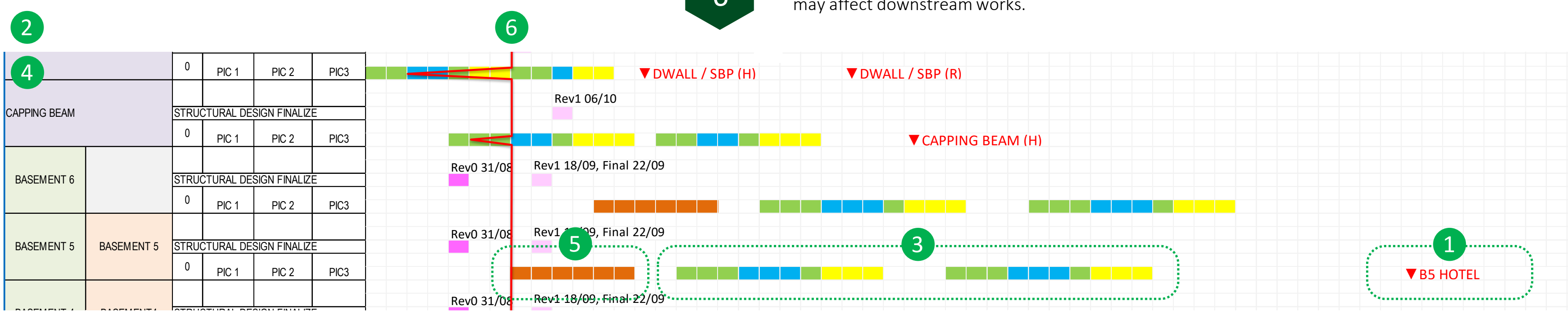
- Drawing preparation
- Coordination with all trade input
- Reviews and shop drawing / model approval
- Necessary expected revisions
- Any other necessary inputs by subcontractors

STEP 4
Highlight critical activities in the schedule. Critical areas or activities may include:

- Physical mock-up construction
- Areas that are complex in design (as determined by Consultant)
- Areas that are complex to construct (as determined by the Project Manager)
- Areas with congested services
- Handover dates and other important milestones

STEP 5
For every location and construction activity note critical information that needs to be provided or confirmed, as well as who must be providing this information.

STEP 6
Regularly track and monitor schedule (e.g weekly) and check for any delays or unresolved issues that may affect downstream works.



2 VDC ACTIVITIES IN CONSTRUCTION

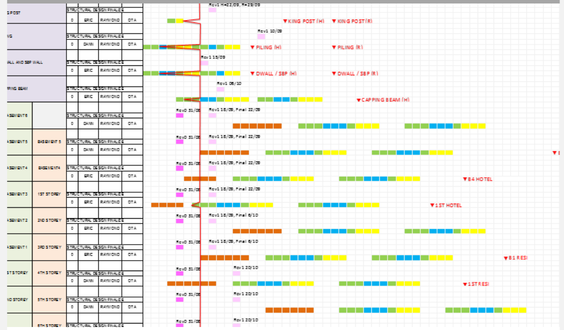
This table covers the details of the typical tasks that utilizes the construction model for purposes of construction reviews, simulations, analyses, and to bring BIM to Field.

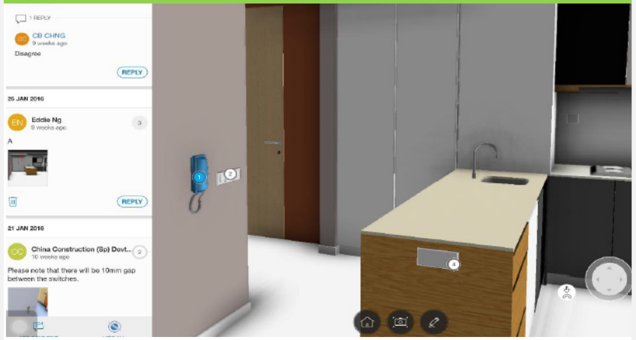
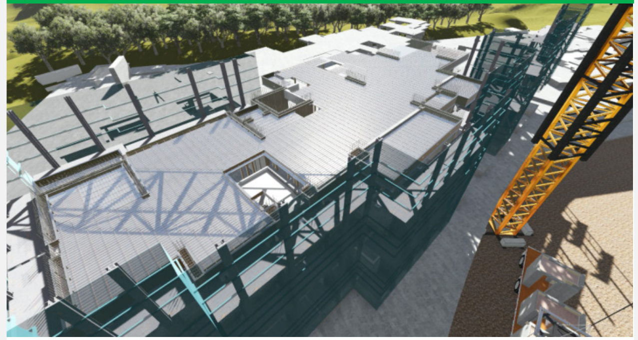
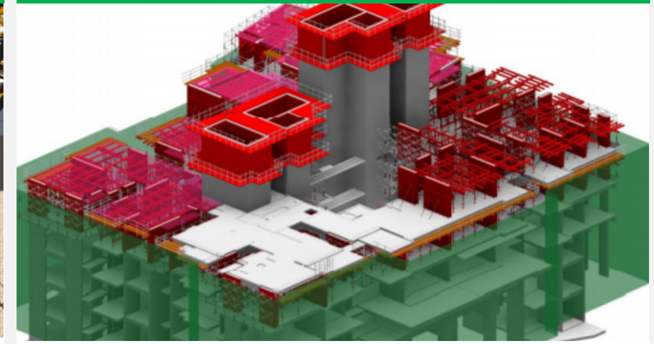
Each activity has specific targets which may serve to:

1. support overall project goals and objectives (e.g. eliminate rework, reduce material wastage)
2. improve performance and productivity in performing that specific task (e.g. increase cycle time in shop drawing production)

The components of BIM, Ecosystem, and Process best practices indicated here is in support of the targets and objectives.

In all cases, always bear in mind what the target is for each activity, and do not confuse the means to the ends. For example, a target may be to improve communication and visualization on the field, through any means appropriate. Providing mobile tablets to supervisors is only one possible means.

ACTIVITIES	VDC SCHEDULE	VIRTUAL MOCKUP DEVELOPMENT
		
	• To ensure that all tasks are carried out in a timely manner by location in according to the most updated site schedule • To identify which key stakeholders must be involved by when and which information must be confirmed by when	• To develop the model (or isolated areas in the model) to a level of detail, completeness, and accuracy fit for specific downstream use i.e. constructability analyses, fabrication, virtual reviews, materials take-off, etc
	• N.A.	• Completeness and accuracy of all items that are required for the intended use (embedded pipes, fixtures, tiles, etc.) and modelled according to how it will be used (e.g. to obtain correct unit of measure and quantities for materials procurement)
	MAIN CONTRACTOR • Prepare schedule and seek approval from consultant • Update schedule throughout entire project • Manage all tasks and ensure conformance with schedule SUBCONTRACTORS, SPECIALIST CONTRACTORS, SUPPLIERS • Conform with approved schedule • Provide own trade schedule highlighting any long lead time items affecting overall coordination schedule CLIENT • Commit to involvement where their approval is required • Provide information according to the schedule • Review progress as as per schedule CONSULTANT • Review and approve schedule • Commit to involvement and provide information according to schedule • Review progress as per schedule	MAIN CONTRACTOR • Identify areas for virtual mock-up development • Determine level of detail and content of virtual mock-up according to its intended use • Manage model development and update of all subcontractor and trade models SUBCONTRACTORS, SPECIALIST CONTRACTORS • Update individual trade model completeness, locational and dimensional accuracy of components of their own trade • Update model based on resolved issues • Obtain material / system approval to integrate into model • Ensure models are well-developed to consider accuracy, completeness, clearances, tolerances, and integration of trade knowledge CONSULTANTS • Approve final virtual mockup
	• Monitor planned vs actual of all tasks in VDC schedule	

ACTIVITIES	VIRTUAL REVIEWS	VIRTUAL CONSTRUCTION SIMULATIONS	SAFETY STUDIES
			
	• To ensure all key stakeholders (clients, end-users, consultants) have a clear visual understanding of the final end product • To ensure all possible client and consultant changes are captured while still in the virtual model	• To simulate sequence and methodology of construction / execution in order to identify and remove time-space constraints • To identify and clear temporal clashes prior to execution	• To identify possible safety risks in each key phase of construction • To identify necessary measures to mitigate risks • To simulate safety measures, especially as integrated with construction works
	• Accurate representation of final product in the model including actual finishes, model, size, and location of fixtures, design-intent modulation of tiles and ceiling, type and location of furniture, etc.	• Model all equipment, temporary structures or facilities needed for planning or may affect planning • Ensure construction base models capture details required for planning such as casting zones, temporary openings & supports, excavation by zone, etc.	• Utilize model to visualize construction for safety or risk hazards • Model safety measures where required to an appropriate level of detail required for specific purposes of simulation, visualization, and/or safety briefings
	MAIN CONTRACTOR • Upload and update models for virtual reviews by all stakeholders • Lead virtual review sessions • Update model as per virtual view inputs CLIENTS & CONSULTANTS • Review virtual models and provide input, feedback, and confirmation in a timely manner RE • May have involvement in some reviews	MAIN CONTRACTOR **Project Managers, Site Engineers, and/or Planners** • Identify and initiates development of virtual planning / sequencing where needed • Determine methodology, sequencing, & overall planning • Identify space/time clashes when reviewing sequence • Advices on necessary measures for issues found • Choose and advise on construction equipment and temporary structures to be utilized **BIM Coordinator / Modeler** • Coordinates with planner to identify what needs to be modelled and to what level of detail according to inputs above • Create and update the model according to methodology and sequence & create work sequences / animations where necessary	MAIN CONTRACTOR **Safety Officer** • Review model for any constructability or safety issues by phase • Provide safety requirement input and advises on safety measures • Advices on safety measures **BIM Coordinator / Modeler** • Coordinates with safety officer to identify what needs to be modelled and to what level of detail according to inputs above • Create and update the model according to inputs
	• BIM studios, virtual labs, and AR-VR technologies • Model sharing and review platforms (BIM A360)		
	• Document all comments and feedback at every review session • Have final model and documents signed off by all involved parties, and indicate cut-off date of any other further changes and comments for each area		
	• Decision latency • Reduced number of abortive works on site from client changes	• Planned vs Actual schedule • Consistent representation between planned and actual works	

QUANTITY TAKE-OFF

- Accuracy of QTO measurements for procurement or resource allocation
- Increased productivity in quantity take-off process

- Modelling technique should be such that it produces the correct unit of measurement for every item to be taken of
- Ensure acceptable accuracy and model quality for reliability of quantities in the model
- Ensure model elements are grouped by location / zone

MAIN CONTRACTOR

QS

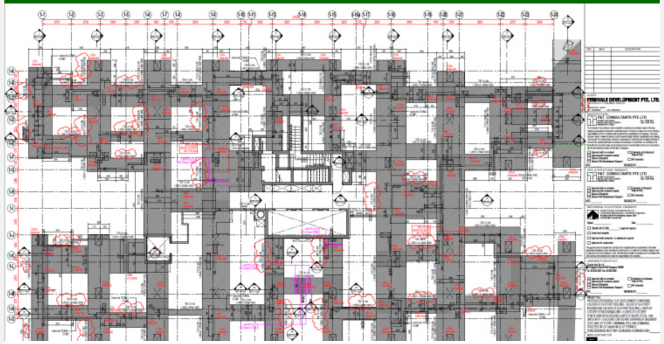
- Determine which quantities are required for the project as well as the unit of measure and standard of measurement
- Prepare cost plan or cost estimates based on model quantities*

BIM Coordinator / Modeler

- Ensure model quality and completeness for take-off of identified items

- % of BOM items directly (or indirectly) quantified from BIM model (by project cost)
- Time spent on quantity take-off (traditional vs new process)

CONSTRUCTION DRAWING PRODUCTION



- Effective translation of final coordinated models into shop drawings for execution
- Reduce cycle time in shop drawing production

- Completeness of all modelled items to be shown in shop drawings
- Geometric & locational accuracy of all items or components to be included in shop drawings
- Core information of all tags required for shop drawing production

MAIN CONTRACTOR

- Ensure timely shop drawing production and approval as per schedule
- Ensure shop drawings are extracted from the most updated approved coordinated model
- Manage drawing revisions

MAIN CONTRACTOR

- Ensure timely shop drawing production
- Ensure shop drawings are extracted or referenced from the most updated approved coordinated model

- Shop drawing cycle time
- % of shop drawings that are BIM-based

SITE BRIEFING

- Ensure crews are thoroughly briefed of the end product through virtual reviews including what to build, how to build, and safety issues and constraints

- Model views may be filtered to show only what is required for actual inspection

MAIN CONTRACTOR

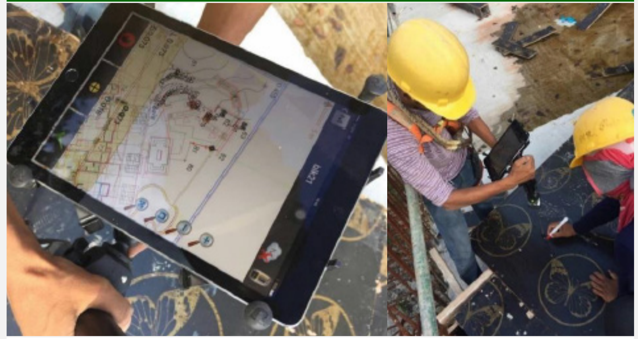
- Arrange regular virtual reviews and briefings with subcontractors, all related RE's and RO's

SUBCONTRACTORS, SUPPLIERS

- Prepare presentation and perform trade demonstrations where necessary

RE TEAM

- Participate in briefings and trade demonstrations to provide a look out items and issues to pay attention to
- Highlight what they are more particular with in inspection

	VISUALIZATION & COMMUNICATION	LAYOUT AND SURVEY	DIGITAL FABRICATION
ACTIVITIES			
	• Improved visualization and clarity of what is to be built by site workers • Availability of the most updated approved models, drawings, and documents to site personnel	• Accuracy in model translation of coordination from the final approved coordinated model to site • Increase productivity in site layout and survey	• Accuracy of fabrication as per modeled component or assembly • Increased productivity in fabrication as a result of automation • Reduced dependency on 2D fabrication drawings
	• Model may be filtered out to show only the relevant room/areas and model components for viewing	• Completeness of all modelled items to be surveyed • Geometric & locational accuracy of all items or components to be surveyed	• Geometric accuracy of modelled components for fabrication • Thorough and quality coordination to prevent errors in actual on-site installation
	MAIN CON • Prepare the model for mobile access • Ensure accessibility of the most updated models, drawings, and other documents for relevant site personnel **SUBCONTRACTORS, SPECIALIST CONRACTORS** • Check and view most updated models, drawings, and documents as reference for installation	**MAIN CONTRACTOR, SUBCONTRACTOR, SPECIALIST CONTRACTOR** • Ensure completeness and accuracy of model for survey • Prepare model points for survey • Accurate layout according to approved model	**MAIN CONTRACTOR / FABRICATOR** • Identification of components for fabrication **FABRICATOR** • Development of fabrication model • Fabricate as per final approved and coordinated model
	• Model sharing cloud platforms • QR codes on site to facilitate ease of access of relevant models		
	• Implement QR code system for scanning and viewing of relevant documents in key areas on site • Also implement the same system to show sequence of installation where required		
		See Annex C6: Digital Layout Workflow	
	• % or No. Of key personnel (site supervisors, foremen, PM, engineers) trained • % or No. of key personnel with cloud access to files and models	• Time taken for survey works • Manpower required for survey works • Accuracy of survey works	• % of project scope that is digitally fabricated (automated)

SITE CONTROL "VERIFY PLANNED VS ACTUAL"

- Verify physical representation of actual as per virtual
- Timeliness of actual progress as per planned schedule

- Consistent zoning of the model according to actual work sequence zones
- Core information may include task IDs, zones, and/or planned and actual execution dates

MAIN CONTRACTOR

Planner, Site Engineers

- Gather, double check, and keep track of daily site progress data
- Track reason of delay, if any

Project manager

- Endorse accuracy of information provided by the planner / enggr
- Plan out how to mitigate delays

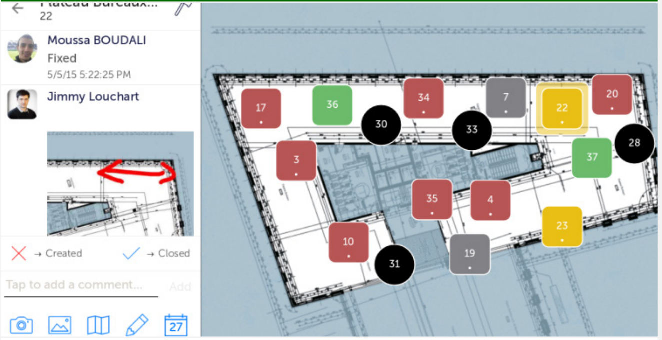
BIM coordinator / modeler

- Update the progress model in terms of actual accomplishment data from planner

- Field management platforms that combines mobile technology with cloud based collaboration and reporting

- Planned vs actual

QUALITY & DEFECTS MANAGEMENT



- Seamless and systematic management of defects
- Reduced time in issue reporting and response latency

- Model views may be filtered to show only what is required for actual inspection

MAIN CONTRACTOR

- Inspect site installation and records quality and defects issues for appropriate action by responsibly party
- Keeps track of status of issues

SUB CONTRACTORS, SPECIALIST CONTRACTORS

- Respond and take prompt action to any quality or defects issues

- Field management platforms that combines mobile technology with cloud based collaboration and reporting

- Time spent in issue reporting
- Issue response / resolution latency

VERIFICATION OF AS-BUILT

- Improved accuracy of as-built documentation
- Increased productivity of as-built survey

- Update physical geometry of model as per exact as-built survey

MAIN CONTRACTOR

- Accurate recording of as-built data
- Accurate translation of data into as-built models

- Time spent in as built preparation

4.1 SITE LOGISTICS & UTILIZATION

Covers planning of placement and logistics of construction site equipment, vehicles, and temporary facilities. Site logistics planning may be particularly critical in sites with limited space or have site constraints such as adjacent traffic and existing structures

OVERVIEW

What makes this activity critical?

a. **Site logistics and planning is a continuously on-going activity**
Planning needs to adapt to the specific equipment and site requirements, site conditions, and constraints at every critical phase of construction and in accordance to the specific construction activities occurring at each stage.

b. **Some activities and sites pose more risks that need to be mitigated in planning**
These include projects with constrained space and access and activities such as deep excavation, traffic diversion, equipment maneuvering, etc.

c. **Ensuring site safety throughout the entire construction duration is paramount**
Careful safety planning necessitates a visualization of planned works by stage in order to perform risk and hazard assessments and determine necessary safety measures

Site safety. Example of safety risks include falls from height. Being able to detect these hazards in a virtual model allows a project team to accurately plan necessary safety measures and locate placement of safety barriers as the project moves phase by phase.

Deep excavation & ERSS. Activities such as deep excavation and ERSS involves more risk due many considerations including safety, accessibility of equipment to excavated levels, complexity of the methodology, among many others.

Interfacing between temporary and permanent works. Another critical point of consideration as the project progresses is sequenced interfacing between the temporary structures required or installed at that particular phase and the permanent works to be erected (e.g. a lift wall). A situation may arise on site where the permanents works are scheduled to be constructed but temporary works are still in place, thereby requiring more time, resource, and manpower in the workaround or rectification of the problem.

GOAL	OBJECTIVES	ACTIVITIES
To minimize risk and increase predictability of site logistics activities through all critical stages of construction	**Determine type, number, location, & coverage of construction equipment** • predetermine type, weight and location of components to be hoisted • To select appropriate type, number, and location of equipment for hoisting • Ensure all components to be hoisted are within crane hoisting capacity and reach • Determine type, number, and allocated area or space for equipment to be utilized in specific activities such tower crane dismantling, material and passenger hoisting, etc. **Improve Site Safety** • Visually identify potential risks and safety issues at every major construction phase or milestone • Determine necessary safety measures to mitigate risks • Capture safety measures in the model especially if these structures affect planning and sequencing of other activities • Conduct site safety briefings or training to highlight identified safety risks and measures to site crews **Optimize construction sequencing** • Determine critical site activities which may require detailed planning and sequencing • prevent temporal conflicts between temporary works, permanent works, and equipment maneuvering • Plan sequencing so as to not disturb existing structures, utilities, and traffic **Ensure site accessibility** • Determine size of equipment selected and the required space they need to maneuver and park • Identify and capture both temporary and permanent works erected at that specific point in time that may affect access of materials and equipment • Determine and capture provisions for temporary access roads, ramps, working platforms, etc. **Plan and determine location and required space of temporary site facilities and structures** • Capture all site facilities and provisions required by regulation • Determine and capture all other required temporary facilities in model, by stage **Calculate and optimize cut and fill volumes** • Accurately model earth works by phase and stage • Calculate and obtain minimum volume for soil export out of site or fill import (for economy)	**Crane hoisting and capacity planning** • Predetermine weight and location of components to be hoisted • Select appropriate type, number, and location of equipment for hoisting • Ensure all components to be hoisted are within crane hoisting capacity and reach **Site logistics and utilization planning and modelling** • Capture type, number, and allocated area or space for equipment to be utilized in specific activities such tower crane dismantling, material and passenger hoisting, etc. • Identify and capture both temporary and permanent works erected at that specific point in time that may affect access of materials and equipment • Determine and capture provisions for temporary access roads, ramps, working platforms, etc. • Capture safety measures in the model especially if these structures affect planning and sequencing of other activities • Capture all site facilities and provisions required by regulation • Determine and capture all other required temporary facilities in model, by stage **Earthworks planning** • Accurately model earth works by phase and stage • Ease and accuracy of earthworks calculation • Calculate and obtain minimum volume for soil export out of site or fill import (for economy) **Sequencing and access studies** • Determine critical site logistic activities which may require detailed planning and sequencing • prevent temporal conflicts between temporary works, permanent works and maneuvering equipment • Plan sequencing so as to not disturb existing structures, utilities, and traffic **Safety studies** • Visually identify potential risks and safety issues at every major construction phase or milestone • Determine necessary safety measures to mitigate risks • Capture safety measures in the model especially if these structures affect planning and sequencing of other activities **Site briefings** • Conduct safety briefings to highlight safety risks and measures

CONSIDERATIONS			PERFORMANCE MEASUREMENT
Tower crane location considerations • Point of supply or pick up of materials • Site area and building footprint. Ideal location is outside the building footprint, unless site has limited space, • Full coverage over the plan area of the building	**Calculation of number of tower cranes** • Time of transfer of materials (carnage cycle time) • Required length of boom	**Available opening for climbing crane considerations:** • Adequate space of temporary opening through structure • Early handover of lift core, in which case	**Consistent representation of actual sequence versus the planned sequence**
Equipment Tower cranes Mobile cranes Vehicles Passenger hoists Machinery	**Temporary structures** ECM drains ERSS Jump forms Scaffolds Safety barriers Working platforms Temporary supports	**Site facilities** Hoarding and access gates Washing bay Storage areas Access roads	
Earthwork planning considerations • Planned excavation zones according to project phase milestones • Capture soil stability slope angles • Planned depths of excavation by stage	• design, layout, and location of ECM drains and hoarding (with supports) which may affect boundary of excavation • Earth ramps, working platforms, and other means of access to excavated levels	**Earthwork calculation considerations** • Minimum volume requirement for soil removal and delivery • Available space for temporary stockpile in cases of cut and fill	
Critical activities for sequencing studies • Sequence of dismantling of tower cranes • Sequence of delivery of large items • Traffic diversions • Maneuvering in critical areas such as top down construction • Excavation, ERSS, & basement construction	**Planning considerations** • Location of gate and point of entry • Exact size of equipment and how it maneuvers • Adequate space for parking of equipment (in consideration of outrigger size) • Turning radius of delivery vehicles and equipment • Appropriateness of selected methodology		
Typical safety risks • collapse risks of freestanding structures • Collapse zones of equipment such as tower cranes, piling rigs, etc. • Fall from heights			

BIM, Ecosystem, Process Optimization

See Annex C2 for further details on BIM, Ecosystem, and Process Optimization

BIM

Products:

- Architectural Construction Base Model
- Structural Construction Base Model
- MEP Model (for equipment)
- Existing MEP services
- Façade Model
- Steel Structure Model / Precast Models
- Site Utilization & Logistics Model
- Existing Site Model
- Earthworks model
- ERSS

Ecosystem

Stakeholders:

- Main Contractor
- Subcontractors, specialist subcontractors
- Equipment suppliers
- Fabricators / Precasters

Process Optimization

Process focus:

- Lookahead planning to identify all possible constraints
- Crane hoisting and capacity planning
- Earthworks planning
- Virtual planning and sequencing of critical areas and activities

Site Logistics Model Set-Up:

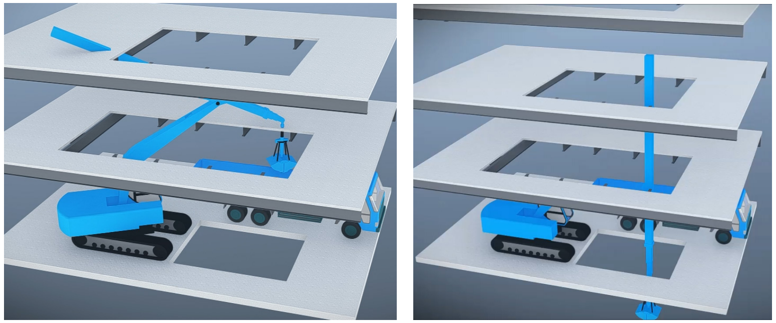
1 COMBINED MODEL

Combine site, earthworks, logistics, ERSS* in one model

* If file size is manageable

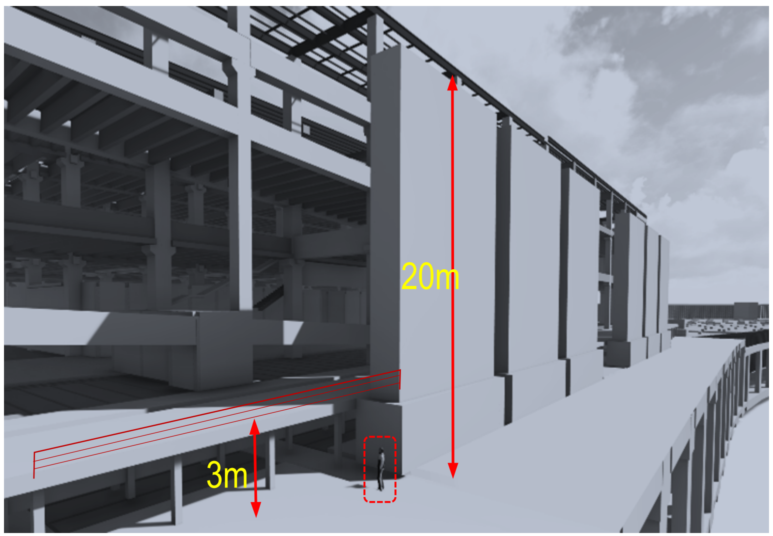
3 SPLIT BY SCOPE

* If file size is still too unmanageable
* If different or specialized software is required for earthworks, civil works modelling, or steel structures



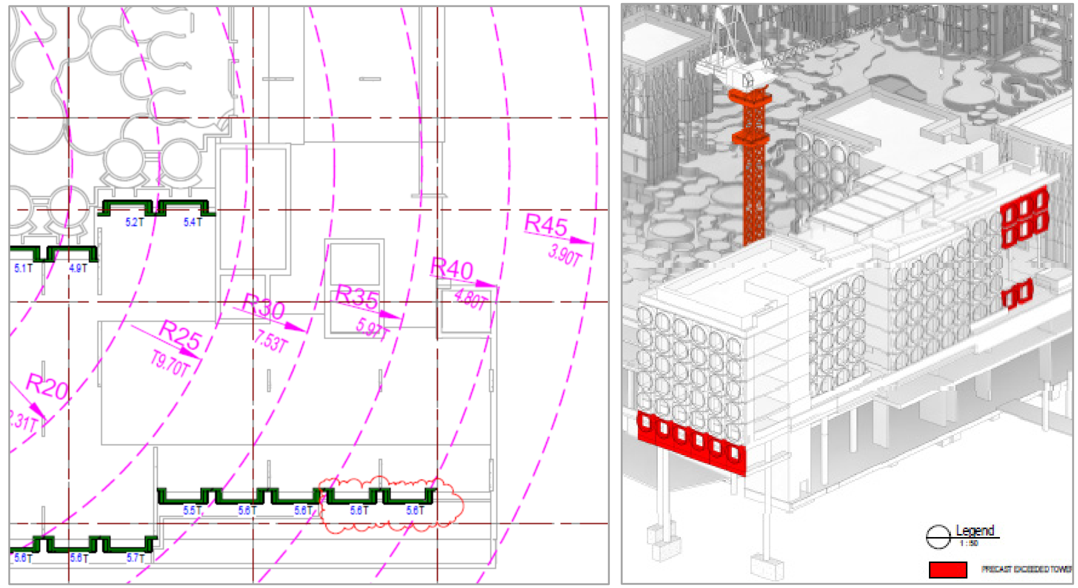
Equipment maneuvering

Equipment maneuvering studies can be simulated in critical areas such as top down construction. In this example, the exact overall size of the equipment as well as how it maneuvers has been captured in the simulation in order for it to be as reliable and as predictable as possible. Analyses such as this requires not only visualization of physical form but also study of movement and access, which can only be captured through virtual simulations.



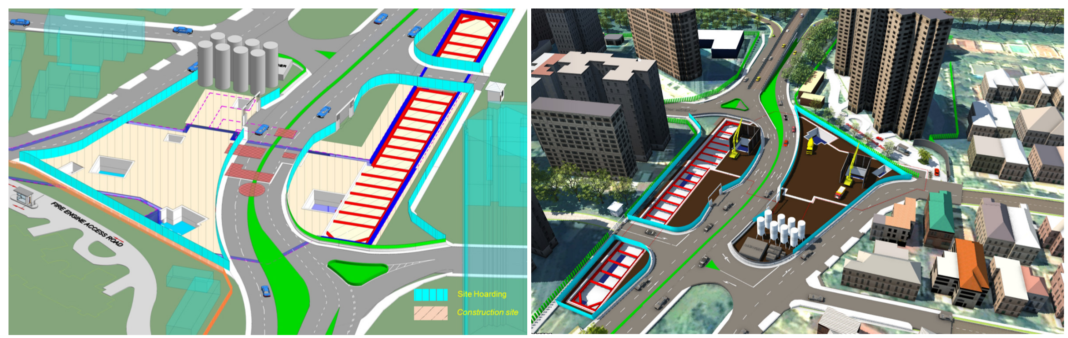
Safety and risk reduction

This image shows two safety risks: 1. a three meter fall from height risk which requires provision of safety barriers, and 2. a 20 m tall free standing and unsupported structure which may pose a collapse hazard.



Crane hoisting and capacity planning

This image shows how the BIM model was utilized to automate or semi-automate the process of crane hoisting and capacity planning. The components to be hoisted have been pre-identified in the model (in this case, precast panels), and the weight of each panel is tagged on plan, wherein the value is automatically calculated based from the volume of the component as generated by the model geometry. All panels whose weight exceeds the hoisting capacity at its exact location is highlighted in red.



Traffic diversion planning

Traffic diversion planning requires capturing existing and planned traffic routing as well as how this interfaces with the site at every stage. This is particularly critical in busy areas such as the CBD, or where the site area is constrained in terms of size and access.

4.2 PBU INSTALLATION

PBU or Prefabricated Bathroom Units are bathroom units that have been manufactured and preassembled off-site complete with finishes, sanitary fittings, bathroom cabinets, concealed pipework, conduits, and ceiling before delivering and installing into position on site.

OVERVIEW

What makes this activity critical?

a **PBU is a specialist long lead item which requires upfront planning and coordination**
All possible issues and constraints must be identified and resolved, and all fabrication details integrated during planning and coordination prior to commencement of fabrication in order to ensure PBU quality and reduce on-site rectification.

b **Maneuvering of PBU into final position requires careful sequencing with site works**
Upon completion of PBU fabrication, special care must be taken to ensure PBU safety during delivery, storage, hoisting, and installation

c **Off-site and on-site activities need to be closely synchronized and monitored**
PBU installation requires management of off-site PBU manufacturing and delivery schedules to tie together with on-going construction, which entails careful tracking and monitoring of planned versus actual progress of various on-site and off-site activities.

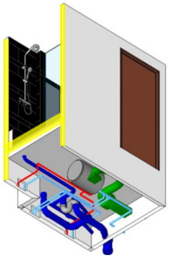
PBU is a type of DfMA (Design for Manufacturing and Assembly) component. The principles herein may apply for other DfMA technologies such as PPVC (Prefabricated Prefinished Volumetric Construction).

PBU quality. Issues and details that have not been captured and resolved prior to PBU fabrication may result to poor PBU quality issues including overprovision of recesses, errors in MEP provisions, etc. which result to on-site re-patching works.

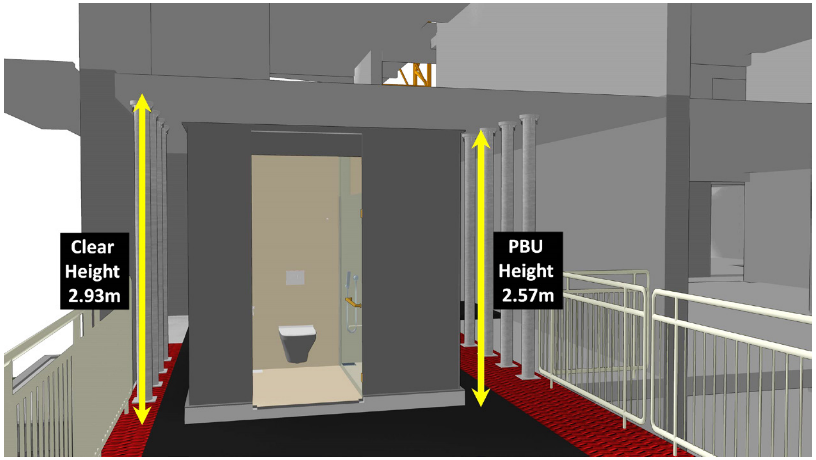
Over-provision of recess for electrical conduits

Water pipes recess works

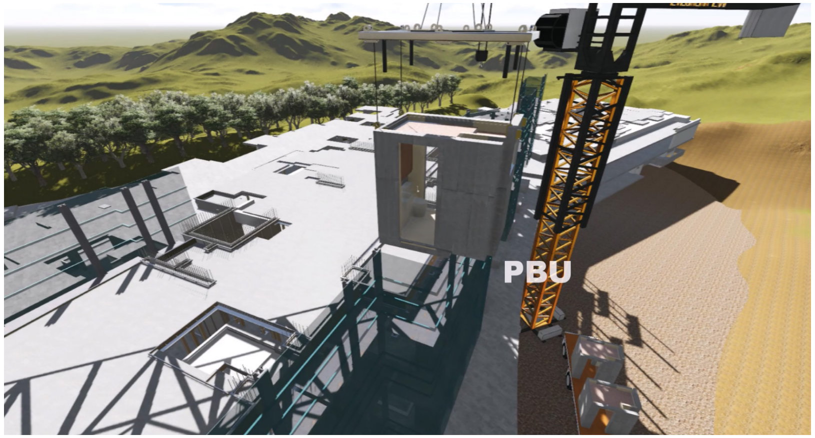
Error in height of aircon pipe opening provision



PBU safety. PBU safety issues during delivery and storage may include ensuring safety of MEP services integrated into the PBU unit. The structural concrete profile must be coordinated so as to consider the space required for concealed MEP services to prevent damage in handling.



Non-critical PBU clear access. For non-critical PBU installation, or PBU installation into a finished structure, the sequence and path of installation must be studied to ensure a clear path when maneuvering the PBU inside of the completed structure, in consideration of the clear height of the structure, and clear openings and access along the path of installation



Critical PBU installation. For critical PBU installation, or PBU installation which is done simultaneously with structural floor casting, possible temporal clashes included collision with jump forms or safety barriers and scaffolds.

GOAL	OBJECTIVES	ACTIVITIES

GOAL

PBU quality, safety, and planning predictability in PBU design, fabrication, delivery, and installation.

OBJECTIVES

PBU quality

- Completeness and precision of modelled components, especially for embedded MEP services
- Accuracy of location and sizes of all MEP opening and recess provisions
- Coordination of PBU alignment and connections
- Capture look and feel of actual finished PBU for final design confirmation
- Simulate and rehearse sequence of fabrication and finish application to ensure that factory works are carried out in an efficient, assembly line manner and to avoid any need for rework.
- Accuracy of PBU fabrication as per approved coordinated models

Accuracy and timeliness of procurement

- Accuracy of modelled components for procurement QTO
- Finalize type and number of PBU for procurement
- Accuracy of QTO of selected finished materials
- Timeliness of procurement in consideration of required lead time and in accordance to master schedule

PBU safety during delivery, storage, hoisting, and installation

- Clear path for installation with no spatial and temporal conflicts with installed structure and temporary works
- Coordination of concrete profile to consider safety of MEP services to prevent damage in delivery and storage

Timeliness of delivery and installation

- Establish system of PBU status tracking from coordination to installation
- Continuous monitoring and control of PBU activities in terms of planned versus actual schedule
- Keep forecast of potential delays and constraints and implement mitigation measures

Ease of PBU serviceability

- Accessibility to service shaft after installation

ACTIVITIES

Construction Coordination

- Coordination of concrete profile to consider safety of MEP services to prevent damage in delivery and storage
- Accessibility to service shaft after installation
- Coordination of PBU alignment and connections

PBU Virtual Mock-up development

- Capture look and feel of actual finished PBU for final design confirmation
- Completeness and precision of modelled components, especially for embedded MEP services
- Accuracy of location and sizes of all MEP opening and recess provisions
- Accuracy of modelled components for procurement QTO

PBU logistics & installation sequencing

- Clear path of delivery and installation with no spatial and temporal conflicts with installed structure and temporary works
- To simulate and rehearse sequence of fabrication and finish application to ensure that factory works are carried out in an efficient, assembly line manner and to avoid any need for rework.

Procurement

- Finalize type and number of PBU for procurement
- Timeliness of procurement in consideration of required lead time and in accordance to master schedule
- Accuracy of QTO of selected finished materials

Fabrication & BIM to Field

- Accuracy of PBU fabrication as per approved coordinated models
- Fabrication as per rehearsed sequence of installation

PBU tracking & progress monitoring

- Establish system of PBU status tracking from coordination to installation
- Continuous monitoring and control of PBU activities in terms of planned versus actual schedule
- Keep forecast or lookahead of potential constraints and implement mitigation measures

CONSIDERATIONS

Coordination issues to clear
- Alignment of FFL of PBU with main floor, considering finish thickness
- Alignment of MEP vertical stack
- Finalization of concrete profile

Coordination considerations
- Effect of final coordinated wall setting out on GFA requirements
- Regulatory compliances
- Required tolerances for double wall
- Actual size of critical items such as water tank which may affect clear height of ceiling and concrete profile

Virtual mock-up development considerations
- Actual finish of materials for visualization
- Size and modulation/alignment of finishes especially tiles, which may affect accuracy of QTO
- Actual look and location of sanitary fixtures

Critical activities for sequencing studies
- ❖ PBU delivery and storage
- ❖ Critical PBU installation
- ❖ Non-critical PBU installation
- ❖ Structural floor casting cycle time

PBU delivery and storage considerations
- Turning radius of PBU delivery trucks
- Ample space for PBU storage

Critical PBU installation planning considerations
- critical temporary structures (e.g. jump form, surrounding scaffold platform) that may obstruct installation
- Clear access for manual installation of PBU into final location
- To consider correct sequence of installation with context to adjacent built works

Non-critical PBU installation planning considerations
- Height of delivery trolley which may affect vertical clearance
- Identification of structural or architectural elements (e.g. walls) to be installed or cast later
- Clear access for manual installation of PBU into final location

PBU procurement considerations
- Readiness of delivery of PBU depends on available site storage capacity (e.g. delivery must be one floor ahead of actual installation)
- Procure items with sufficient lead time to fabricate that item (e.g. 3-4 weeks)

Materials procurement considerations
- Procure materials such that it arrives on time with enough lead time for purchasing and delivery

Typical PBU finish items for procurement
- Tiles
- Sanitary wares
- Cabinetry
- Doors
- Etc.

Fabrication considerations
- Available number of prepared molds which affects production cycles

PBU & site status for monitoring
- Structural casting date
- Date of PBU delivery
- Date of PBU installation

PERFORMANCE MEASUREMENT

- **Consistent representation of actual installation in terms of sequence of installation**
- **Planned versus actual dates or PPC (Planned Percentage Complete)**
- **Planned versus actual (or ahead vs delayed) progress of critical PBU and structural activities**

BIM, Ecosystem, Process Optimization

See Annex C3 for further details on BIM, Ecosystem, and Process Optimization

BIM

Products:

- Architectural Construction Base Model
- Structural Construction Base Model
- MEP Trade Models
- Site Utilization & Logistics Model
- PBU virtual mock-ups

Ecosystem

Stakeholders:

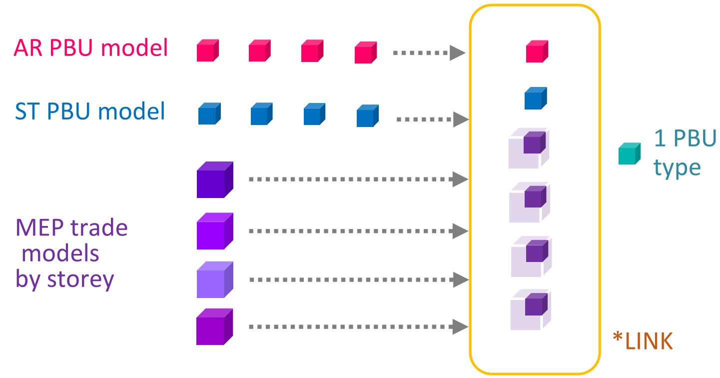
- Main Contractor
- MEP Subcontractors
- Fabricator, Precaster
- Client
- Consultants

Process Optimization

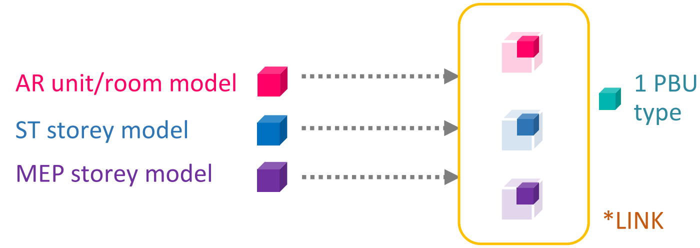
Process focus:

- On-site and off-site tracking and monitoring
- Virtual planning of critical areas and activities
- Lookahead planning to identify possible constraints

PBU Model Set-Up:

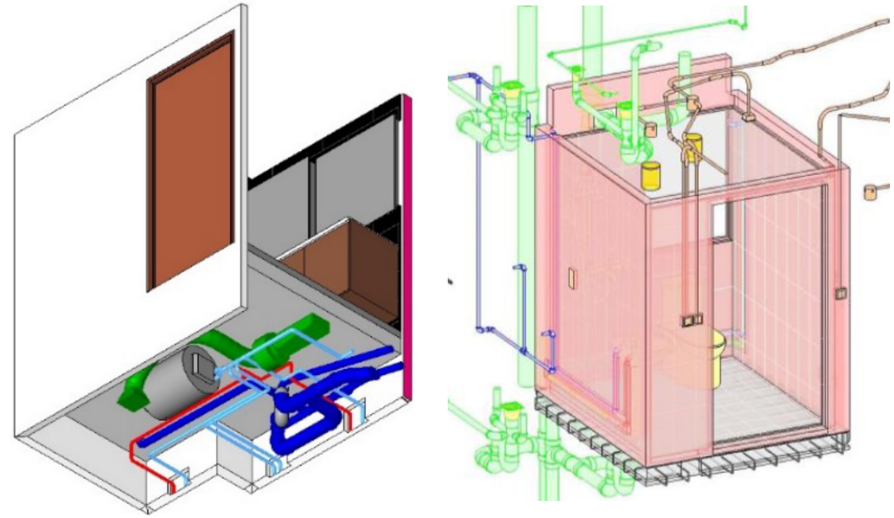


1. 3 DISCIPLINES ARE MODELLED SEPARATELY PER PBU
Architectural and Structural PBU models are modelled separately, and MEP is linked from the main MEP trade models per floor
*to save modelling time and effort in cases where there are fewer structural PBU iterations compared to architectural and MEP iterations per PBU.



2. PBU IS MODELLED AS PART UNIT AND STOREY MODELS
*if each PBU type is unique to that unit only

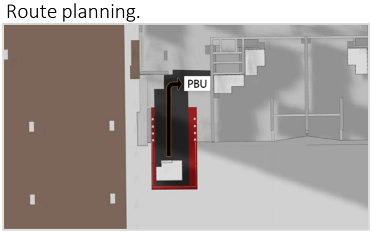
PBU mock-up development
Detail and finish items of actual components are integrated into the PBU mock-up for ease of visualization by all stakeholders during virtual reviews



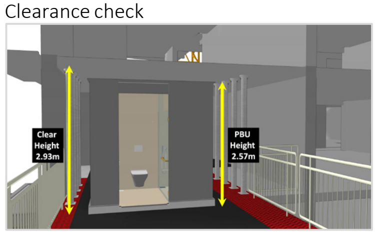
Accuracy of modelled components
Model all components that are critical to coordination and fabrication, especially concealed and embedded MEP components. The left image shows above ceiling MEP services that have been integrated into the PBU unit. Critical large items such as water heater drums have to be modelled to accurate size for concrete profile coordination.

Non-critical virtual construction sequence
The following images are snapshots of a detailed virtual sequence of non-critical PBU installation from delivery to final installation.

Route planning.

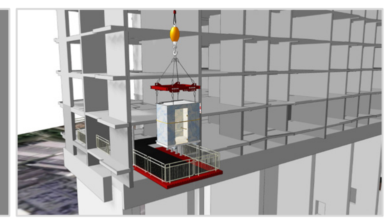


Clearance check

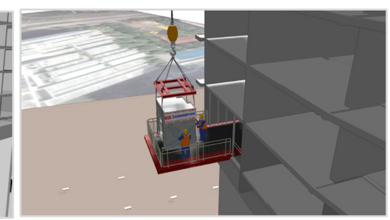


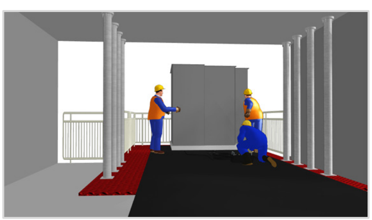
1. Preparation

2. Hoisting

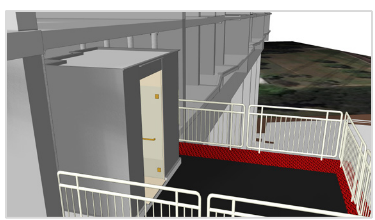


3. Positioning





4. Air Caster



5. Level Check

6. Aero Jack

Complete

4.3 MEP INSTALLATION

This section covers the spatial coordination, planning ,and installation of all MEP services and the management of various MEP trades.

OVERVIEW

What makes this activity critical?

a MEP coordination requires the management of various trades and models

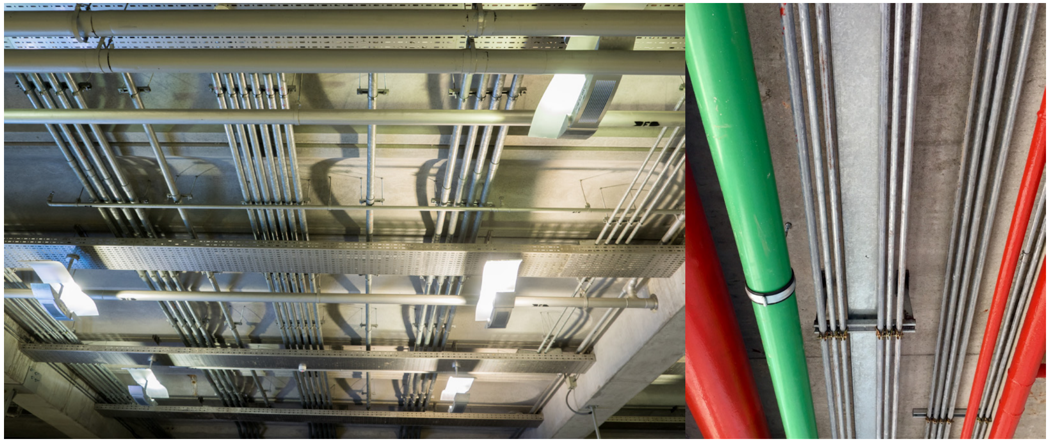
If MEP trade models are authored and handled by the respective MEP subcontractors, then the main contractor needs to ensure consistency of quality, adherence to schedule and deliverables across all models, as well as the management and dissemination of updates and information to all relevant parties. Coordination is also an intensive effort among all trades involved, therefore lean processes must be put in place in order to avoid duplicate work.

b There is typically a gap between what has been coordinated and what has been installed on site

It is important to strive for model reliability and constructability, as opposed to mere geometrically clash free models. Each trade has their own installation, routing, and maintenance requirement, and this field input must be solicited and incorporated for meaningful coordination.

c Critical and congested spaces may pose installation issues from unclear flow and sequence of work

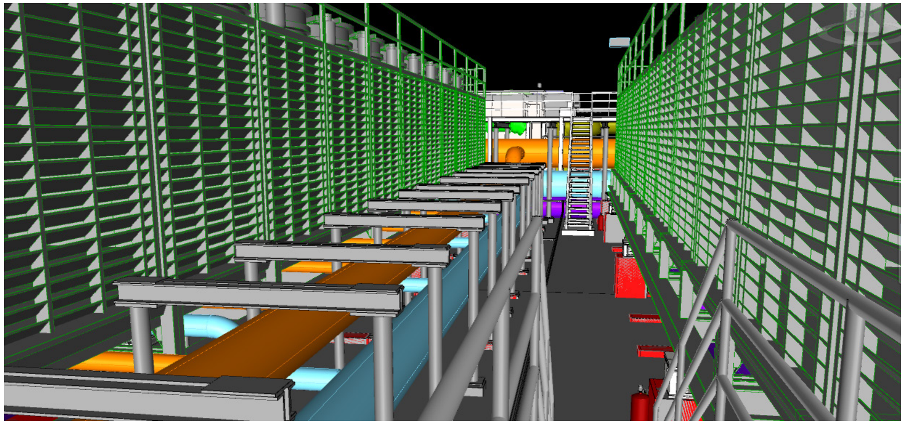
Areas such high volume spaces which require scaffolds or temporary working platforms, as well as activities such as hoisting and installation of large MEP equipment requires careful planning and simulation of optimized sequence of work.



Model completeness. Deviation of actual installation from the BIM model may also be due to model incompleteness. Elements such as embedded conduits are usually excluded in modelling but may be required for in-wall or in-slab coordination. Elements that are not modelled cannot be coordinated, unless space has been reserved for those elements.

MEP installation. Planning and coordination of MEP installation should consider space and access for installation and maintenance, and sequence of installation in cases of congested or critical areas.

Equipment Hoisting. One critical activity that requires careful planning is the hoisting, delivery, and installation of large MEP equipment such as chillers, generator sets, etc. into its final location. Planning these activities need to take into consideration size of the actual component, and size of the access openings, and the weight of the equipment when routing.



MEP interfacing with other trades. Accuracy and reliability of the MEP model for coordination and installation is also dependent on the accuracy and reliability of the other trades which they interface with, such as ceiling, steel structure and steel framing, system furniture, etc.

GOAL	OBJECTIVES	ACTIVITIES

GOAL

To achieve model reliability and constructability through bridging knowledge gaps and through the establishment of a leaner MEP modelling, coordination, and planning processes

OBJECTIVES

To avoid duplicate and unnecessary work from inefficient processes

- obtain early information on items and details that may affect coordination such as specialist contractor details and consultant design intent
- include maintenance input from initial stages of coordination confirm make and model of MEP equipment as early as possible to facilitate proper and timely co-ordination with both Architectural and C&S
- coordinate incrementally through clearing architectural and structural issues first
- perform spatial allocation in critical sections in corridors so each trade knows where to run
- ensure all trades do their own QA/QC and intra-trade coordination prior to model sharing
- ensure that all trades stringently follow expected deliverables, modelling guidelines, and standards
- establish a systematic approach to inter-trade coordination
- freeze coordinated services model before actual construction to ensure stakeholders understand implication of changes coming in at later stages

Correct Installation Sequencing

- identify MEP equipment delivery route from onset of design, i.e. from the time it reaches site to its final installed location
- prevent rework from not following coordinated spatial arrangement especially in congested areas
- manage multiple crews simultaneously installing in critical areas such as congested spaces or high volume spaces

Model reliability and usability

- bridge knowledge gap between BIM modeling & trade expertise
- ensure MEP modelling and coordination captures maintenance requirements, installation clearance requirements, and tolerances
- ensure accuracy & completeness of all modelled components

To bridge gap between the coordinated model and field installation

- all construction drawings are extracted from the most updated approved model
- make the model available and viewable by all necessary parties (supervisors, subcontractors, inspectors, etc.)
- verify if as-built installation against the coordinated model

ACTIVITIES

AR and C&S Pre Coordination

- To coordinate incrementally through clearing architectural and structural issues first
- Obtain early information on items and details that may affect coordination such as specialist contractor details and consultant design intent

Set-up and coordination kick-off meeting

- ensure that all trades stringently follow expected deliverables, modelling guidelines, and standards
- Perform spatial allocation in critical sections in corridors so each trade knows where to run
- To that ensure all trades do their own QA/QC and intra-trade coordination prior to model sharing

Individual Trade Modelling

- To bridge knowledge gap between the BIM modeling and trade expertise
- To ensure MEP modelling and coordination captures maintenance requirements, installation clearance requirements, and tolerances
- To ensure accuracy and completeness of all modelled components

Inter-trade coordination

- To establish a systematic approach to inter-trade coordination
- To freeze coordinated services model before actual construction to ensure stakeholders understand implication of changes coming in at later stages

Sequencing studies

- To manage multiple crews simultaneously installing in critical areas such as congested spaces or high volume spaces

BIM to Field communication

- To ensure that all construction drawings are extracted from the most updated approved model
- To make the model available and viewable by all necessary parties
- To ensure actual installation is as per coordinated model especially in identified congested or critical areas

CONSIDERATIONS			PERFORMANCE MEASUREMENT
AR and C&S issues to clear & finalize: • Coordination of FFL & SFL levels • Layout of walls • Service shaft openings into structure • Pre-coordination and finalization of floor traps location as per architectural layout considering tiling layout design	• Ceiling levels and details, including steel frame support • Update details from specialist subcontractors such as façade, casework, cabinet, steel structure • Final sizes and location of actual components as per installation details that may affect coordination	• Type and location of final fix fixtures: ✓ Diffusers ✓ Lights ✓ Fire Sprinkler ✓ Smoke/ Heat Detector ✓ Smoke Curtain ✓ PA system	**Consistent representation of actual installation in critical areas versus the coordinated construction models whether thru laser scan data, or site photos**
Preparation • Pre-Identify potential critical areas that may need special attention or longer coordination lead times • Identify critical sections for pre-planning & spatial allocation of services • Develop model templates for distribution	**Kick-off meeting targets:** • Make sure everyone is clear on design intent. Preferably M&E consultant/s must explain the design intent to all subcontractors during this briefing • Explain and highlight model QA/QC checks and standards that need to be complied with by each trade	• Highlight critical areas and spatial allocation at congested section • As-built/ Asset Information Model requirements shall be clearly identified to be delivered by the end of the project completion	
Modelling considerations • Model what is required for coordination • Model accuracy as per approved submittals • Integration of trade knowledge in routing	• Consideration of installation clearances, maintenance clearances, and tolerances when modelling • Follow modelling submission schedule • Comply by standards: Follow standards as per BEP	• Pre-coordination: Perform own QA/QC in model • Updates: Use the latest approved base model from main contractor • Core info: Encode asset management parameter (if applicable)	
Coordination considerations • Achieve zero **critical** hard clashes in the Coordinated Services Model	• capture installation clearances, maintenance clearances, and tolerance requirements in coordination (soft clashes)	• meet all headroom and clear space requirements in coordination	
Critical activities for planning • Planning of installation of curtain wall scheduling to provide water tightness to allow interior work such as casework or services installation to commence	• Planning of scaffold, scissor lift, or any other temporary works for installation access at height • Large equipment delivery routing and hoisting as well as timing	• Planning of ceiling closure schedule prevent re-opening ceiling for undone M&E works	
Shop drawing production • Establish a proper system for revision management	Model access Site briefing: • highlight in the model critical areas or items that need special attention • highlight sequencing of trades where necessary as per sequencing studies		

BIM, Ecosystem, Process Optimization

See Annex C4 for further details on BIM, Ecosystem, and Process Optimization

BIM

Products:

- Architectural Construction Base Model
- Structural Construction Base Model
- MEP Trade Models
- Façade Model
- Furniture / Casework Model
- Steel Structure Model
- Site Utilization & Logistics Model

Ecosystem

Stakeholders:

- Main Contractor
- MEP Subcontractors
- Specialist Contractors: Façade, Steel, Furniture
- Client
- Consultants

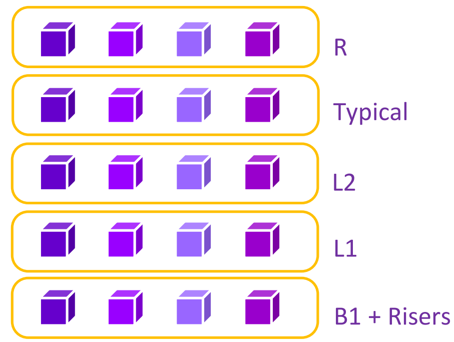
Process Optimization

Process focus:

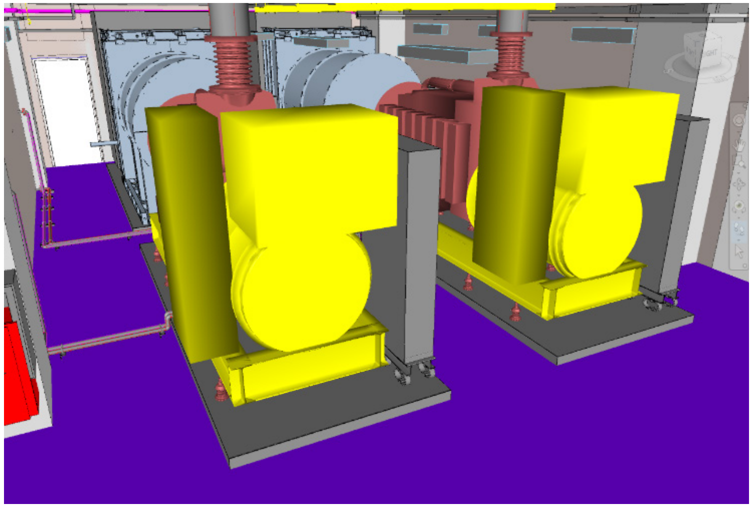
- Streamlined and leaner modelling and coordination process
- Virtual planning of critical areas and activities
- Lookahead planning to identify possible constraints

MEP Model Set-Up:

1. **BLOCK MODEL**
   Model all trades by block or zone
2. **SPLIT BY TRADE**
   To distribute models to respective subcontractor

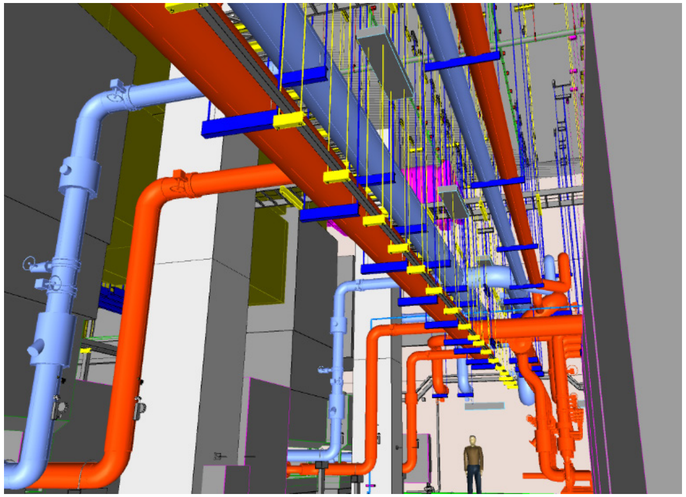


3. **SPLIT BY LEVEL**
   * If file size is still too unmanageable
   * If required for ease of coordination and information management

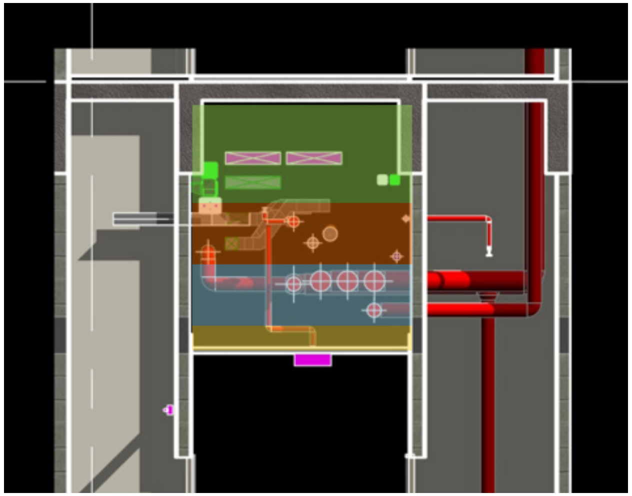


Model accuracy. Update model components such as equipment, fixtures, and fittings, to correct overall geometry as per approved submittals for coordination.

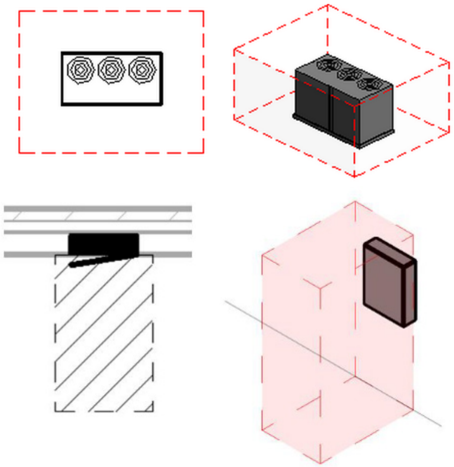
Headroom requirements. Check for headroom requirement and visual arrangement of services in public and exposed areas such as basement car parks.



Bracket Coordination. Services brackets may have to be modelled for coordination where congestion is expected (e.g. plant room).



Spatial allocation. Perform spatial allocation of services in critical sections such as service corridors and other congested areas prior to individual trade modelling.



Equipment maintenance clear space. Consider clear space for equipment maintenance in coordination. One best practice is to build in clear space zones into modelled components.

4.4 ARCHITECTURAL FIT-OUT

Fit-out installation pertains to the completion of interior spaces to be suitable for occupation. The scope of fit-out typically includes interior finishes, furniture, appliances, casework, installation of final fix MEP fixtures, and all other fixed or loose items as required by clients and end users.

OVERVIEW

What makes this activity critical?

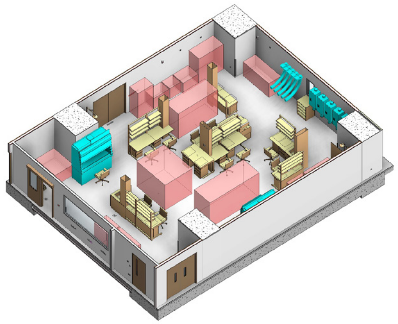
a **The nature of fit-out design and construction is heavily dependent on designer, client, and user feedback and confirmation**
Fit-out works tend to concern clients and end users much more compared to other construction activities because it deals with the final look, feel, and use of the space. Therefore, input, confirmation, and sign-off prior to start of execution is paramount to prevention of rework and unnecessary A&A works after construction.

b **Fit-out requires management of information coming at various stages**
Information may take the form of client, consultant, supplier or subcontractor feedback or confirmation of details. It is critical that information come in at the right time at every stage in order to prevent duplicate efforts from re-modelling or re-coordination.

c **Tight construction schedules and milestones**
Being that this activity occurs towards the end of a typical construction program, should ever any delays are accrued in structural works or any other earlier activities, no further delays or rework can be afforded for fit-out works if the deadline of handover is to remain unchanged.

One of the easiest ways to communicate and obtain feedback, information, and confirmation from these various stakeholders is through design and end user reviews.

Design Reviews. Design Reviews are intended to firm up design intent of spaces in terms of the spatial quality, choice of materials, modulation of finishes, colours, etc. These reviews therefore require input from consultants, developers, and higher level decision makers. Some examples of spaces that typically require design reviews include lobbies, auditoriums, hotel rooms, condominium units, etc.



End user reviews. End user reviews focus more on the **functionality of the space** and its **suitability of use** for its specific function, wherein the suitability of use is dictated by the **final end users** after considerations of their own workflows, spatial layout requirements, sizing and configuration of furniture and special equipment, etc. Spaces that usually require end user reviews are doctor's offices and laboratories, medical clinic, etc.

Unit Mock-Up. Traditionally, a mock-up of the room or section of the room has to be constructed before designers and clients can visualize and confirm all details prior to the construction of the rest of the typical units. However, due to time or schedule constraints, the typical units will have already commenced without waiting for final confirmation and approval of the physical mock-up. This would result to multiple reworks across all of these units should ever there are coordination errors found on site, or if design or client changes are still being done at this stage.

Installation sequencing. One other challenge that is typical to fit-out works is the interfacing and management of multiple trades that oftentimes have to install simultaneously within a given space. Problems at the construction site may arise when closing out architectural works (e.g. ceiling or wall board) are not carefully coordinated with installation of embedded MEP works in terms of accessibility and sequence of installation.

GOAL	OBJECTIVES	ACTIVITIES

GOAL

To prevent fit-out rework and delays through proper management of information, client expectations, as well as timeliness and quality of execution by various trades.

OBJECTIVES

Management of information

- Determine what information needs to be obtained for every area and at every stage
- Identify who is supposed to be providing this information and when it must be provided
- Ensure that this information is captured accurately and thoroughly in the model and in the coordination process in a timely manner

Reduction in design changes by consultants, clients, and end users

- Ensure that design and functional expectations from all parties are captured and managed throughout the entire coordination and review process
- Capture and highlight cost and time implications of design changes coming at late stages
- Ensure that all parties have a clear visual and spatial understanding of what is to be expected in the final end product
- Obtain final confirmation and sign-off by relevant parties
- Ensure that works on site are executed as per confirmed details

Prevent rework as a result of unclear sequencing of works

- Ensure that all trades are able to access and install without interference with other trades
- Study and communicate optimal sequencing of works in critical areas to crews

Eliminate any potential delays in schedule and further improve productivity

- Identify all possible constraints at all stages and eliminate them prior to execution
- Implement location-based management

ACTIVITIES

Prepare schedule of information & make ready tasks
- To determine what information needs to be obtained for every area and at every stage
- To identify who is supposed to be providing this information and when it must be provided
- Implement location-based management of information and issues

Model update and virtual mock-up development
- Ensure that design and functional expectations from all parties are captured
- Ensure that this information is captured accurately and thoroughly in the model and in the coordination process in a timely manner

Construction Coordination
- Ensure that design and functional expectations from all parties are captured and managed throughout the entire coordination and review process

Virtual Design Reviews
- Ensure that all parties have a clear visual and spatial understanding of what is to be expected in the final end product
- Obtain final confirmation and sign-off by relevant parties
- Capture and highlight cost and time implications of design changes coming at late stages

Sequence of installation between various trades
- Ensure that all trades are able to access and install without interference with other trades
- Study and communicate optimal sequencing of works in critical areas to crews

BIM to Field
- Ensure that works on site are executed as per confirmed details
- Identify all possible constraints at all stages and eliminate them prior to execution

CONSIDERATIONS			PERFORMANCE MEASUREMENT
1st stage of information gathering • Review and determine the extent of information that is already provided in the contract documents e.g. **walls, ceiling, finishes, architectural & MEP fixtures**. • For information that is still incomplete, determine who must be providing details e.g. clients, consultants, suppliers, sub-contractors, specialist contractors, etc.	**2nd Stage of information gathering** • Determine what requirements designers and clients want to see or what to put in later that is not necessarily part of the contract but may affect coordination e.g. **loose furniture, owner supplied items, signage.** • consider all requirements necessary for authority compliance that may affect the space such as **escape widths, handicap clearances, etc.**	**2nd Stage of information gathering** • Determine what items or other requirements will be put in by end user upon their occupancy e.g. **racks, TVs, display screens, trolleys, consoles.** • Identify any requirements for concealed provisions e.g. **bracketing in wall or ceiling** for mounting of fixtures, **clear spaces in ceiling** for future installation.	**Consistent representation of actual installation in critical areas versus the coordinated construction models whether thru laser scan data, or site photos**
Modelling considerations • Capture all items as per contract, design intent, and user intent requirements as per stages of Information (above)	• Ensure timely update of model to correct and final approved size, look, and finish as information comes in	• Model all other items that may affect coordination especially with other trades	
Coordination issues and details to clear • Authority-related issues (most critical) - Height of cabinets (which may affect sprinkler coverage requirement) - FSSD requirements for clear access widths - Accessibility requirements - Material selection for wall finishes along escape corridors, fire lift lobbies, etc. to be non-combustible	• Embedded MEP in walls and floors - SOB location whether cast in or screed. This must be coordinated with system furniture, floor mounted signage, etc. - Conduit in columns or structural walls provisions to be allowed for during structural casting stage • Ceiling coordination - Ceiling fixture arrangement in RCP - Projector boxes, clearances of space, AV fixtures, pelmets	• Design intent modulations - Sizes and alignment of materials - Alignment with doors and window - Arrangement of fixtures at lift lobbies • Cabinets and fixed furniture vs MEP - Ventilation requirements - Access panels & DB coordination - Furniture with wall related MEP fixture • Coordination of all fixtures - Location, height, spacing, arrangement - Ease of access	
Virtual review considerations • Capture actual details as closely as possible in the virtual model, including finishes, design-intent modulation, furniture and fixtures, etc.	• Ensure all possible amendments or requirements are captured while still in the virtual environment • Ensure all relevant stakeholders has easy access to virtual models for comments		
Critical areas for planning • Any area where access is constrained, or if area is accessible only in one side • Congested areas such as corridors and lift lobbies			
Shop drawing considerations • ensure that scopes of work by each trade are indicated clearly • Show "clear zones"" for owner-supplied fixtures or items	**Site briefing considerations** • perform trade demonstrations for major item trades so that all stakeholders are clear on methodology and interfacing with other trades,	• Raise all potential concerns and constraints with trade interfacing prior to first installation	

BIM, Ecosystem, Process Optimization

See Annex C5 for further details on BIM, Ecosystem, and Process Optimization

BIM

Products:

- Architectural Models / Virtual Mock-ups
- MEP Fixtures Model
- Façade Model
- Steel Structure Model
- ID Subcon Model

Ecosystem

Stakeholders:

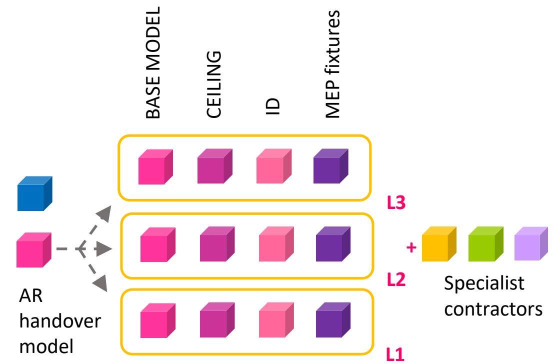
- Main Contractor
- Architectural Subcontractors: ID
- Specialist Contractors: Façade, Steel, Furniture
- Client
- Consultants

Process Optimization

Process focus:

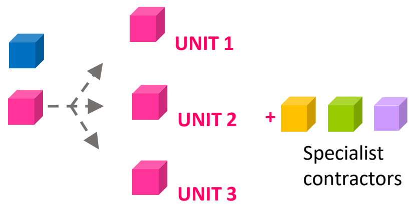
- Just-in-time management of information
- Virtual reviews of key areas with stakeholders
- Lookahead planning to identify possible constraints

Architectural Model Set-Up:



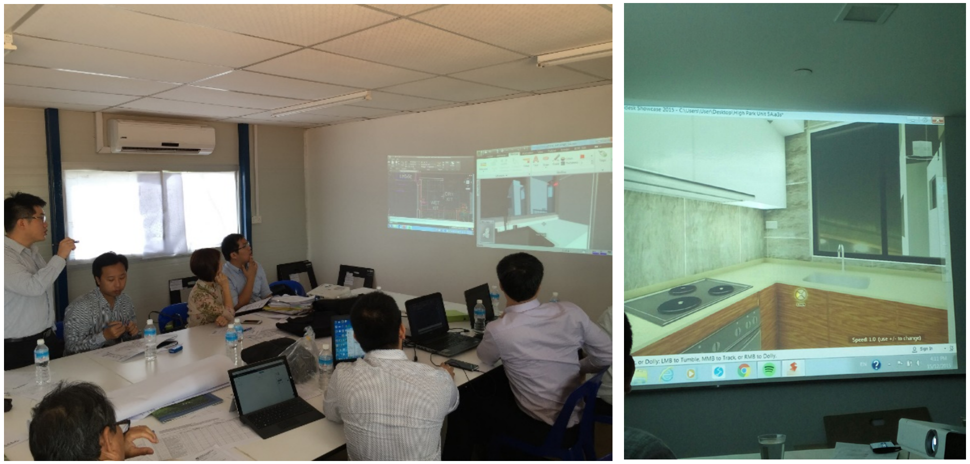
1 SPLIT BY FLOOR & SCOPE OF WORK

- When the complexity of each level is such that might it might take a longer time to develop or to fully clear all issues prior to moving to the next storey
- When there are few typical areas or rooms (e.g. typical residential units)
- Typologies such as hospitals, museums, shopping malls, schools and universities, etc.

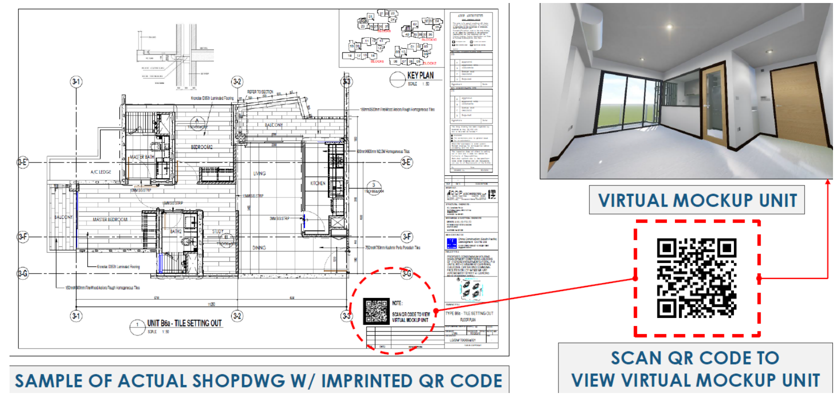


2 SPLIT BY TYPICAL UNITS

- When there are many typical units or rooms
- Typologies such as residences, HDBs, condominiums, etc.

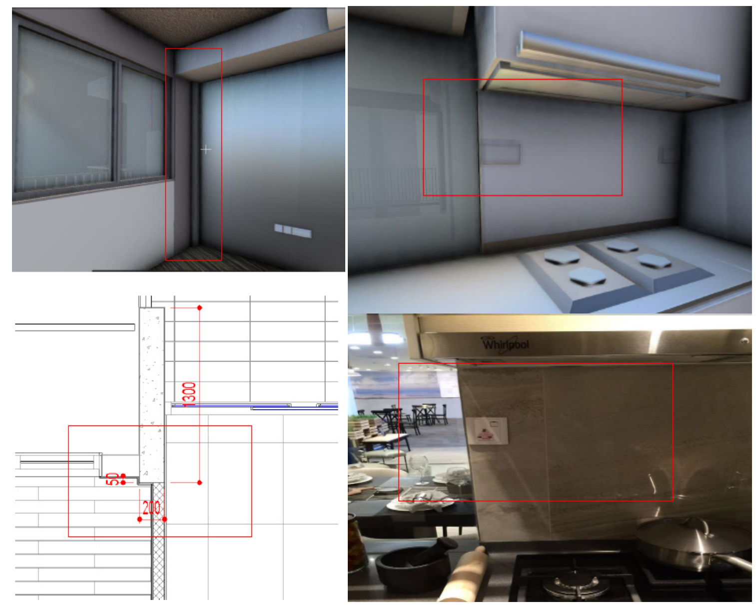


Virtual Reviews with Clients and Consultants
Virtual reviews are conducted using the virtual mockup to capture and firm up all client and consultant requirements and feedback and manage all changes while still in the virtual environment. To be successful, the model has to developed to the appropriate level of accuracy and realism as per finish and details.



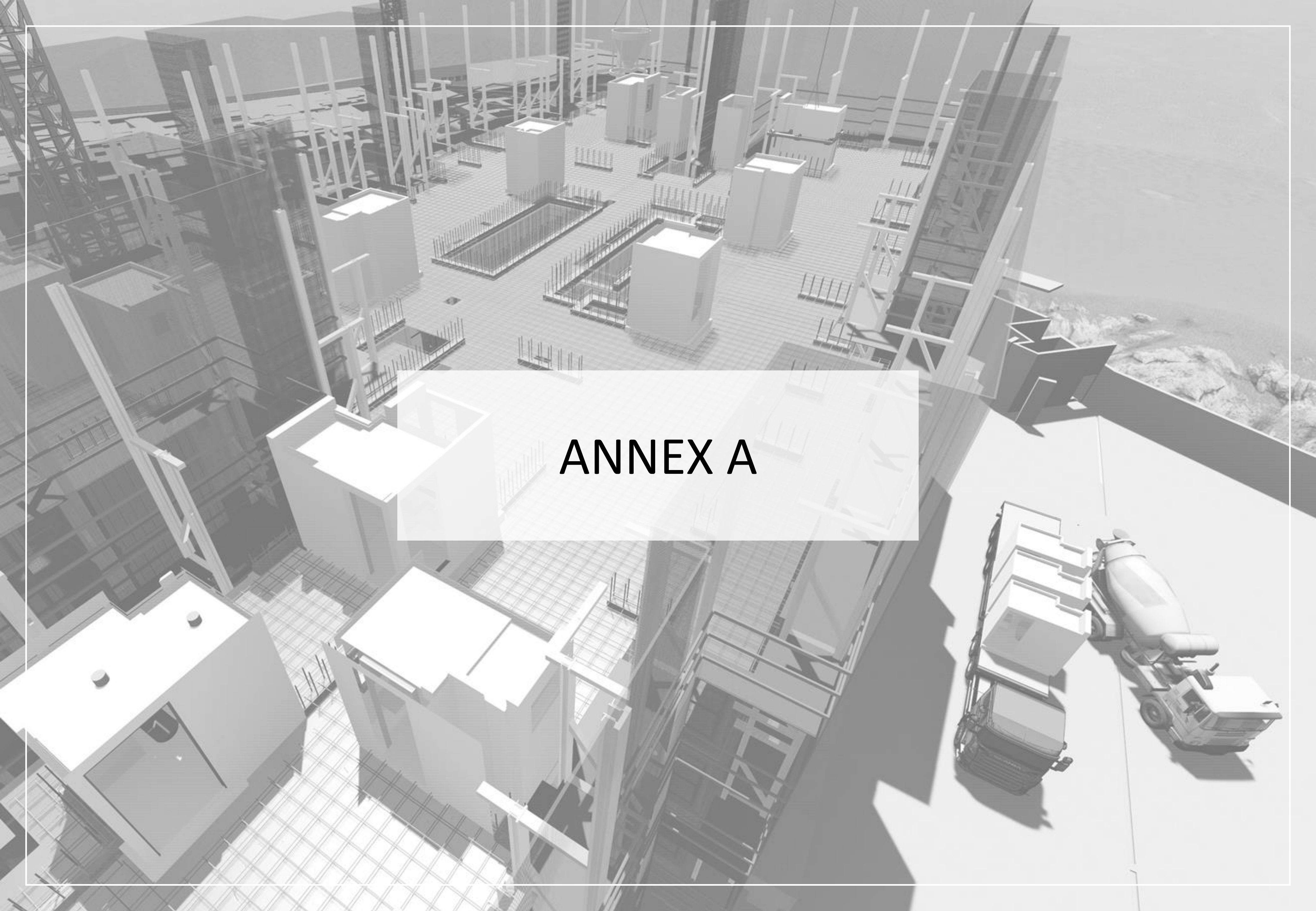
Shop Drawings with QR Codes
These approved models, as well as sequence of installation per unit, may also be made accessible to site personnel via QR codes integrated into the shop drawings.

Virtual Reviews and Site Briefings with Subcontractors
After final approval and confirmation, the virtual mock-up may also be utilized to brief subcontractors and trade supervisors on the expected final product.



Fit-out coordination
Fit out coordination may include, among many others, exact size and location of fixtures in alignment with tile or finish modulation, ceiling bulkhead coordination, MEP to furniture coordination.

ANNEX A



Sample Metrics

ACTIVITIES	TARGETS	METRICS
MODELLING WORKS	To quantify the productivity of BIM Modelling Works for the purpose of: ▪ Improving accuracy of BIM modelling resource planning and scheduling ▪ Improve overall modelling productivity	▪ Total modelling man-days per discipline OR ▪ Total GFA modeled per man-days per discipline
ICE MEETINGS	To ensure all necessary stakeholders and decision makers are in attendance	▪ No. Of REQUIRED key project team members in attendance
	To reduce decision latency	▪ Targeted no. of issues closed per session ▪ No. of items closed within __ minutes
COORDINATION WORKS (DESIGN COORDINATION / CONSTRUCTION COORDINATION)	To reduce RFI or Issue latency for design coordination items	▪ Comparison no. of issues opened vs closed per session ▪ Target vs actual latency duration
	To fully maximize the use of BIM for visualization and communication of issues to be coordinated	▪ % of project scope coordinated with a 3D model OR ▪ % of coordination meetings carried out with 3D models
	To reduce total coordination period or improve productivity for design coordination during construction (ICP)	▪ Lead time between actual execution and clearance of all design issues for the same area/floor/zone
	To better strategize the coordination process through prioritizing which issues to be tackled first	▪ Track types of issue raised per meeting
SHOP DRAWING PRODUCTION	To track productivity in shop drawing preparation in order to: ▪ Improving accuracy of BIM modelling / drafting resource planning and scheduling ▪ Improve overall shop drawing productivity	▪ Time spent on preparation of shop drawings
	To maximize the use of BIM data for shop drawings	▪ % of shop drawings prepared in BIM vs CAD
VALUE ENGINEERING	To easily quantify and track how many accepted variation orders for proposed alternatives through BIM	▪ No. of BIM-based VE items accepted
PLANNING AND SCHEDULING	To improve visualization and reliability of plan through better integration with BIM	▪ No. of BIM-supported planning/scheduling meetings ▪ % of construction activities managed with a 4D model
QTO & COST PLANNING	To maximize opportunities for BIM-based QTO	▪ % of BOM items directly (or indirectly) quantified from BIM model (by project cost)
	To track productivity and time spent on QTO or BOM/BOQ preparation	▪ Time spent on BOM preparation comparison between manual and BIM-based
	To track and improve accuracy of QTO	▪ Comparison between tender quantities vs actual quantities

Sample Metrics

ACTIVITIES	TARGETS	METRICS
OFF-SITE FABRICATION	To maximize opportunities for prefabrication	▪ % of project scope (in terms of cost, GFA, etc.) fabricated off-site
	To maximize opportunities of automation for prefabricated items	▪ % of scope of pre-fabricated off-site items to be mass produced are automated (e.g. CNC)
BIM TO FIELD COMMUNICATION AND VISUALIZATION	To ensure key personnel have the necessary skills to utilize model of navigation and visualization	▪ % or No. Of key personnel (site supervisors, foremen, PM, engineers) trained
	To ensure key personnel have access to most updated (and approved) models, shop drawings, sequencing, etc.	▪ % or No. of key personnel with cloud access to files and models
SITE BRIEFING / SAFETY BRIEFING	To utilize BIM for better visualization and communication during site briefings or safety briefings	▪ No. of BIM-supported safety briefings
PROGRESS MONITORING & PRODUCTION CONTROL	To check whether project is on track per schedule. Also to determine accuracy and reliability of plan/schedule	▪ Planned vs Actual ▪ Ahead vs Delay
	For a more detailed breakdown of project schedule by monitoring progress/schedule per trade	▪ Planned vs Actual, by trade
	To track actual trade productivity to rates for better accuracy of calculated schedule durations for future projects	▪ Average productivity rates by trade
	To track plan reliability in terms of committed tasks vs actual tasks performed per day	▪ Planned Percent Complete (PPC) ▪ 85% plus: great ▪ 75-85%: acceptable ▪ <75%: not acceptable
WASTE & COST MONITORING	To forecast and determine whether wastes accrued (e.g. for rebar, concrete, and formworks) are within targeted contingency, and to manage accordingly	▪ Planned quantities vs procured quantities
	To understand the impact of rework to cost from the nature or type of rework in order to better manage and strategize accordingly	▪ Track Site Instructions for rework, as well as type and reason for rework
QUALITY	To ensure accuracy of as-built works as per coordinated BIM model	▪ Laser scanning or other field-to-BIM technology

Sample KPIs

RELEVANT SAMPLE GOALS / OBJECTIVES PERTAINING TO:	KPI	EXAMPLE
QUALITY	% inspections passed on the first time	▪ Targeted: 90% ▪ Average / Previous similar project: 75&
TIME	Reduced construction period (months)	▪ Contract: 46 months ▪ Actual: 36 months
WASTE	Reduce material waste (RC, Rebar, Formworks, etc.)	▪ Targeted: 3% Variance ▪ Average / Previous similar project: 8%
ISSUE RESOLUTION	Reduced latency in issue resolution during coordination or ICE meetings	▪ Targeted: 3 Days ▪ Average / Previous similar project: 7 days
SHOP DRAWING CYCLE TIME	Reduced cycle time from shop drawing preparation to approval	▪ Targeted: 7 Days ▪ Average / Previous similar project: 21 days

*Other metrics can also translate to targeted KPIs.

Environment and Facility Types and Best Practices

CO-LOCATED BIG ROOM	MEETING ROOM	VIRTUAL BIG ROOM	FIELD ENVIRONMENT
			
Multiple trades or disciplines are co-located in a single space for in either or both design and construction phases, providing the benefits of real-time collaboration of shared knowledge, as well as improved information flows and rapid feedbacks. The primary benefit of co-location is elimination of information-sharing and decision-making latency. e.g. • Construction model development / production and continuous update Since full-time co-location is resource-intensive, other alternatives to full time include: **Recurring**: Participants meet in person on a regularly scheduled, recurring basis (see Chapter 3: ICP) **Hybrid:** Combination of in-person and virtual attendance by select participants	A dedicated meeting room for issue resolution, planning, reviews, etc. where multiple stakeholders and project team members can come together to accomplish a specific tasks or resolve a specific problem, preferably on the spot, through the use of the virtual model, and where the model is interrogated and updated towards resolution. e.g. • Coordination meetings or ICE meetings during design or construction • Site planning and sequencing, safety risk assessment • Project scheduling planning, pull planning, or other planning activities • Work shops • Kick-off meetings	An alternative to physical co-location, in which project teams in different locations to work collaboratively in real time, as though they were in the same room. In this set-up, project models are hosted virtually to permit multiple project team members to access them from wherever they are. e.g. • Design development, coordination, and collaboration with consultants in various locations The technologies required to implement virtual co-location may include BIM platforms (Common Data Environments), visualization and communication platforms, social collaboration and knowledge management platforms, which combined, serve to support entire lifecycle from conceptual design to construction in a virtually co-located space.	A good field environment streamlines the BIM-to-Field connection and brings BIM information to site and site information back to the trailer without any latencies, errors from wrong document versions, and other processing inefficiencies. Examples of information that are shared between the trailer and site are: • Latest approved drawings, specifications, and other approvals • Approved models for visualization and inspection • Model points for digital stake-out • As-built information • Quality and defects reporting • Progress tracking and monitoring • Safety issues reporting Setting up this sort of environment requires real time information therefore usually involves mobile technologies and cloud-based collaboration and reporting, and other technologies and equipment.
Good practice tips: ✓ Organize by clusters, or by most number of interactions ✓ Large, open, flexible spaces so that teams can quickly reconfigure when needed, with break-out areas ✓ Lots of blank wall space ✓ File & information sharing structure and connectivity	Good practice tips: ✓ Provide at least 2 sets of projector screens, or smart boards so that two views of the model or other documents may be viewed at the same time ✓ Provide whiteboards, flip boards, or other means of writing ✓ Provide ample wall space for pull planning or other lean process exercises	Good practice tips: ✓ Provide real-time chat or communication platforms ✓ Centrally hosted model and access to project data is permissions-based, which makes it secure ✓ Improve communication and workflows. Communication may even be more critical, with multiple parties updating the model at once remotely.	Good practice tips: ✓ Provide mobile access to appropriate parties to latest documents and models for reference for execution ✓ Make use of physical site environment to communicate BIM to site workers (e.g. post QR codes in rooms providing a mobile link to finished room visualizations or installation sequencing) ✓ Make use of mobile field platforms to bring data to field and vice versa

Types of "Wastes" in Knowledge Based Work

Waste is any activity that consumes resources, but does not create or add value. The table below defines and provides examples of the type of wastes that typically occur in both site and knowledge-intensive work.

WASTE	DESCRIPTION	PROCESS / KNOWLEDGE WASTES	SITE WASTES
Defects	Errors that result in rework and increased costs	• Model and drawing discrepancies	• Punch lists and defects
Overproduction	Producing something either before it is needed or in too great a quantity	• Over modelling beyond what is required to perform activities	• Overproducing or too-early production of precast or PPVC components
Waiting	Waiting for parts, machines, people	• Resolution response latency • Approval latency	• Delayed materials, equipment, and resources
Non-utilized resources	Failing to use people or resources effectively	• No sharing of knowledge and learnings • Lack of training • Poor communication and unclear deliverables	• Crews available on site but area not ready
Transportation	Unnecessary movement of a product between processes	• Unnecessary back and forth movement of information between trailer and site	• Materials being transported from one jobsite to another
Inventory	Storing product as a result of overproduction	• Shop drawing part prints • Multiple versions of drawings due to production earlier when actually needed	• Extra materials or off-site components
Motion	Any movement of man and/or equipment that does not add value to the process	• Fire fighting repeat problems • Lack of preparation for meetings (e.g. coordination meetings) • Searching for information	• Searching for tools and equipment • Walking across work space to retrieve components or use machines
Extra-Processing	Work that is not specifically asked for by the customer	• Modelling what is not required	• Unclear scope of work

Suitable Lean Tools for the AEC Industry

TOOL	DESCRIPTION
Daily Huddle Meetings	The main purpose of daily huddle meetings is to align the team in terms to the issues to be addressed for the day, order or priorities of the activities to be done for that day, among many other teams. Another critical benefit is to give all team members a platform to voice their concerns to management or supervisors and escalate issues on the ground prior to them being critical.
5S	5S stands for Sort, Straighten, Shine, Standardize, and Sustain. This describes how to organize a work space for maximum efficiency.
First Run Studies	As part of a continuous improvement effort, first run studies are used to redesign critical assignments and streamlining the different functions involved. The first run of any operation is examined in detail, bringing in ideas and suggestions to further explore other ways of doing or streamlining the work. The studies are commonly in the form of video format, graphics, or photos, to illustrate the work instruction.
Visual Management	This is an information communication technique employ to increase clarity any processes through the use of visualization
Fail Safe for Quality	Fail Safe for Quality applies error-proofing in both quality and safety. Error-proofing for quality can be done through standardization of practices
Kanban (Pull System)	A Japanese word which means “billboard or signboard” Kanban is a method for delivering products or services with an emphasis on continual delivery. Kanban is based on 3 basic principles: visualizing what you do today, limiting the amount of work in progress (WIP), and enhancing flow.
5 Whys	This is a management tool for problem-solving that strives to determine the root cause of a problem by asking 5 “Why”s. It stipulates that workers should be asking why five times repeatedly until they identify the underlying root or the nature of the issue and its solution becomes clear, thereby removing the root cause and preventing its recurrence.
FIFO (First In, First Out)	This is an approach for handling work request in order of flow from first to the last.

TOOL	DESCRIPTION
Just-in-time	This is a technique or a production system in which materials or components are delivered just as they are required in order to minimize inventory and storage constraints, which basically translates to waste. Just-in-time is related to the “Pull” concept in production.
Work Standardization	Is a “living” documentation of best practices, which forms the baseline for Kaizen or continuous improvement. As the standard is improved, the new standard becomes the new baseline for further improvement, and so on, thereby making it a never-ending process.
Statistical Process Control (SPC)	This is a quality control tool that monitors and control process in order to ensure that system output variables operate to its full potential through periodic measurement. It uses control charts to gather and analyze data, and helps you determine if the process is “out of control”.
Work Structuring	Work structuring is the most fundamental level of process design, which strives to develop a project’s process design while trying to align engineering, design, supply chain, resource allocation, and assembly efforts.
Pareto Analysis	This is a bar graph that is used for analyzing data about the frequency of the causes or problems in processes. It uses the Pareto Principle (also known as the 80/20 rule), which is the concept that doing 20@ of the work can generate 80% of the benefits of doing the entire job. It utilizes this idea to visually depicts which situation are more important.
Poka-Yoke (Error Proofing)	This is a mechanism design to detect, prevent, correct, or draw attention to human errors in processes with the aim of achieving zero defects.
Continuous Flow	This means to constantly provide, process, or produce through a progressive system of uninterrupted steps. In an ideal production system, the aim is to achieve “one-piece flow” in which each product moves along the value stream independently until it is completed.
Six Sigma	Sets of tools and techniques for improving quality and striving for perfection through identification and removal of defects and reduction of variability in processes.

Suitable Lean Tools for the AEC Industry

TOOL	DESCRIPTION
Bottleneck Analysis	Bottlenecks determine the throughput of the supply chain. Bottleneck analysis identifies constraints or the part of the process that put a limitation on the overall productivity in order to improve the performance of that part.
Kaizen	Kaizen in Japanese means "change for better" and it is Japanese business philosophy for continuous improvement through all aspects. More specifically, it focuses on applying small, daily changes that result to major improvements over time
PDCA (Plan, Do, Check, Act)	This is an iterative approach for improvements implementation. It involves; Plan (set up a plan and expect results); Do (execute the plan); Check (verify anticipated result achieved); and Act (evaluate; do it again).
Muda Walk	Muda is a Japanese word meaning waste. Muda walk is a technique used to identify waste through actual observation of operations, how work processes are conducted, and noting areas where improvements are needed.
Root Cause Analysis	This is a problem-solving technique that focuses on discovering and resolving the real problem instead of quick fix application that only solve problem symptoms.
Check Sheet	Also known as Defect Concentration Diagram, this is a structured form prepared for collecting and analyzing data. It is a generic tool adapted for a variety of purposes including the observation and collection of data on the frequency of patterns of problems, events, defects, causes, etc.
Line Balancing	This involves leveling of workload across all processes in a value stream to remove excess capacity and bottlenecks. Location Based Management System applies this concept.
The Last Planner	The last planner is a person or group of people with the task to control production unit. They are responsible necessitating control of workflow, verify supply stream, design, and installation in all the production units.

TOOL	DESCRIPTION
Value Stream Mapping	A technique for visually analyzing, documenting and improving the flow of a process in a way that highlights improvement opportunities.
Team Preparation	This is a process of conducting training on waste, continuous flow and standardizes work for the lean team or employees.
Construction Process Analysis (CPA)	This utilizes process charts and top-view flow charts common among process analysis methods. These diagrams and charts depend on standardized symbols and effectively describe process flow and enable a quick determination of areas where problems exist in the process. The charts comprise of six symbols; Operation, Storage, Transportation, Volume Inspection, Delay, and Quality Inspection. The process diagram records every progression or step of a construction operation. Furthermore, it records flow within units, sections, and departments
Failure Mode and Effects Analysis (FMEA)	This is a step by step approach for identifying potential failures in product or service, design, and manufacturing, etc. The failures are further ranked to determine the seriousness of their consequences in order to take actions to eliminate them, starting with the highest ranked ones.

Lean Planning Tools: Last Planner® System

Last Planner® System is a production planning system that involves the trade foremen or the team leaders, the "Last Planners", to collaboratively plan in greater and greater detail as the actual execution dates gets closer, thereby increasing plan reliability.

Why use Last Planner?

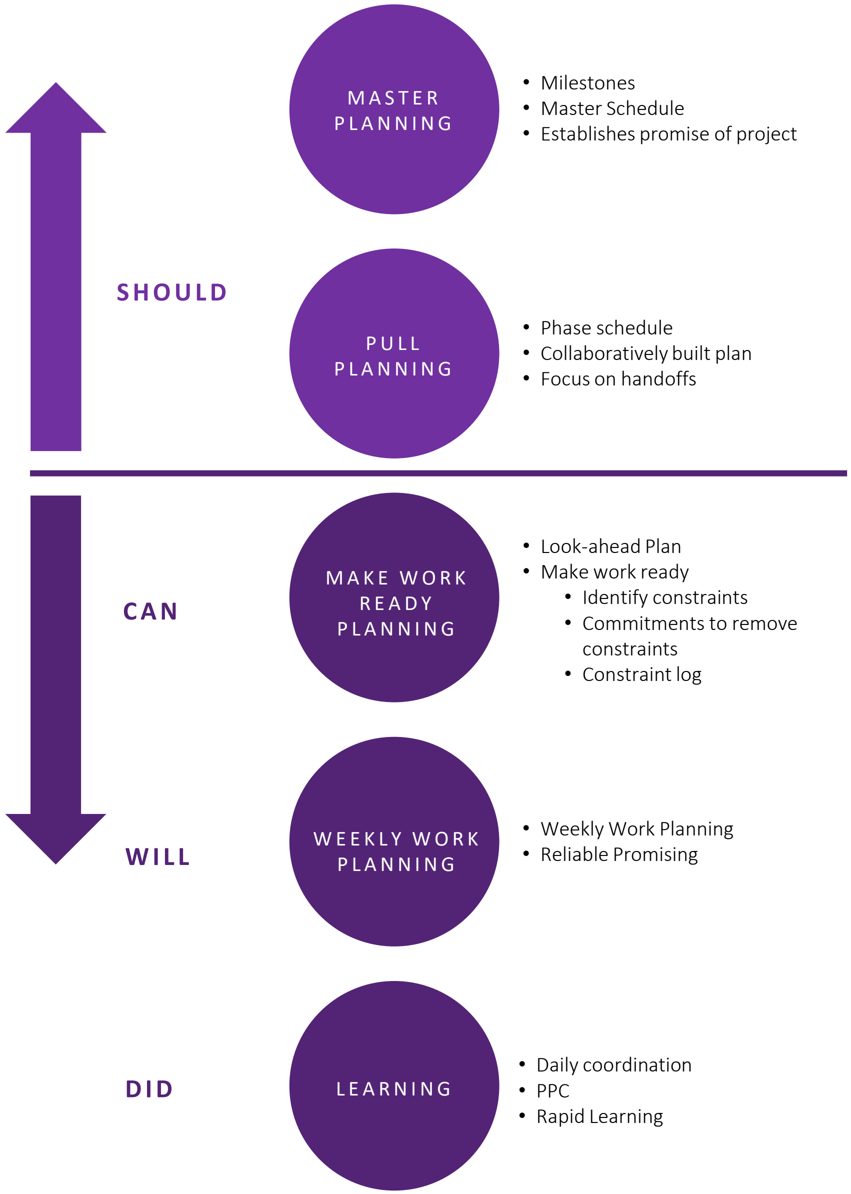
- Traditional planning doesn't produce predictable workflows, therefore crews do not execute the work as scheduled
- Since it directly involves the people who actually execute the work, Last Planner is more proactive rather than reactive

Key Principles

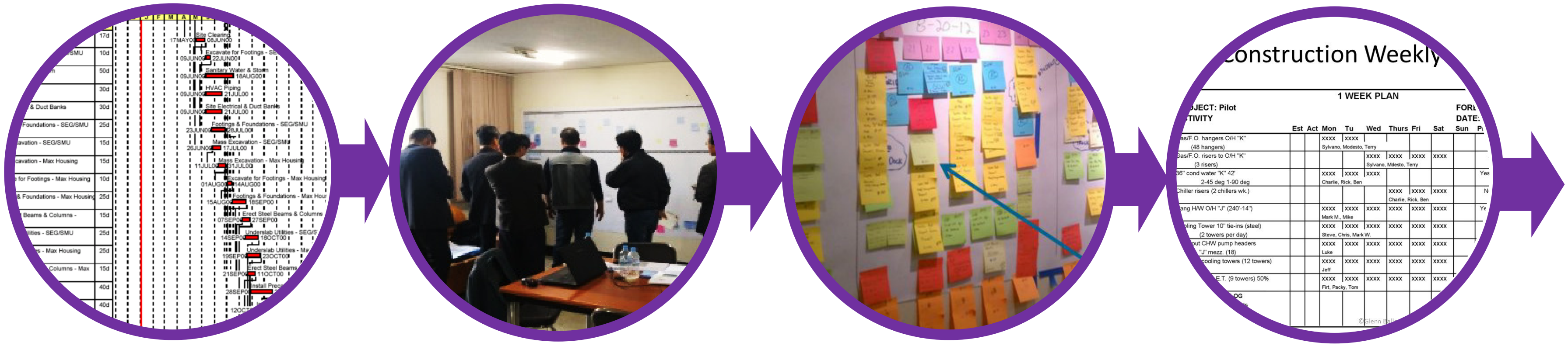
- Plan in greater detail as you get closer to doing the work
- Produce plans collaboratively with those who will do the work
- Reveal and remove constraints on planned tasks as a team
- Make and secure reliable promises
- Measure promises kept (planning capabilities, PPC) in order to improve by learning from variance (work flow disruptions)
- Continuously improve as a team, remove waste and adjust performance

THE EIGHT KEY ELEMENTS OF LPS

1. Master Planning
2. Phase Scheduling
3. Lookahead Planning
4. Weekly Work Planning
5. Daily Huddles
6. Percent Plan Complete
7. Reasons for Variance
8. Rapid Learning



The eight key elements to the Last Planner® System



Master Schedule

During front end planning, the master schedule is produced to identify **key milestones** and the timing of the **various phases** a project goes through. It covers the entire project duration and presents activities at a course level of detail.

Pull Planning

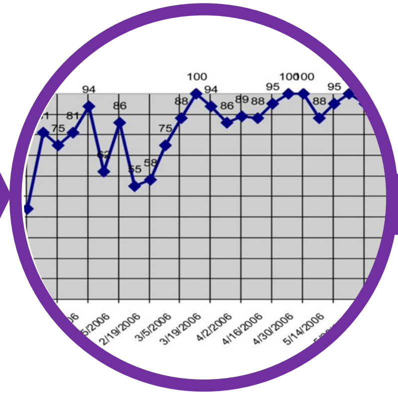
During phase scheduling, the “last planners”, or the people who are responsible for executing the work, are engaged in pull planning sessions to establish the flow of work for each project milestone. The “pull” technique means to work from a target completion date or activity backwards. Through pulling, handoffs are specified between trades so as to ensure a smooth and reliable workflow.

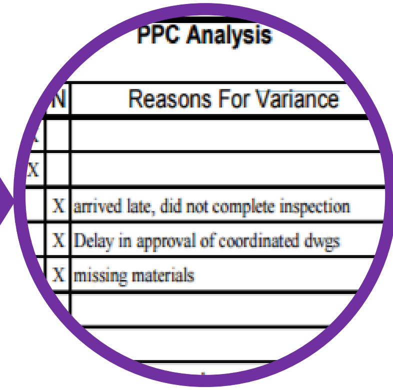
Lookahead Planning

Lookahead planning typically covers a shorter time frame into the immediate future (typically 3-12 weeks) and with a higher degree of accuracy and reliability. During lookaheads, the plan is reviewed collaboratively to make the work ready by removing constraints. Commitment is obtained from each trade stakeholder that each task can be executed as planned and as promised.

Weekly Work Plan

Weekly work planning involves defining all of the activities and scheduled work that should be done and will be done, prior to the start of the work for that week. Activities are identified, timed, and sequenced so as to best serve the project objectives.





Daily Huddle

First line supervisors should check in with their with their work teams on a daily basis to assess progress as and set targets as per the Weekly Work Plan. Factors and constraints affecting resources are also evaluated (absentees, weather, machine breakdown, etc.) and necessary adjustments are taken.

Percent Plan Complete

Percent Plan Complete or PPC is a measure of the percentage of the assignments that are completed as planned or as committed.
In weekly work planning, the last planner tracks the number of actual completions divided by the number of planned completions. The performance measure assesses the reliability of planning work.

Reasons for Variance

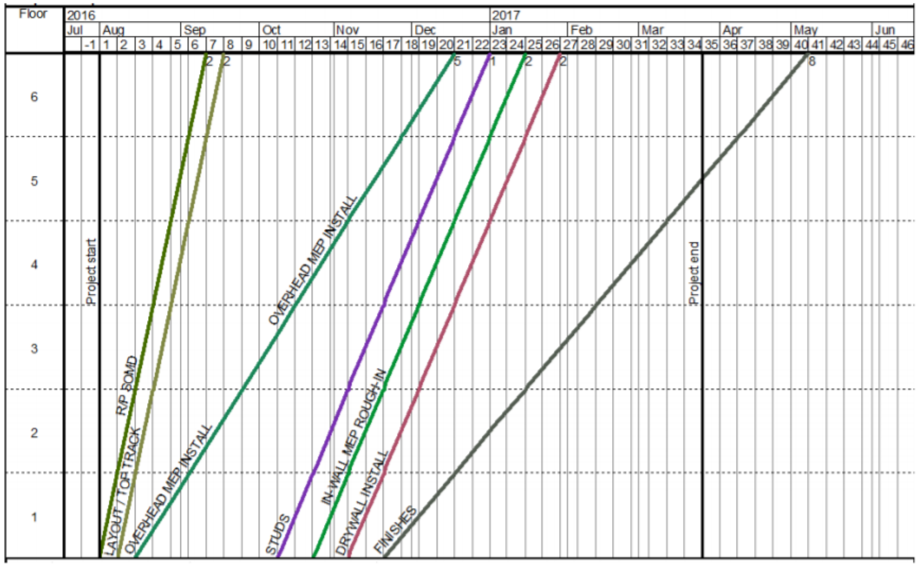
Any work that has not been done as planned or any variance or deviation from plan is tracked and the reason for variance needs to be identified and recorded. The focus should be on identifying what needs to be corrected in order to improve the performance of the upcoming PPC. Problem solving tools to determine reasons for variance include the five whys, root cause analysis, model based problem solving, etc.

Rapid Learning

The use of the Last Planner System focuses on continuous improvement and part of this is to learn from every single project implementation so that succeeding projects will improve in terms of plan reliability, team confidence, and overall mastery.

Lean Planning Tools:
Location Based Management System

The location-based management system focuses on planning, controlling and analyzing the activities of the workflow as each moves location to location.



Why use LBMS?

- Traditional activity based scheduling methods (e.g. CPM & PERT) provide limited insight in to the spatial configuration of projects
- Schedule durations are typically calculated based on rough estimates or experience, not on accurate reliable durations from model-based quantities and actual crew productivity rates.
- Traditional planning does not necessarily guarantee a smooth flow of work as crews move from one place to another.

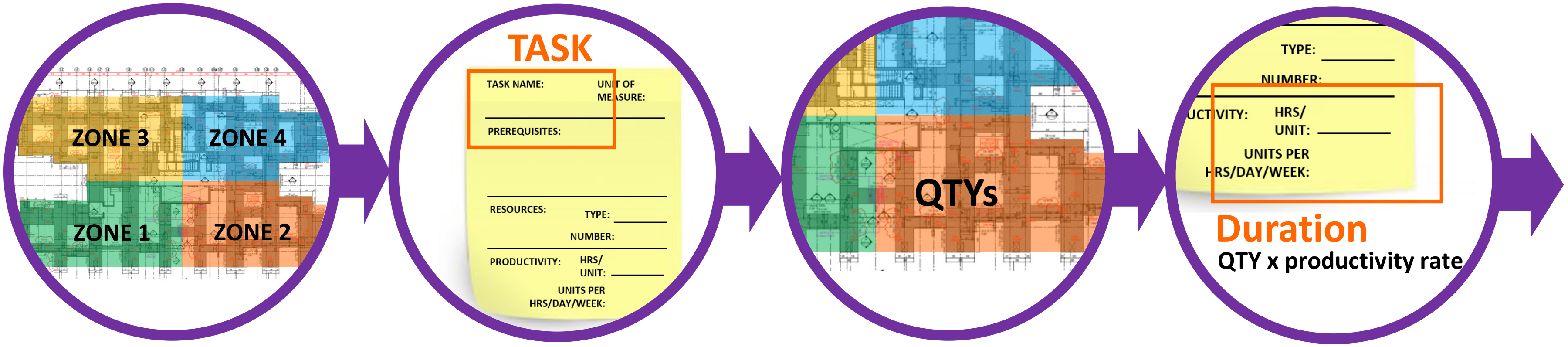
Principles

- Minimize starts and stops
- subcontractors can work at optimum productivity rates with optimum safety and craftsmanship if their location is free of unnecessary materials and other crews

THE EIGHT KEY ELEMENTS OF LBMS

1. Location Breakdown Structure
2. Tasks
3. Quantities by Location
4. Durations
5. Flowline
6. Layered Logic
7. Risk Management & Buffers
8. Schedule Optimization

The eight key elements to the Location Based Management System



Location Breakdown Structure

An LBS is the backbone of location-based management system as it defines work of each trade by their own location breakdowns as they move through the project.

Ideally, all subcontractors working on the same construction phase should agree on one LBS, but it is not necessary in all cases.

Tasks

Tasks are work packages for each trade, and usually contains work in several locations. Each task would require resources and would have a productivity rate. This productivity rate is obtained from the tradesmen, and as actual progress and actual productivity is tracked, becomes more and more reliable as more data is acquired within the project and across projects.

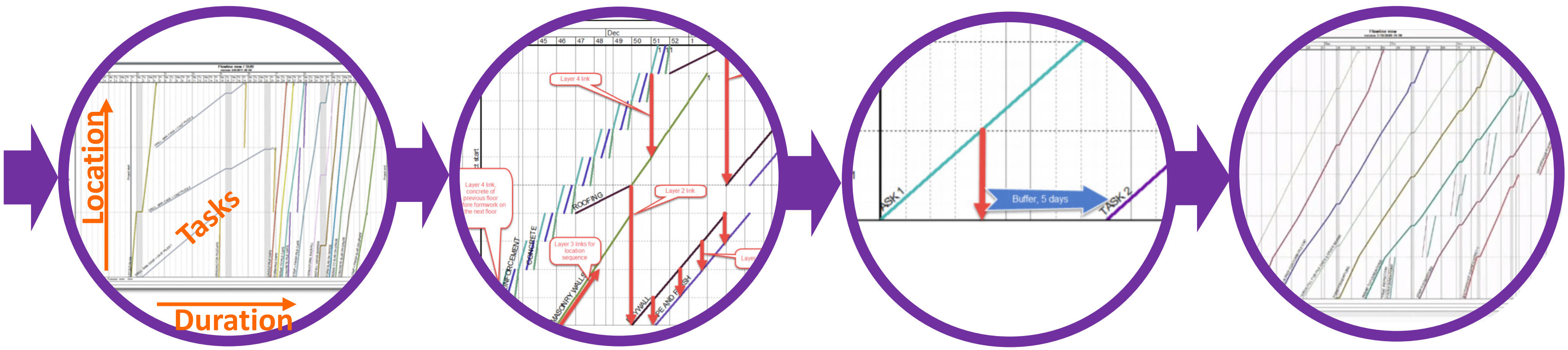
Quantities by Location

The work content of a task is based on quantities. There are two different ways of determining this: Firstly, certain BIM and BIM planning tools may enable you to obtain model-based quantities by location according to the Location Breakdown Structure.

Alternatively, then quantities can be estimated after the tasks have been determined first, perhaps by collaborative planning (through Last Planner)

Durations

Duration in LBMS are then calculated based on the total manhours from multiplying Location Based Quantities (from either of those aforementioned sources) with productivity rates or labour consumption.



Flowline Visualization
A flowline is a representation of duration and location. In a flowline, the Location Breakdown Structure is shown vertically, and time is shown horizontally. Each task is shown as a diagonal line. The slope of the line signifies the production rate of each task. The slopes of the lines also tell a lot about opportunities to optimize or balance out resources.

Layered Logic
LBMS uses the Location Breakdown Structure to automate the creation of logic between tasks. The layered logic of LBMS includes five layers namely:

1. External logical relationships between activities within locations
2. External logical relationships driven by different hierarchy of levels
3. Internal dependency logic between locations within tasks
4. Additional location-based links
5. Standard CPM links between any tasks and different locations

Risk management & buffers
One of the main objectives of LBMS is to reduce the risks related to schedules. After applying layered logic, the remaining risks and variability are protected by including buffers in the schedule to protect the continues flow of critical tasks.

Schedule optimization
The schedule is further optimized by aligning the flowlines in such a way that the empty spaces are eliminated. In location-based planning, improving the alignment of schedules will shorten project durations.

Process Mapping Tools:
Swimlane Diagrams

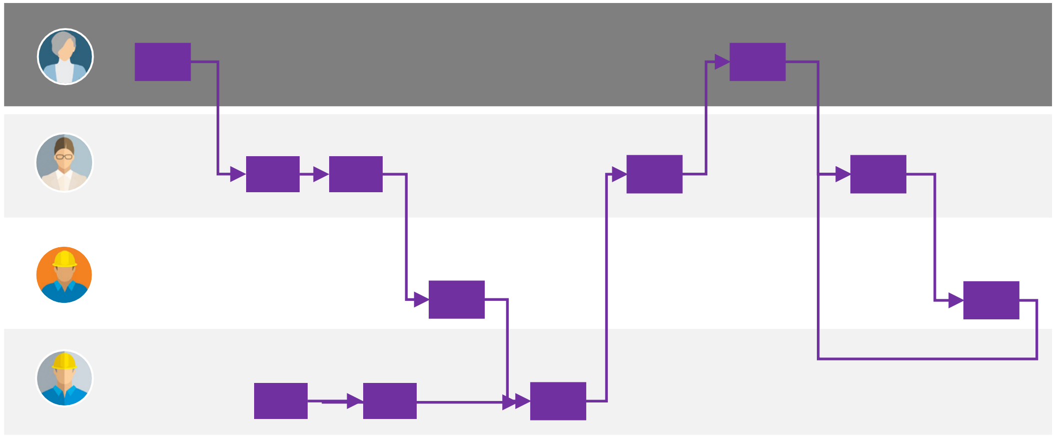
Swimlane diagrams are Cross-Functional Process Maps that delineates who does what in a given process. They provide clarity and accountability by showing both what each stakeholder does in each of their own "swim-lanes" and how each stakeholder's work relate to each other.

Why

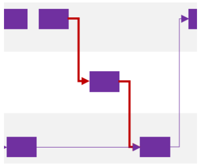
- Helps to ensure that the right hand knows what the left is doing in a particular process
- Information hand-offs between entities are clear (who must receive what from whom)
- Redundancies between different lanes are highlighted, as well as bottlenecks, wastes, unnecessary steps and other inefficacies
- Integrates processes between teams or departments, resulting in a more streamlined process

Applications

- Cross-**discipline** processes (e.g. AR, C&S, MEP integrated processes during the design phase)
- Cross-**department** processes (e.g. flow of information from trailer to Field and vice versa)

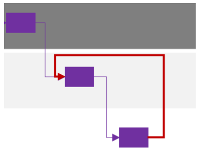


WHAT TO LOOK OUT FOR:



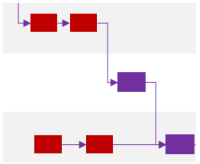
Hand-offs

When a stakeholder "hands off" a task to another stakeholder, it is useful to look at how that hand-off took place (and how long) and whether or not it is the most effective and efficient way to communicate the information



Turn-arounds

In turn-arounds, a stakeholder must revert back to another stakeholder for clarification or more information before they can proceed with their work in their role. If this is recurring, then it is a source of inefficiency.



Parallels & duplicates

When two stakeholders are working on the same work in parallel, thereby creating unnecessary or duplicate work, which translates to waste.

Process Mapping Tools:
Flow Charts

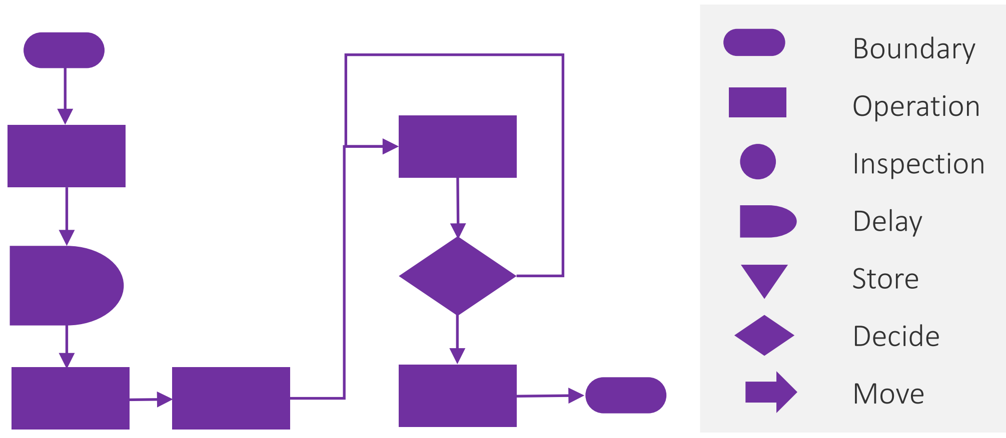
A flow chart is a graphic representation of the sequence of activities used to create, produce, or provide a specific, unique input.

Why

- Drills down within a subset, or portion of a larger process, to show the "ground-truth" reality of what actually happens
- Distinguish between value creating activities and non value creating activities

Applications

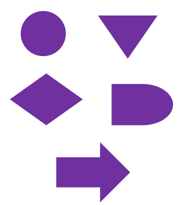
- Specific steps to execute an activity, e.g. transferring points from BIM to field, performing an analysis, etc.



WHAT TO LOOK OUT FOR:

Step 1 - Examine each process step for potential bottlenecks, weak links, poorly defined steps, etc.
Step 2 - Examine each decision symbol. Can this step be eliminated?
Step 3 - Examine each rework loop. Can it be shortened or eliminated?
Step 4 - Examine each activity symbol Does the step add value for the end-user?

Value Creating Activities
Activities that transform the product towards meeting the expected requirements i.e. operation



Non Value Creating Activities
Activities that do not transform the product and create value i.e. inspections, delays, storage, etc.

Process Mapping Tools:
Value Stream Mapping (VSM)

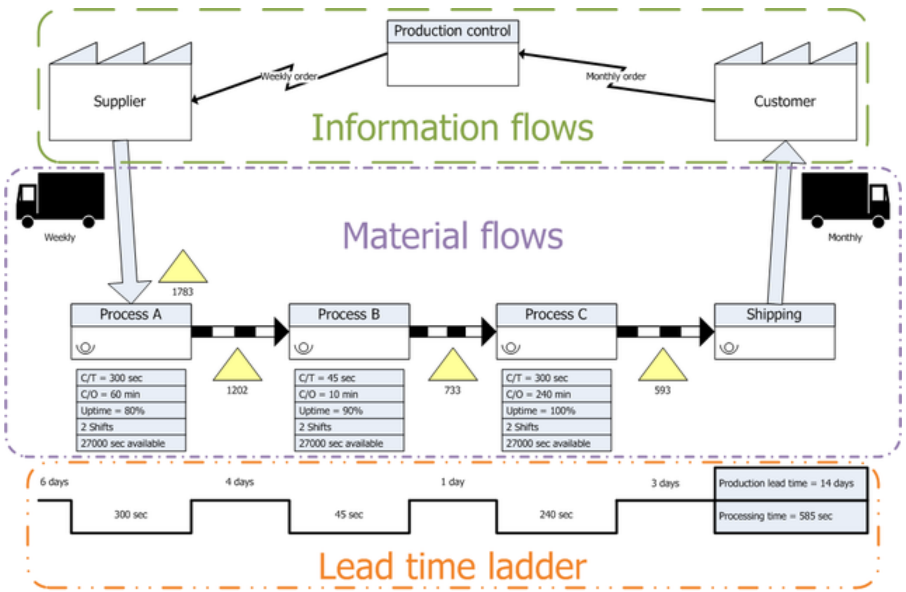
Value Stream Mapping is a Lean tool that helps a project team visualize and understand the flow of material and information as a product makes its way through the value stream. It involves creating a visual representation of the **current state** of a process or system that includes current data on cycle times, inventory levels, material flow paths, and information flow paths in order to guide the project team's efforts towards determining an **ideal future state**.

Why

- To identify reasons for long lead times and low productivity
- Enables people to see the flow of value
- To create a common understanding on how the flow should be

Applications

- Mapping processes to be measured in terms of cycle times or lead times, e.g. PBU/PPVC fabrication,
- Processes performed multiple times, e.g. PBU fabrication, concrete casting cycle



Step 1: Select process to be mapped
Step 2: Select team members to be involved in value stream mapping
Step 3: Collect data and produce current state map – data includes process times, inventory or materials information, demand requirements, etc.
Step 5: Critique Current State – identify areas of wastes and opportunities for optimization.
Step 6: Map Future State – draw out a future state map based on current state critiques
Step 7: Create Action Plan – basing the Future State map develop an implementation plan to deploy future state from current state
Step 8: Measure outcomes – check to ensure that the expected outcomes have been obtained

Improving "Flow"

"Flow" corresponds to the "being worked on" state. Therefore, to improve flows in a process means to streamline and improve the "smoothness" of work. The following are components of a process and the conditions that either helps or hinders flow.

Component	Helps flow if..	Hinders flow if..
Activity	It's value-creating	It's not value-creating, or is waste
Workflow Design	Visible item flow	Item flow not visible
Path	Short, unidirectional "path"	Long, multidirectional "path" with "loop backs"
Series of activities	No handoffs, collaborative pattern	Many handoffs, serial pattern
Resources (required)	All required resources are available when needed	Any required resource is not available when needed
People (interdependent natural workgroup)	Co-located	Dispersed in multiple locations
Equipment or files	Located in easy reach	Located down the hall

Damelio, R. (2011). The Basics of process mapping.

OTHER PROCESS STREAMLINING TIPS:

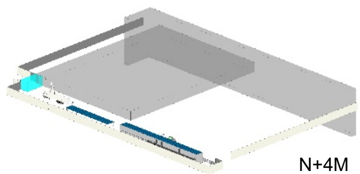
1. Combine several activities into one
2. Eliminate rework activities
3. Standardize the process and the way it is performed
4. Centralize data and decentralize operations
5. Capture data as close as possible to the source
6. Integrate parallel activities

Integration of BIM & Production Planning / Scheduling

Steps	Master Planning	Phase Planning	Work Cycle Review	Weekly Work Planning
Interval	Overall Process	Month/ 2 Weeks term	Day	Week
BIM	Massing of various phases of the project, whether by level, zone, and/or trade, or however the project milestones are defined	Building elements are defined per zone or phase, sizes may be indicative	All elements required for planning for one cycle are defined, with geometric accuracy for quantity take-off	4D models and sequences are communicated to crews for their feedback. Temporary works may also be indicated in the model.
Review Items	▪ Milestone Review ▪ Trades Relationship Review	▪ Consultant Model Use ▪ Determine critical areas ▪ Casting Schedule	▪ Duration for 1 Cycle ▪ Quantity Review for 1 Cycle ▪ Below & Upper Floor	▪ Subcontractor's Feedback ▪ Practical Site Issues ▪ Temp. Work & Equipment's

Sample Images

Master Planning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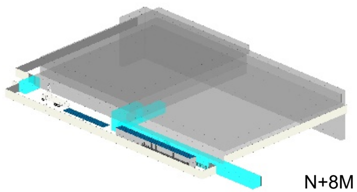
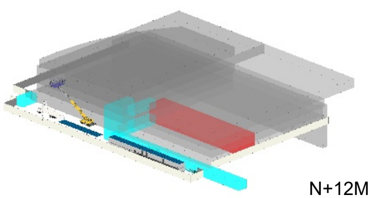

N+8M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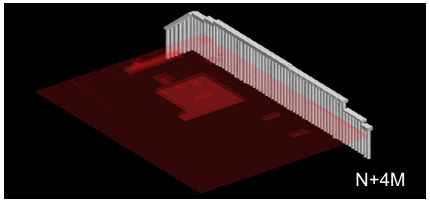
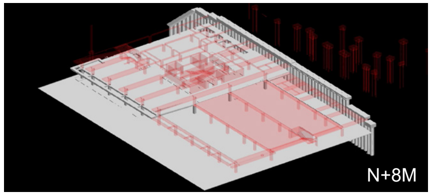
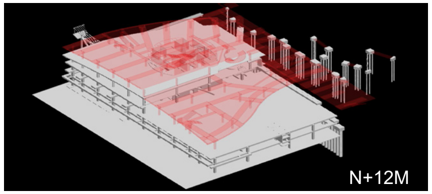
Phase Planning

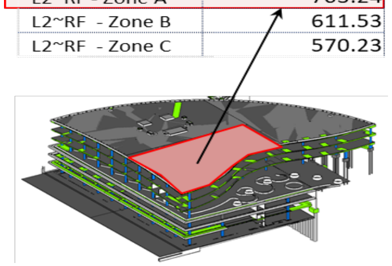




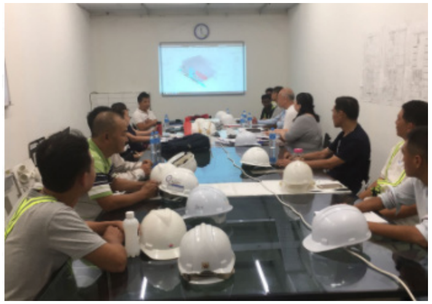


Work Cycle Review

Zone & Level	Conc' (m3) - Target *
B4~B3 - Zone A	761.58
B4~B3 - Zone B	680.18
B3~B2 - Zone A	412.41
B3~B2 - Zone B	820.3
B2~B1 - Zone A	1622.1
B2~B1 - Zone B	929.64
B1~L1 - Zone A	818.1
B1~L1 - Zone B	612.35
B1~L1 - Zone C	677.97
L1~L2 - Zone A	796.43
L1~L2 - Zone B	606.63
L1~L2 - Zone C	586.4
L2~RF - Zone A	703.24
L2~RF - Zone B	611.53
L2~RF - Zone C	570.23



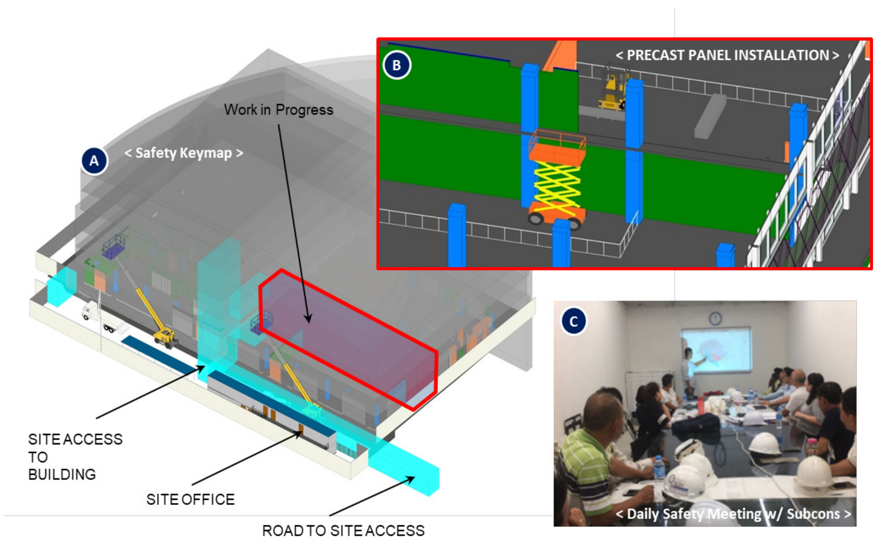
Weekly Work Planning

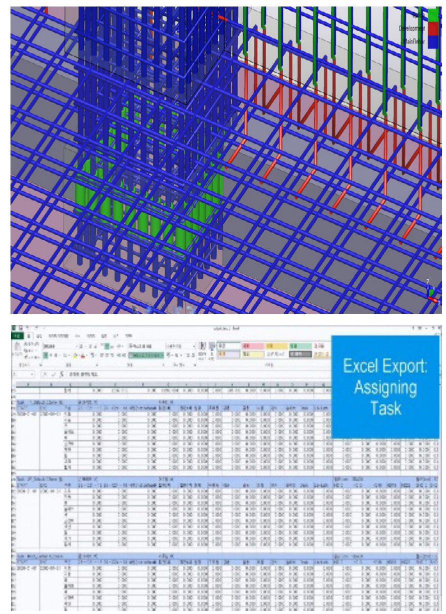


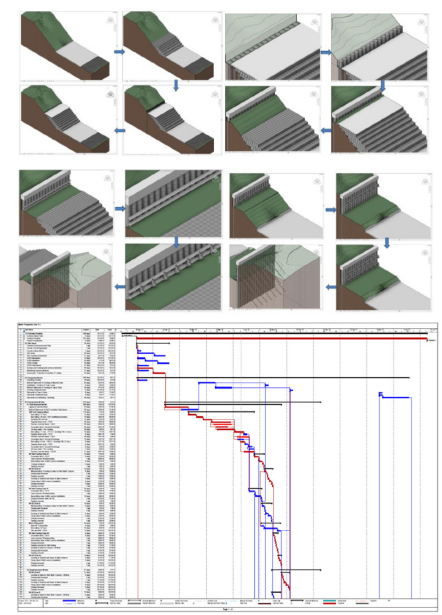
Integration of BIM & Production Planning / Scheduling

Steps	Method Confirmation	Site Meetings	Review of Process Mapping	Documentation (Sign-off master schedule)
Frequency	Week	Day	Day	Daily Tracking Sheet
BIM	Model all components of the proposed methodology to an appropriate level of detail required for planning and reviews.		Elements that are used as basis for resource planning and materials take-off are modelled to data extraction.	In certain areas or activities, the model may be sequenced to show daily (or within a day's) work.
Sample Images	see below	see below	see below	see below
Review Items	▪ Temp Work such as Scaffolding & Support, Access, T/C M/C	▪ Daily Work Coordination ▪ Set up Full Process Mapping	▪ Detailed Review and Update Schedule	▪ Documentation & sign off ▪ Update (if necessary)

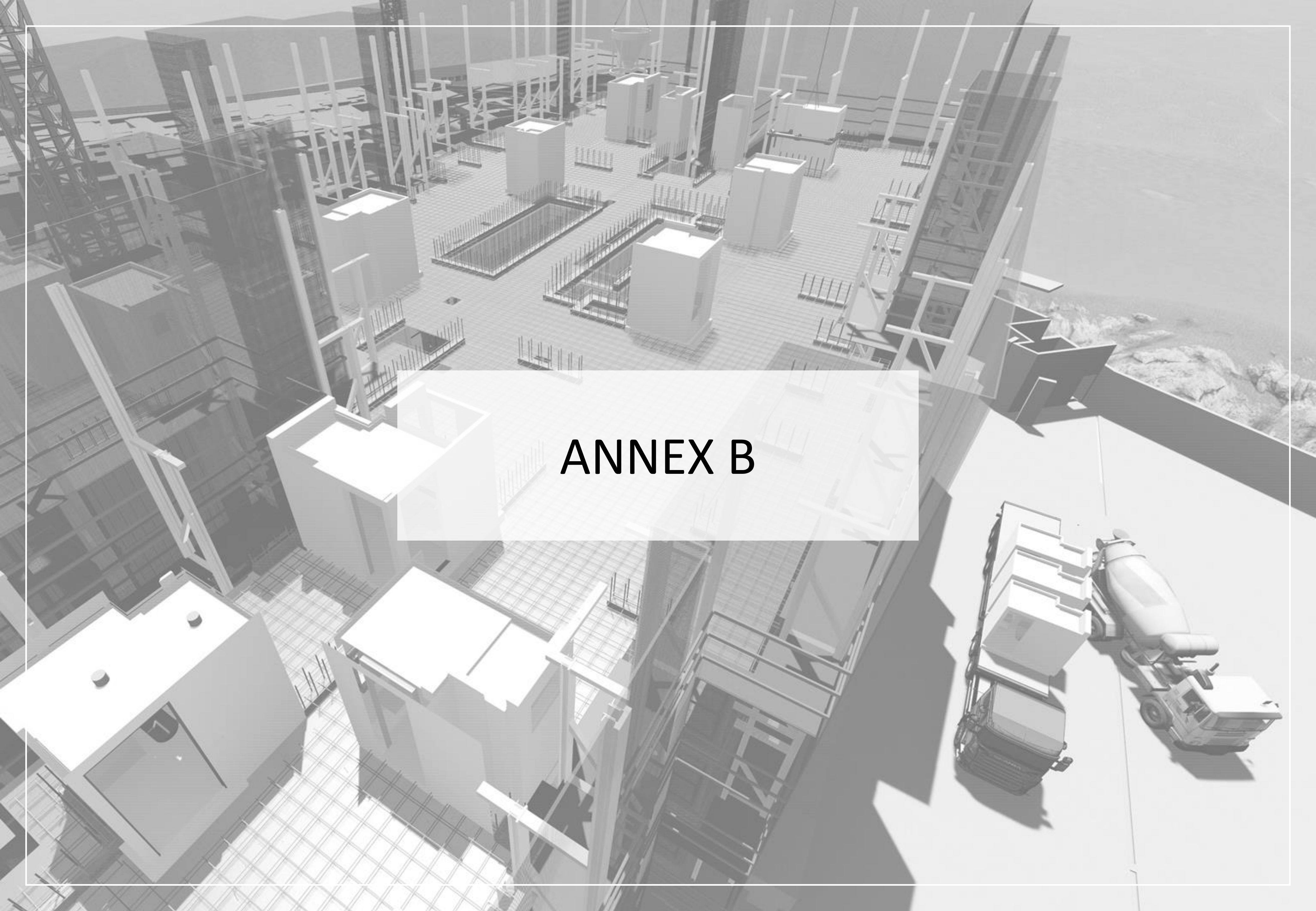
Sample Images







ANNEX B



ARCHITECTURAL REQUIREMENTS

1 GENERAL

This section describes the approach to modelling and communication of tender information for each package listed below:

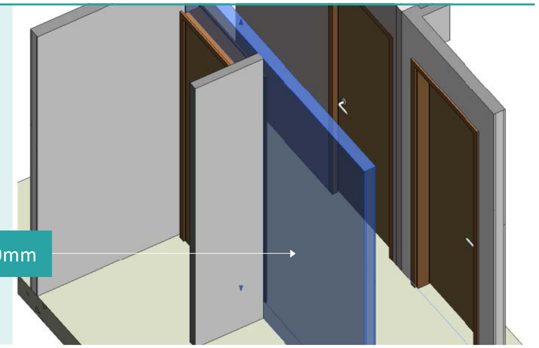
Walls

Walls shall be distinguished between WALL STRUCTURE and WALL FINISH.

WALL STRUCTURE

Main Reference:
Modelled element

Internal Dry Partition Wall - 100mm



a. Wall Structure

The WALL STRUCTURE information, including the partition type and wall mark, shall be taken from the wall element itself as part of its core information.

Ideall, only Non-Structural walls must be modelled inside of the Architectural Model. Structural Walls are to be modelled only inside of the Structural Model and shall be linked into the Architectural Model as a reference. If in the case where Structural Walls need to be modelled inside of the Architectural Model for coordination purposes, they must be indicated clearly and correctly as Structural.

b. Wall Finish

The WALL FINISH may be taken from either the room data, modelled wall finishes, or the 2D blow up room details, in that order.

The main reference for wall finishes is the ROOM DATA (See item 1.4 on Finishes), and this shall be the minimum information requirement for purposes of QTO. However, depending on the scope of work defined in the BEP, the project team may opt to model all wall finishes separately from the core. In this case, the modelled wall finish shall serve as the main reference for QTO, and all necessary core information must be embedded in the wall finish element and scheduled.

<Room Schedule>

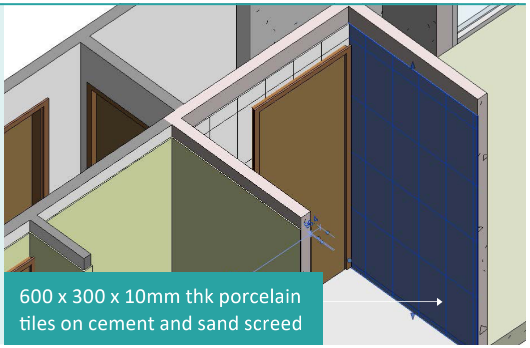
A	B
Name	Wall Finish
BEDROOM 2	
MASTER BATH	600 x 300 x 10mm thick porcelein/ homogenous tiles in polished with approved on cement and sand
MASTER BATH	600 x 300 x 10mm thick porcelein/ homogenous tiles in polished with approved on cement and sand
MASTER BATH	600 x 300 x 10mm thick porcelein/ homogenous tiles in polished with approved on cement and sand
MASTER BATH	600 x 300 x 10mm thick porcelein/ homogenous tiles in polished with approved on cement and sand
MASTER BATH	600 x 300 x 10mm thick porcelein/ homogenous tiles in polished with approved on cement and sand
MASTER BATH	600 x 300 x 10mm thick porcelein/ homogenous tiles in polished with approved on cement and sand
MASTER BATH	600 x 300 x 10mm thick porcelein/ homogenous tiles in polished with approved on cement and sand
MASTER BEDROOM	Skim coat plaster 5mm thick with 3 coats emulsion paint to wall
MASTER BEDROOM	Skim coat plaster 5mm thick with 3 coats emulsion paint to wall
MASTER BEDROOM	Skim coat plaster 5mm thick with 3 coats emulsion paint to wall
MASTER BEDROOM	Skim coat plaster 5mm thick with 3 coats emulsion paint to wall
MASTER BEDROOM	Skim coat plaster 5mm thick with 3 coats emulsion paint to wall
MASTER BEDROOM	Skim coat plaster 5mm thick with 3 coats emulsion paint to wall
MASTER BEDROOM	Skim coat plaster 5mm thick with 3 coats emulsion paint to wall

WALL FINISH

1st Reference:
Wall finish as Core Information inside of Room Data

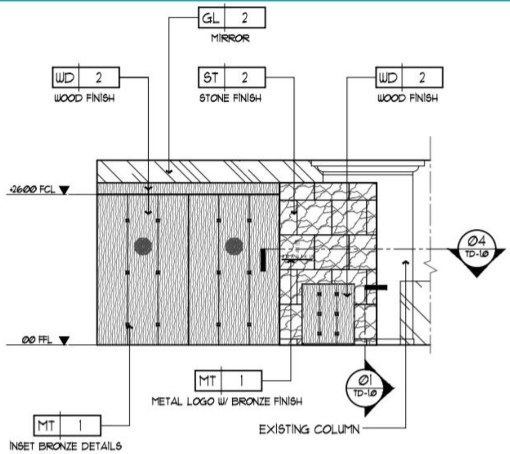
WALL FINISH

2nd Reference:
Wall finish as modelled element, finishes modelled separately from core



WALL FINISH

3rd Reference:
Wall finish found in 2D blow up room details



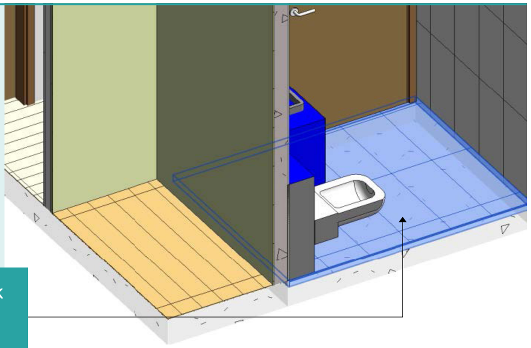
Floor

Floors shall pertain only to FLOOR FINISHES, and only the FLOOR FINISH shall be modelled in the Architectural Model. The FLOOR SLAB must be modelled inside of the Structural Model alone.

Floor finish information is found both in the room data as well as the floor object itself, as part of its core information. Both sources of information must be consistent with each other.

FLOOR FINISH

Main Reference:
Floor finish as modelled element



600mm x 600mm x 100mm thick porcelain / homogenous tiles in polished finish

<Room Schedule>

A	B
Name	Floor Finish
BEDROOM 2	
MASTER BATH	600mm x 600 mm x 100 mm thick porcelain/ homogenous tiles in polished finish
MASTER BATH	600mm x 600 mm x 100 mm thick porcelain/ homogenous tiles in polished finish
MASTER BATH	600mm x 600 mm x 100 mm thick porcelain/ homogenous tiles in polished finish
MASTER BATH	600mm x 600 mm x 100 mm thick porcelain/ homogenous tiles in polished finish
MASTER BATH	600mm x 600 mm x 100 mm thick porcelain/ homogenous tiles in polished finish
MASTER BATH	600mm x 600 mm x 100 mm thick porcelain/ homogenous tiles in polished finish
MASTER BATH	600mm x 600 mm x 100 mm thick porcelain/ homogenous tiles in polished finish
MASTER BEDROOM	Selected laminated timber floor at min. 1216mm x 196mm x 8mm thivk w/ compl
MASTER BEDROOM	Selected laminated timber floor at min. 1216mm x 196mm x 8mm thivk w/ compl
MASTER BEDROOM	Selected laminated timber floor at min. 1216mm x 196mm x 8mm thivk w/ compl
MASTER BEDROOM	Selected laminated timber floor at min. 1216mm x 196mm x 8mm thivk w/ compl
MASTER BEDROOM	Selected laminated timber floor at min. 1216mm x 196mm x 8mm thivk w/ compl
MASTER BEDROOM	Selected laminated timber floor at min. 1216mm x 196mm x 8mm thivk w/ compl
MASTER BEDROOM	Selected laminated timber floor at min. 1216mm x 196mm x 8mm thivk w/ compl

FLOOR FINISH

Main Reference:
Floor finish as Core Information inside of Room Data

Ceiling

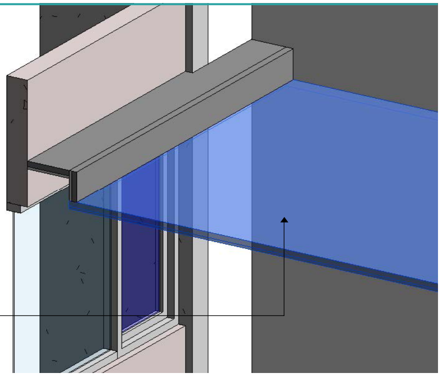
Ceiling, for purpose of definition, shall refer to FALSE CEILING, and not structural slab soffits.

All horizontal components of the ceiling, i.e. the flat ceiling, must be modelled so that area can be measured from there.

The vertical component of the ceiling, or ceiling details such as recesses, coves, etc. which are usually measured by length, need also be modelled for ease of quantity takeoff, coordination, and visualization.

CEILING

Main Reference: Ceiling, including all ceiling details, as modelled element.



Finishes

Finishes include floor, wall, ceiling, and skirting

The main reference for finish information is Room Data. All Rooms shall include a Room Finish Key as part of its core information and this Key shall tie back to a Schedule of Room Finishes. The purpose of a Room Finish Key is to group rooms with the same finishes, such as “All Master Bedrooms” or “All T&B”.

For rooms with multiple finishes or have Interior Design details, the main reference shall be the finishes as modelled elements, or ID Detailed Drawings. The finishes model may or may not be a separate model, but it shall contain modelled finishes such as wall finishes and skirting on top of the base model.

<Room Schedule>

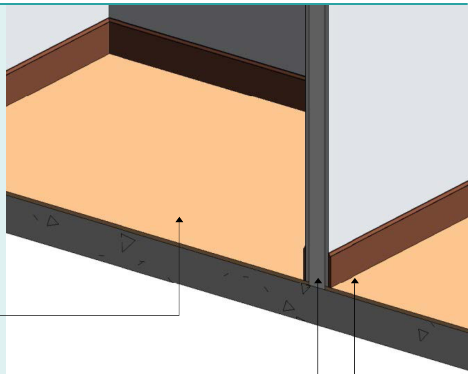
A	B	C	D	E
Name	Floor Finish	Wall Finish	Ceiling Finish	Skirting Finish
BEDROOM 2				
MASTER BATH	600mm x 600 mm x 100 mm thick porcelain/ homogenous	600 x 300 x 10mm thick porcelein/ homogenous	9mm thick moisture resistant calcium silicateceiling	N.A
MASTER BATH	600mm x 600 mm x 100 mm thick porcelain/ homogenous	600 x 300 x 10mm thick porcelein/ homogenous	9mm thick moisture resistant calcium silicateceiling	N.A
MASTER BATH	600mm x 600 mm x 100 mm thick porcelain/ homogenous	600 x 300 x 10mm thick porcelein/ homogenous	9mm thick moisture resistant calcium silicateceiling	N.A
MASTER BATH	600mm x 600 mm x 100 mm thick porcelain/ homogenous	600 x 300 x 10mm thick porcelein/ homogenous	9mm thick moisture resistant calcium silicateceiling	N.A
MASTER BATH	600mm x 600 mm x 100 mm thick porcelain/ homogenous	600 x 300 x 10mm thick porcelein/ homogenous	9mm thick moisture resistant calcium silicateceiling	N.A
MASTER BATH	600mm x 600 mm x 100 mm thick porcelain/ homogenous	600 x 300 x 10mm thick porcelein/ homogenous	9mm thick moisture resistant calcium silicateceiling	N.A
MASTER BATH	600mm x 600 mm x 100 mm thick porcelain/ homogenous	600 x 300 x 10mm thick porcelein/ homogenous	9mm thick moisture resistant calcium silicateceiling	N.A
MASTER BEDROOM	Selected laminated timber floor at min. 1216mm x 196mm	Skim coat plaster 5mm thick with 3 coats emulsi	Skim coat plaster 5mm thick with 3 coats emulsion p	
MASTER BEDROOM	Selected laminated timber floor at min. 1216mm x 196mm	Skim coat plaster 5mm thick with 3 coats emulsi	Skim coat plaster 5mm thick with 3 coats emulsion p	
MASTER BEDROOM	Selected laminated timber floor at min. 1216mm x 196mm	Skim coat plaster 5mm thick with 3 coats emulsi	Skim coat plaster 5mm thick with 3 coats emulsion p	
MASTER BEDROOM	Selected laminated timber floor at min. 1216mm x 196mm	Skim coat plaster 5mm thick with 3 coats emulsi	Skim coat plaster 5mm thick with 3 coats emulsion p	
MASTER BEDROOM	Selected laminated timber floor at min. 1216mm x 196mm	Skim coat plaster 5mm thick with 3 coats emulsi	Skim coat plaster 5mm thick with 3 coats emulsion p	
MASTER BEDROOM	Selected laminated timber floor at min. 1216mm x 196mm	Skim coat plaster 5mm thick with 3 coats emulsi	Skim coat plaster 5mm thick with 3 coats emulsion p	
MASTER BEDROOM	Selected laminated timber floor at min. 1216mm x 196mm	Skim coat plaster 5mm thick with 3 coats emulsi	Skim coat plaster 5mm thick with 3 coats emulsion p	

FINISHES

Main Reference:
Floor Finish, Wall Finish, Ceiling Finish, Skirting as Core Information inside of Room Data

FINISHES

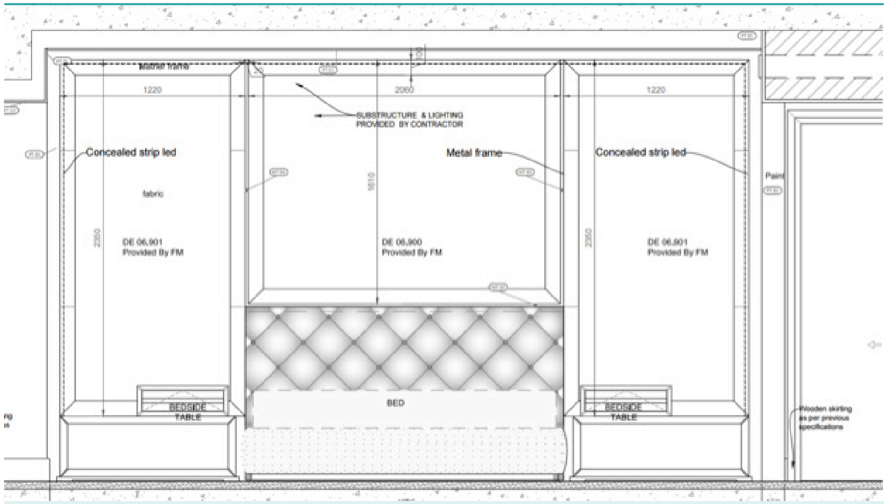
2nd Reference:
Floor Finish, Wall Finish, Skirting as modelled elements



Selected laminate timber floor

Skim coat plaster 5mm thick with 3 coats emulsion paint to wall

Selected laminate timber skirting



FINISHES

3rd Reference:
Floor Finish, Wall Finish, Skirting, and Ceiling Finish found in 2D blow up room details

Doors

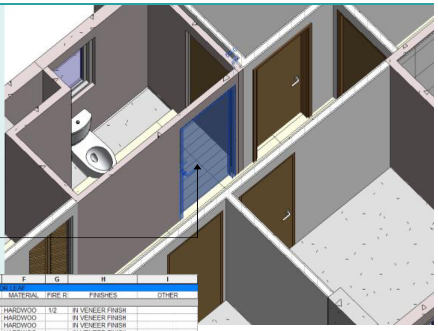
To prevent discrepancies between the 3D model and door schedules that have been generated separately from the model, each door must be embedded with the information that typically constitute door schedules. Door schedules must therefore be extracted from the model itself, calling out this same embedded information.

Windows

Similar to doors, windows must be embedded with the information that typically constitutes window schedules. Window schedules must therefore be extracted from the model itself, calling out this same embedded information.

DOORS

Main Reference:
Doors as modelled element.

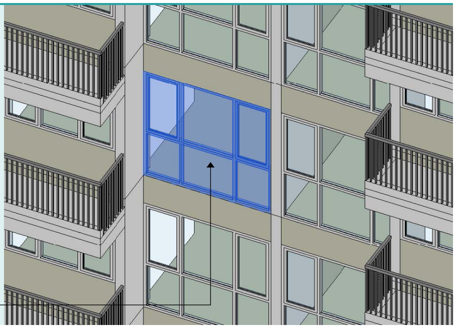


D10: Single leaf timber swing door

A	B	C	D	E	F	G	H	I
			DOOR LEAF					
COUNT	ID	Location	TYPE	DOOR WIDTH	MATERIAL	FIRE R	FINISHES	OTHER
1	D1	MAIN ENTRANCE DOOR	DOUBLE LEAF TIMBER SWING DOOR	1400	HARDWOO	1/2	IN VENEER FINISH	
1	D2	BATHROOM	SINGLE LEAF TIMBER SWING DOOR	1000	HARDWOO		IN VENEER FINISH	
5	D3	MASTER BEDROON, COMMON BEDROOM &	SINGLE LEAF TIMBER SWING DOOR	900	HARDWOO		IN VENEER FINISH	
1	D4A	COMMON BEDROOM & BATHROOM	SINGLE LEAF TIMBER SWING DOOR	800	HARDWOO		IN VENEER FINISH	
1	D5C	KITCHEN	DOUBLE LEAF TIMBER SLIDING DOOR	800	HARDWOO		IN VENEER FINISH	
1	D7A	TOILET	SLIDE & FOLD PD DOOR	650	PVC		SELCTED COLOR	
1	D7B	STORAGE ROOM	SLIDE &FOLD TIMBER DOOR W/ LOUVRE	700	HARDWOO		SELECTED TINT	
1	SD7-1	LIVING ROOM	TRIPPLE LEAF SLIDING GLASS	2700	GLASS		SELECTED TINT	
1	SD9	MASTER BEDROOM	DOUBLE SLIDING GLASS DOOR	1850	GLASS		SELECTED TINT	
13								

WINDOWS:

Main Reference:
Windows as modelled element.



W2-2: 2 Panel Casement Fixed Aluminum: 1000 x 1350

CO	ID	UNIT TYPE	LOCATION	GLASS MATERIAL	Family and Type	Width	Height
2							
1	W2-2	4C1, 4C1a	COMMON BEDROOM	Float glass (6mm thk in sele	2 Panel-Casement-Fixed-Aluminum: 2450 x 1	2450	1750
1	W2-4	3C1-a, 3D1, 4C1, 4C1a	COMMON BEDROOM	Float glass (6mm thk in sele	2 Panel-Casement-Fixed-Aluminum: 2550 x 1	2550	1750
1	W26-1	3D1, 4C1a	KITCHEN	Float glass (6mm thk in sele	2 Panel-Casement-Aluminum: 1000 x 1350m	1000	1350
1	W33	4C1, 4C1a	MASTER BEDROOM	Float glass (6mm thk in sele	1 Panel-Casement-Aluminum: 700 x 1350mm	700	1350
1	W54-1	3D1, 4C1, 4C1a	TOILET	Float glass (6mm thk in sele	1 Panel-Top Hung-Aluminum: 600 x 650mm	600	650
1	W54-2	3C1-a, 3D1, 4C1, 4C1a	BATHROOM	Float glass (6mm thk in sele	1 Panel-Top Hung-Aluminum: 750 x 650-1m	750	650
1	W56-1	4C1, 4C1a	BATHROOM	Float glass (6mm thk in sele	1 Panel-Casement-Aluminum: 750 x 1225mm	700	1225
9							

Ironmongery

Ironmongery need not be physically modelled. A door's Ironmongery Set may be defined as a parameter to be embedded inside of the Door Element. A separate Ironmongery Schedule shall itemize and describe each Ironmongery Set.

	LOCATION	DOOR LEAF	DOOR TYPE	FIRE RATING	S/S 2BB 127x89x3MM THICK HINGES	SASHLOCKSET C/W S/S STRIKE PLATE/STRIKE BOX	DEADBOLT LOCK C/W S/S STRIKE PLATE/STRIKE BOX	PASSAGE LATCHSET C/W S/S STRIKE PLATE/STRIKE BOX	REBATED COMPONENT	THUMBTURN CYLINDER	PRIVACY THUMBTURN CYLINDER	DOUBLE CYLINDER	MK48 / KEYALIKE / MASTERKEY	S/S "C.D.L" DESIGN LEVER HANDLE C/W ESCUTCHEON	S/S "H" PULL HANDLE, 600MM	DOOR CLOSER HS 1800 (SIZE 3)	HS 3000 CONCEALED OVERHEAD DOOR CLOSER (SIZE 3)	S/C DOOR STOPPER (FLOOR MOUNTED)	S/S DOOR STOPPER (WALL MOUNTED)	BOXED TYPE FLUSH BOLT 200/300MM	S/S DUST PROOF SOCKET W/ REMOVABLE COVER
					A1	B1	B2	B3	B11	C1	C2	C4	C5	D3	D4	E3	E5	G2	G3	H1	H4
					HINGE	LOCKCASES				CYLINDERS				HANDLES		CLOSERS		STOPPER		FLUSHBOLT	
FD1	OFFICE, STORE, WIFI	SL	T	1	3			1						1		1		1			
FD2	ALL STAIRCASES	SL	T	1	3			1						1		1		1			
FD3	OFFICE, STORE, WIFI	SL	T	1	3			1						1		1		1			
FD4	ALL SERVICE DUCTS (ELECT, ELV, TEL, WATER)	DL	T	1	6			1	1					1		1		2		1	1
FD5	BMS, CSR ROOM	DL	T	2	6	1			1	1			1	1		2		2		1	1
FD5A	SERVICE DUCTS AT BLOCK 81	DL	T	1	6			1	1					1		1		2		1	1
FD6	MDF ROOM & MDS ROOM AT BLOCK 77	DL	T	0.5	6	1			1	1			1	1		2		2		1	1
FD7	ESS SWITCHROOM (CABLE CHAMBER)	DL	T	2	6	1			1	1			1	1		2		2		1	1
FD8	ESS SWITCHROOM	DL	T	2	6	1			1	1			1	1		2		2		1	1
FD9	SPRINKLER, PUMP ROOM & TANK ROOM	DL	T	0.5	6	1				1			1	2		2				1	1
MD1	DOUBLE LEAF SOLID METAL DOOR	DL	ALU		8		1		1	1					2		2	2		1	1
TD1	ALL MALE/FEMALE TOILETS	SL	T		3	1					1			1					1		
TD2	ALL HANDICAP TOILETS	SL	T		3	1					1			1					1		

IRONMONGERY:

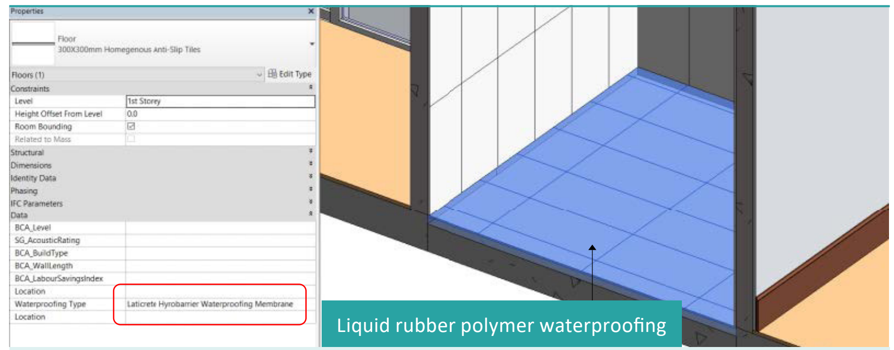
Main Reference:
Ironmongery Set as part of Door Core Information

Waterproofing

Waterproofing need not be physically modelled. Waterproofing information may be found primarily in Floor Data, as this is usually tied to room / area type and type of floor finish.

The Secondary reference of waterproofing information are Waterproofing Plans, which may be area plans particularly for common areas where rooms are not defined.

Another reference is Room Data, since some rooms by nature need to be waterproofed, such as toilets.

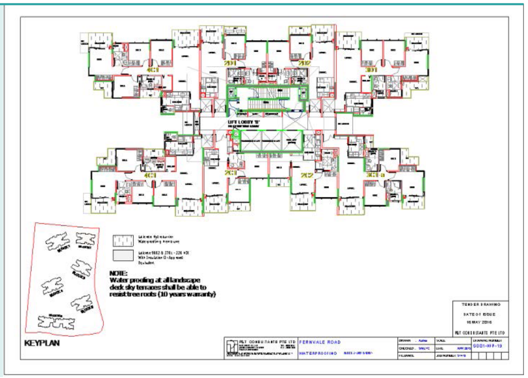


WATERPROOFING:

Main Reference:
Waterproofing as Core Information inside of Floor Data (same is applicable for modelled wall finishes)

WATERPROOFING:

2nd Reference:
Waterproofing found in 2D Waterproofing Plans



A	B
Name	Waterproofing
MASTER BATH	Liquid rubber polymer waterproofing
MASTER BEDROOM	N.A.
T-01	

WATERPROOFING:

3rd Reference:
Waterproofing as Core Information inside of Room Data

Cabinetry, Appliances, Fixtures, Furniture

For Cabinetry, Appliances, Fixtures, and Furniture, modelling a PLACEHOLDER is sufficient so long the location and counts are correct as well as embedded core information.

Owner Supplied Items that are excluded from the contract need not be modelled.

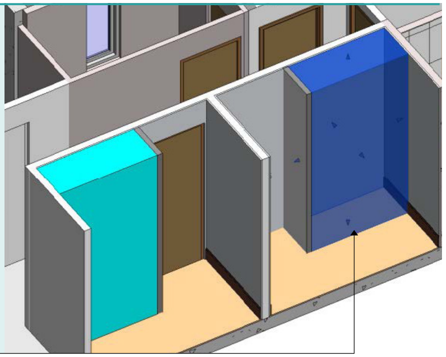
a. Cabinetry, appliances and furniture

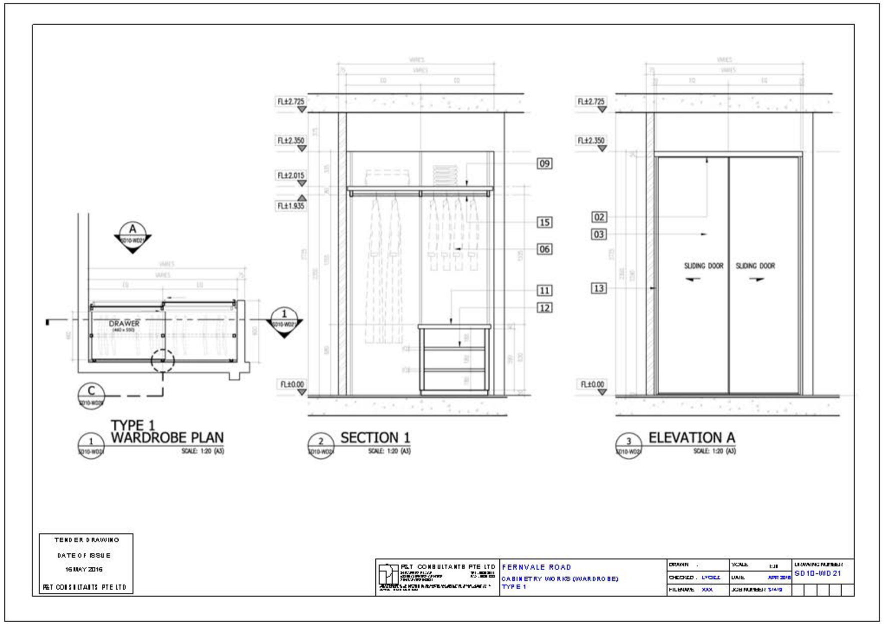
Items such as wardrobes, stoves, cabinets, etc. need not be modelled in detail, but may be represented through a simple volume of the design-intent overall dimension for coordination purposes, which must be consistent with that of 2D details.

CABINETRY

Main Reference:
Cabinetry modelled as simple object with core info and of correct overall dimensions and detailed in 2D drawings.

TYPE 1 Wardrobe





b. Fixtures

Fixtures refer to PLUMBING & LIGHTING FIXTURES such as sinks, water closets, showers, etc.

If the plumbing fixture model is known, model the MEP connector to its correct location, especially for wall hung water closets. If not, model as a simple object of approximate overall dimensions.

For lighting fixtures, refer to MEP Requirements in this guide for required core information and modelling convention.

Roof

For all types of roofs or roof designs, whether roof deck / flat roof or pitched roof, model all of the major components of the roof to design intent dimensions.

Exclusions

The following packages need not be referenced primarily from the model for the purpose of quantity take-off and costing. The main reference may be 2D drawings.

- Drainage
- Irrigation
- Landscape
- External works
- Water features
- Interior design works

2 MODELLING REQUIREMENTS AND CORE INFORMATION FOR ARCHITECTURAL ELEMENTS

The Core information listed below are minimum information required for Tender purposes. Items in gray are Core Information over and above Architectural e-Submission requirements.

ELEMENT	MODELLING REQUIREMENT	CORE INFORMATION	REMARKS
CEILING	• Define the Ceiling "Type" clearly • Make sure to model flat ceilings for areas and perimeters to be extracted from the model. • Model coves, recesses, bulk head, drops, etc. to design-intent dimension • Model Access Panels • Model complex ceilings such as curvilinear ceilings to exact geometry	Name / Type	
		Level	
		Ceiling Mark	
COLUMN (ARCHITECTURAL)	• If the column is a structural column with an architectural cladding, model the cladding finish as Wall • If the column is a non-structural false column, model it as an architectural column.	Name / Type	
		Base Level	
		Top Level	
		Build Type	
		Labour Savings Index	

ELEMENT	MODELLING REQUIREMENT	CORE INFORMATION	REMARKS
DOOR	• Define the door type clearly. Ensure that locations and counts are correct per type. • Do not over model. Ensure that overall door size is correct. Door details may refer to 2D typical details. • Door shall be coordinated with structural openings if it is in Structural Wall • Ironmongrey shall be indicated as core information in schedule and do not need to be modelled • Model roller shutter doors to design-intent size, including the box up. • Location shall be with regards to the from room or to room	Name / Type	
		Dimensions	
		Level	
		Door Mark	
		Door Description	
		Location	
		Door Leaf_Type	
		Door Leaf_Thickness	
		Door Leaf_Material	
		Door Leaf_Fire Rating	
		Door Leaf_Finishes	
		Door Frame_Type	
		Door Frame_Material	
		Door Frame_Finishes	
		Acoustic Rating	
		Ironmongery Set	
FLOOR / SLAB	• Model floor finish only which must be separate from and not overlapping with structural slab. • The structural slab must be modelled in the Structural Model and its visibility turned off in the Architectural model when linked • Model to exact design-intent FFL including all drops in levels	Name / Type	Finish material
		Thickness	
		Level	
		Waterproofing type	

ELEMENT	MODELLING REQUIREMENT	CORE INFORMATION	REMARKS
PARKING LOT		Name / Type	
		Level	
		Dimension	
		If Accessible	
		Number	
RAMP	• Use the floor element to model ramps if necessary to obtain quantities • Include the finishes and mark the FFL • Ensure the slope is correct as well as the overall size and extents in plan.	Name / Type	
		Thickness	
		Level	
		Slope Gradient	
		Finish Material	Description
RAILING	• Do not over model. Ensure that length/extents of railing are correct, as well as the railing height. Railing details may refer from 2D typical details. • Model balusters to design-intent locations for purpose of coordination and manual counting • Include Height in Type Name. This must be consistent with actual railing height • Model parapets as walls	Name / Type	Also indicate height
		Height	
		Level	
		Mark	
ROOF	• For flat roofs, only the roof finish i.e. screed must be modelled in the architectural model. The roof slab must be modelled in the structural model. Ensure both finish and slab are aligned and not overlapping. • For pitched roofs, mark the top of roof and slopes • Model drains scuppers to exact length and extents. Model downspouts to exact locations • Do not over model. Roof details may refer to 2D typical details.	Name / Type	
		Level	
		Material	

ELEMENT	MODELLING REQUIREMENT	CORE INFORMATION	REMARKS
ROOM / SPACE	• Make sure that room boundaries are correctly defined and marked as areas of finishes will be extracted from here.	Name	
		Level	
		Mode of Ventilation	
		If Accessible	
		Area	
		Room Finish Key	
		Waterproofing type	
		Floor Finish	
		Wall Finish	
		Skirting Finish	
		Ceiling Finish	
STAIRCASE	• Do not over model. Ensure that the riser and tread numbers and dimensions are correct, as well as the overall extents and profile of stairs. • Stair details may refer to 2D typical details.	Name / Type	
		Level	
		Riser Height	
		Run Width	
		Tread Depth	
		Number of Risers	
		Material	
		Detectable Warning	

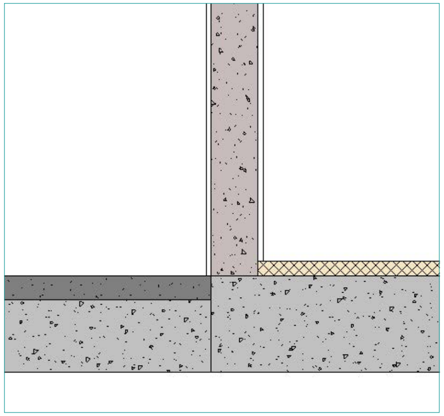
ELEMENT	MODELLING REQUIREMENT	CORE INFORMATION	REMARKS
WALL - CORE	• Make sure that the Wall "TYPE" is well defined • Ensure that overall partition thickness, including finishes, is correct as per design intent. • Model the walls individually for each storey/level • Terminate height of wall at soffit of beam and slab, or to exact design-intent height. • Structural walls must be modelled in the structural model, and linked inside of the architectural model. Structural walls may also be modelled inside of the Architectural model for coordination but must be hidden for handover and filtered out of the schedules.	Name / Type	
		Level	
		Build Type	
		Material	
		Thickness	
		Fire Rating	
		Acoustic Rating	
		Loading / Non-loading	
		Interior / Exterior	
		Wall Mark	
WALL - FINISH	• Make sure that the Wall "TYPE" is well defined as finish code • Model the finish height to design-intent termination. • Model the 100mm (approx.) extension above ceiling if applicable	Name / Type	Finish Code
		Description	Finish description
		Waterproofing	
WINDOW	• Define the window "TYPE" clearly. Ensure that locations and counts are correct per type. • Do not over model. Ensure that overall window size is correct. Window details may refer to 2D typical details. • Window to be coordinated with Structural Openings if it is in Structural Wall	Level	
		Build Type	
		Material	
		Thickness	
		Fire Rating	
		Acoustic Rating	
TOPOGRAPHY		Loading / Non-loading	
		Interior / Exterior	
BOUNDARY LINE		Wall Mark	

ELEMENT	MODELLING REQUIREMENT	CORE INFORMATION	REMARKS
PLANTS / TREES		Name / Type	
		Phase Created	
		Dimension	
		To remove / retain	
FIXTURES, CABINETRY, APPLIANCES, FURNITURE	• Model as simple placeholders or volume/box of the same overall size.	Fixture Type / Code	
		Description / Specification	
		Location	Can be linked unit model file name
		Residential Unit Type	Room name
HOARDING*	Model layout of hoarding using wall or curtain wall tool	Type	Default
	Model gates	Height	Default

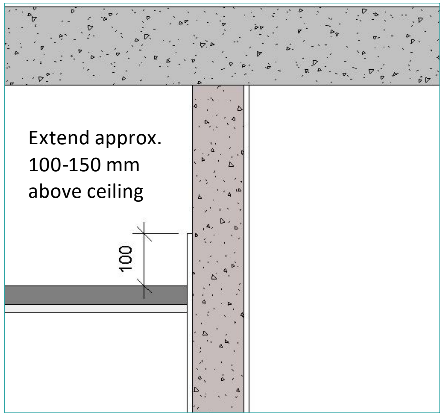
**Optional*

a. Modelled Finish Terminations

WALL TO FLOOR TERMINATION



WALL TO CEILING TERMINATION



4 2D & 3D VIEWS AND SCHEDULES [INFORMATION FORMAT REQUIREMENTS]

Tender Information shall be presented through the following views and schedules that are generated from the model unless otherwise indicated.

2D VIEWS	SCHEDULES	3D VIEWS
• Floor Plans • Blow Up Details • Spot Details / Typical Details • 2D Plans, Elevations, Sections, of other packages in the exclusion list	• Room Schedule • Door Schedule • Window Schedule • Floor and Waterproofing Schedule • Wall Schedule • Ceiling Schedule • Railing Schedule • Finishes Schedule • Plumbing Fixture Schedule • Furniture Schedule* • Cabinetry Schedule* • Appliance Schedule* • Tree Schedule*	• Overall 3D View • 3D Part Views of every floor

**Optional, if included in contract*

a. 2D Views

- Floor Plans

  - General Floor plans and Layout Views such as Reflected Ceiling Plans must be generated from the BIM model.

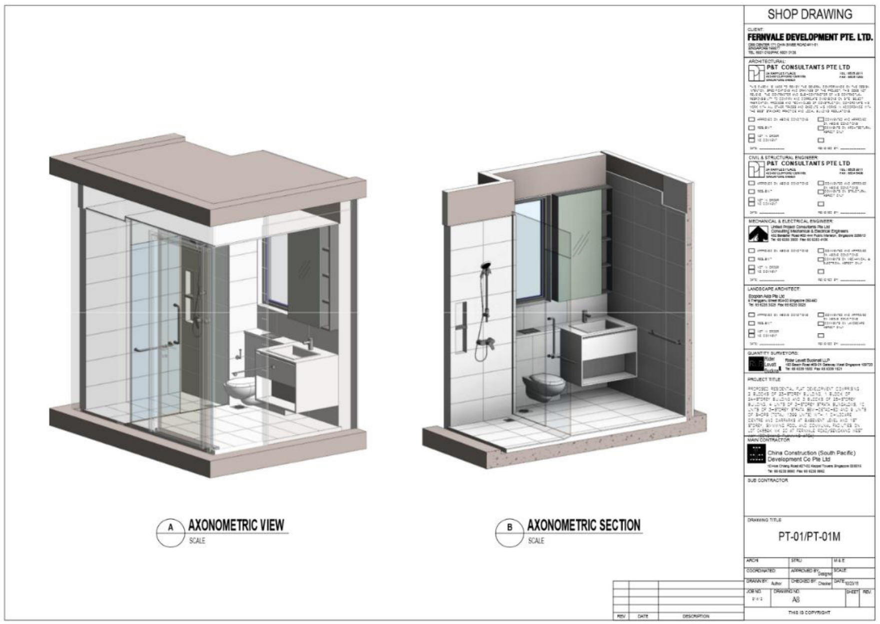
  - Detailed annotation may not be necessary provided core information is correct and complete.

- Blow Up Details

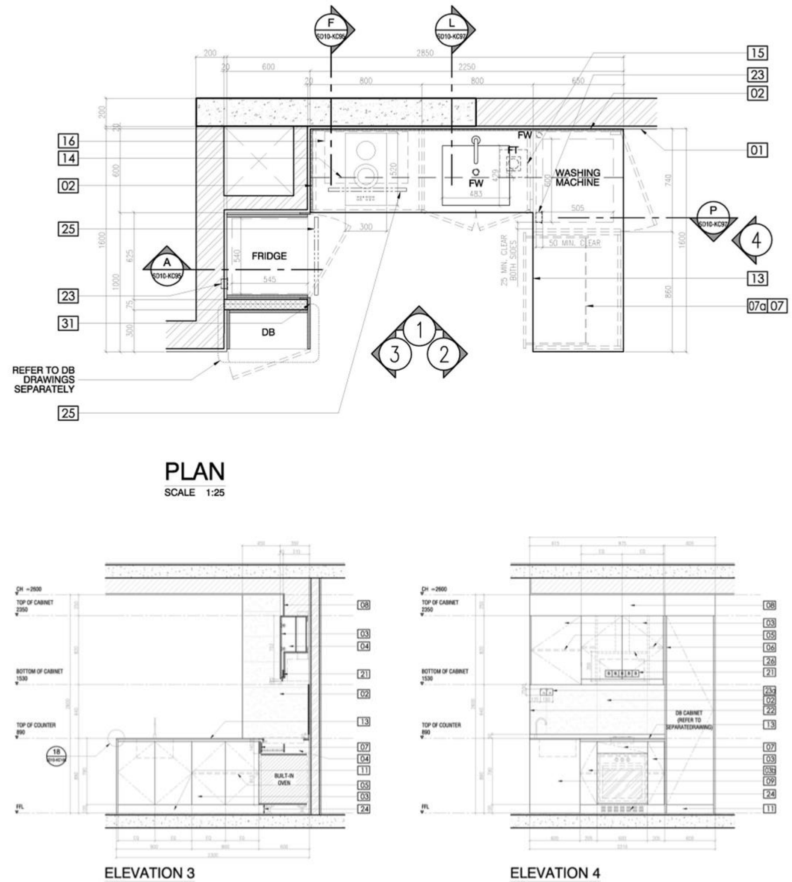
  - Blow up details pertain to details of rooms or areas of the building such as toilets and kitchens. These details are non-typical, and therefore must be produced from the BIM model to avoid inconsistency.

  - Some Blow Up Details need not be required provided the model is reliable enough in terms of element geometry and completeness and correctness of Core Information.

- Toilet Details
  - Toilet Details need not be required if placeholders of bathroom elements such as fixtures, mirrors, accessories, etc. have been modelled in and the core information of these elements are availableand correct, and if all finish information are available and correct.
  - Toilet Details may only be required for toilets with intricate ID or finishes which may not easily be communicated with BIM.

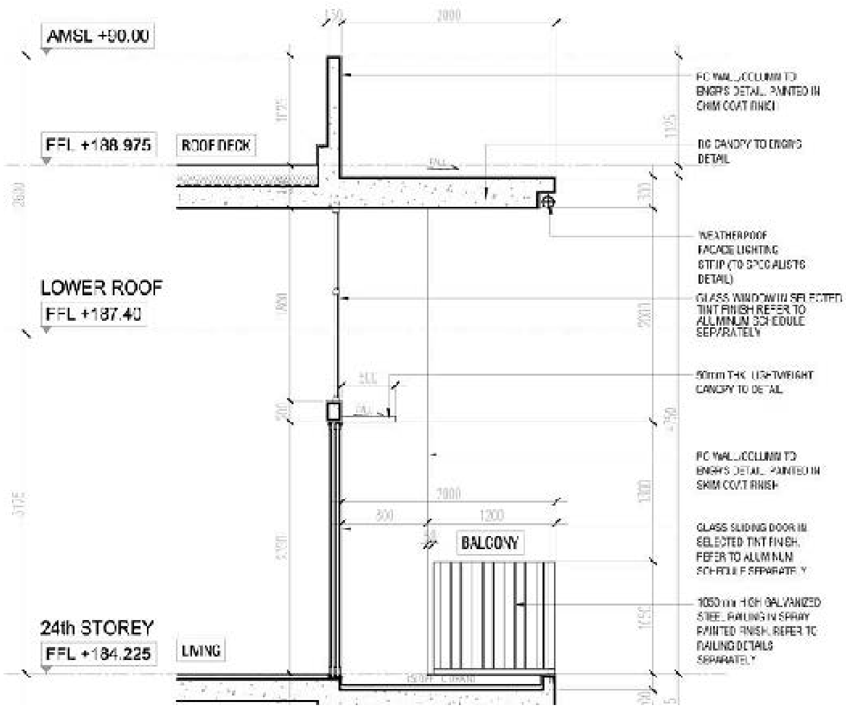


- Kitchen Details
  - Kitchen details still be need to be provided since most of the details are of the cabinetry/casework, which are typically not modelled to fabrication level detail.



- Façade Details

  - Façade blow up details need not be required if major elements have been modelled to correct design-intent geometry and the core information of these elements are available and correct.



- Spot Details / Typical Details

  - Spot Details or Typical Details may be produced as drafting views or CAD details linked into the model. Typical details include but are not limited to:

  - Stair Details
  - Wall Details
  - Roof Details
  - Window Details
  - Door Details
  - Finishes Details
  - Threshold Details
  - Railing Details
  - Lift Car Details
  - Façade Details
  - Waterproofing Details
  - Miscellaneous

- 2D Plans, Layouts, Details of other packages in exclusion list

  - The plans and details of the following packages need not be generated from the BIM model as long as there is consistency between 2D drawings and the 3D model.

  - Drainage
  - Irrigation
  - Landscape
  - External works
  - Water features
  - Interior design works

- Schedules

  The following are the list of schedules that must be extracted from the Architectural BIM model.

a. Room Schedule

- NAME pertains to Room Name
- KEY is a generalized room group that have the same finishes

ROOM SCHEDULE							
NAME	KEY	FLOOR FINISH	WALL FINISH	CEILING FINISH	SKIRTING FINISH	WATER-PROOFING	AREA
MASTER BEDROOM	ALL BEDROOMS	Selected laminated timber floor	Skim coat plaster 5mm thick with 3 coats emulsion paint to wall	Skim coat plaster 5mm thk with 3 coats emulsion paint to soffit	Selected laminated timber skirting	Liquid rubber polymer water proofing	16.4
MASTER BATH	ALL BATHROOMS	600 x 600 x 10mm thk porcelain tiles on cement and sand screed	600 x 300 x 10mm thk porcelain tiles on cement and sand screed	9mm thk moister resistant calcium cilicate ceiling	N.A.	Liquid rubber polymer water proofing	3.5

b. Door Schedule

DOOR SCHEDULE													
DOOR MARK	LOCATION	WIDTH	HGHT.	IRON-MONGERY SET	DOOR LEAF					DOOR FRAME			COUNT
					TYPE	MATERIAL	FIRE RATING	FINISHES	ACOUSTIC RATING	TYPE	MATERIAL	FINISHES	
D10	Lift lobby	1000	2100	C	Single leaf timber swing door	Hard-wood	1/2	Laminate Finish		Timber	Hardwood	Veneer	8
D10A	Smoke Stops Lobby	800	2100	B	Single leaf metal swing door	Metal	½	Selected Paint Color		Metal	Metal	Selected Paint Color	2

c. Window Schedule

- TYPE must be indicated in the Object Name + Type Name. Type Name may be the window size

WINDOW SCHEDULE						
WINDOW MARK	TYPE	WIDTH	HEIGHT	UNIT TYPE	LOCATION	COUNT
W2-2	2 Panel Casement Fixed Aluminum: 1000 x 1350	1000	1350	4C1, 4C1a	Common Bedroom	23

d. Floor & Waterproofing Schedule

- TYPE of floor finish is indicated in the Type Name Floor and Waterproofing Schedule

FLOOR AND WATERPROOFING SCHEDULE			
FLOOR MARK	TYPE	WATERPROOFING TYPE	AREA
F2	600 x 600 x 10mm thk porcelain tiles on cement and sand screed	Liquid rubber polymer waterproofing	3513

e. Wall Schedule

- TYPE must include partition type / build type and thickness. Thickness must be consistent with actual geometry thickness

WALL SCHEDULE							
TYPE MARK	TYPE	WIDTH	LENGTH	FIRE RATING	ACOUSTIC RATING	AREA	STRUCTURAL
W1	ABC-Precast Concrete Panel / Wall with Skim Coat – 100mm	100	5,465	2 HRS		18.56	Y
W2	ABC-Internal Dry Partition Wall – 100 mm	100	2,465	½ HRS		235.65	N

f. Ceiling Schedule

CEILING SCHEDULE				
CEILING MARK	TYPE	WIDTH	PERIMETER	HEIGHT OFFSET FROM LEVEL
W1	12.5mm moisture resistance mineral fibre board	5315	3254	2400

g. Railing Schedule

RAILING SCHEDULE			
MARK	TYPE	HEIGHT	LENGTH
R03	AC Ledge Railing 1225 mm	1225 mm	4532

** Refer to 2D details for details of materials, balustrades, etc.*
** Railings modelled as walls may be scheduled as walls, but must show the same information as above*

h. Finishes

- Finishes are scheduled from Rooms
- KEY is a generalized room group that have the same finishes

SCHEDULE OF FINISHES				
KEY	FLOORING	WALL	CEILING	SKIRTING
All Bedrooms	Selected laminated timber floor	Skim coat plaster 5mm thick with 3 coats emulsion paint to wall	Skim coat plaster 5mm thk with 3 coats emulsion paint to soffit	Selected laminated timber skirting
All Bathrooms	600 x 600 x 10mm thk porcelain tiles on cement and sand screed	600 x 300 x 10mm thk porcelain tiles on cement and sand screed	9mm thk moister resistant calcium cilicate ceiling	N.A.

i. Fixture, Appliance, Furniture, Cabinetry Schedule

PLUMBING FIXTURE SCHEDULE			
MARK	DESCRIPTION	LOCATION	COUNT
SF01	Teramo Wall Hung WC Ceramic- White	Master Bath	13

APPLIANCE SCHEDULE				
CODE	TYPE	LOCATION	DESCRIPTION	COUNT
KA07	77cm gas hob	4-bedroom unit	Model: AKC830C/BLS-8	16

FURNITURE SCHEDULE				
CODE	TYPE	LOCATION	DESCRIPTION	COUNT
WS-01	Storage System	3-bedroom unit	Allsteel Align Storage	12

CABINETRY SCHEDULE				
CODE	TYPE	LOCATION	DESCRIPTION	COUNT
1S1-P	TYPE 1 900 x 300	Penthouse		4

STRUCTURAL REQUIREMENTS

1 GENERAL REQUIREMENTS

This section describes the approach to the communication of tender information for structural works which typically consist of the following:

Concrete Works

Concrete works pertain to all structural concrete elements such as foundations, beams, columns, and slabs, which typically constitute the biggest bulk of the structural package.

a. Though concrete is measured in volume, the method of measurement for different structural elements may not be the same, and so it is important that these elements are modelled correctly so as to generate the correct measurement.

b. Following the modelling requirement for each element, ensure that the overall geometry and core information is correct.

Rebar

Rebar need not be fully modelled. Rebar information may be provided through the following options: (1) Rebar Schedules (2) Hybrid and (3) 3D Rebar. See CoP on Structural e-Submission Requirements for details.

b. For OPTION 1 and 3: actual rebar take-off may be possible

c. For OPTION 2: contractors may refer to Eurocodes minimum and maximum range for rebar ratio

Formworks

Formworks are not modelled, but quantities may be inferred from the model geometry.

2 MODELLING REQUIREMENTS AND CORE INFORMATION FOR STRUCTURAL ELEMENTS

The Core information listed below are minimum information required for Tender purposes.

Items in gray are elements and core information over and above regulatory submission requirement.

2.1 Sub Structure

ELEMENT	MODELLING REQUIREMENT	CORE INFOMRATION	REMARKS
Piles	• For single piles: model the piles separately from the pile cap • For pile groups, the • Model the piles for design intent depth subject to verification of soil conditions. (Normally engineers require contractors to adjust pile length to anchor to hard strata with an embedment of 1-2m)	Pile Mark	
		Pile Type	
		Pile Diameter / Size	
		Pile X-Easting	
		Pile Y-Northing	
		Pile As-Built Length (SHD)	
		Pile Cut Off Level (SHD)	
		Pile Toe Level (SHD)	
		Loading (kN)	
		Material Grade	
		Element Classification	
		Remarks/Status	
		Project Title	

ELEMENT	MODELLING REQUIREMENT	CORE INFOMRATION	REMARKS
		Developer	
		Embedment	
		Rebar Ratio*	
Pile Cap	• Foundation shall be modelled to the exact dimension and levels • Model structural foundation wall were necessary	Pile Cap Mark	
		Pile Cap Type	
		Pile Cap Size	
		Pile Cap X-Easting	
		Pile Cap Y-Northing	
		Group Loading (kN)	
		Concrete Grade	
		Element Classification	
		Remarks/Status	
		Project Title	
		Developer	
		Rebar Ratio*	
Substructure Slab	• Model the structural floors at SFL to be coordinated with Architectural FFL • Model slabs as individual elements from beams • Model slab drops as required for coordination	Slab Mark	
		Slab Type	
		Slab Thickness	
		Slab Opening Size	
		Slab Direction	
		Slab X-Easting	
		Slab Y-Northing	

ELEMENT	MODELLING REQUIREMENT	CORE INFOMRATION	REMARKS
		Concrete Grade	
		Element Classification	
		Remarks / Status	
		Rebar Ratio*	
Retaining Wall		Wall Mark	
		Wall Type	
		Wall Thickness	
		Wall Openings Size	
		Wall X-Easting	
		Wall Y-Northing	
		Concrete Grade	
		Element Classification	
		Remarks/Status	
		Rebar Ratio*	
Pier		Pier Mark	
		Pier Type	
		Pier Dimensions	
		Pier X-Easting	
		Pier Y-Northing	
		Concrete Grade	
		Element Classification	
		Remarks/Status	
		Rebar Ratio*	

ELEMENT	MODELLING REQUIREMENT	CORE INFOMRATION	REMARKS
Grade Beams	• Model the beams from and to the centre of the column • For CIP structures, join beams to slabs (clear the connections) • Model in beam haunches to designed dimensions • Model sloping beams to design intent	Grade Beam Mark	
		Grade Beam Type	Indicate if grade beam
		Grade Beam Dimension	
		GB X-Easting	
		GB Y-Northing	
		Concrete Grade	
		Element Classification	
		Remarks/Status	
		Rebar Ratio*	
Substructure Framing	• Model the beams from and to the centre of the column • For CIP structures, join beams to slabs (clear the connections) • Model in beam haunches to designed dimensions • Model sloping beams to design intent	Beam Mark	
		Beam Type	
		Beam Size	
		Beam Offset	
		Beam Rotation	
		Construction Method	
		Loading (Kn/m)	
		Concrete / Steel Grade	
		Element Classification	
		Remarks/Status	
		Material Specifications	
		Waterproofing	

ELEMENT	MODELLING REQUIREMENT	CORE INFOMRATION	REMARKS
Substructure Specialist (e.g. Precast, PPVC, etc.)		Element Mark	
		Element Type	
		Element Dimensions	
		Element Offset	
		Element X-Easting	
		Element Y-Northing	
		Material Grade	
		Element Classification	
		Remarks Status	
Critical Connections		Element Mark	
		Element Type	
		Element Dimensions	
		Element Offset	
		Material Grade	
		Element Classification	
Column	• Model the structural column individually for each storey • Model the columns from SFL to SFL of floor above • Model the stumps (portion between the pile cap/footing and level 1 column) separately • Include Drop Panel, Corbel, etc (for precast columns) • Use library/objects for non-standard columns. Avoid using model-in-place	Column Mark	
		Column Type	
		Column Diamater / Size	
		Column Offset	
		Column Rotation	
		Construction Method	
		Loading (kN)	

ELEMENT	MODELLING REQUIREMENT	CORE INFOMRATION	REMARKS
		Concrete / Steel Grade	
		Element Classification	
		Remarks / Status	
		Rebar Ratio*	
Substructure Walls	• Model the structural walls from SFL to the SFL of floor above • Coordinate location, alignment, and extents of structural wall with Architectural Model • Coordinate all openings with Architectural Model • Coordinate major openings through wall with MEP model	Wall Mark	
		Wall Type	
		Wall Thickness	
		Wall Offset	
		Wall Opening Size	
		Material Grade	
		Element Classification	
		Remarks/Status	

** Only applicable for Rebars that have been detailed as option 2 (Hybrid)*

2.2 Super Structure

ELEMENT	MODELLING REQUIREMENT	CORE INFOMRATION	REMARKS
Slab	• Model the structural floors at SFL to be coordinated with Architectural FFL • Model slabs as individual elements from beams • Model slab drops as required for coordination	Slab Mark	
		Slab Type	
		Slab Thickness	
		Slab Opening Size	
		Slab Direction	
		Slab X-Easting	
		Slab Y-Northing	
		Concrete Grade	
		Element Classification	
		Remarks / Status	
Superstructure Framing	• Model the beams from and to the centre of the column • For CIP structures, join beams to slabs (clear the connections) • Model in beam haunches to designed dimensions • Model sloping beams to design intent	Beam Mark	
		Beam Type	
		Beam Size	
		Beam Offset	
		Beam Rotation	
		Construction Method	
		Loading (Kn/m)	
		Concrete / Steel Grade	
		Element Classification	
		Remarks/Status	
		Material Specifications	

ELEMENT	MODELLING REQUIREMENT	CORE INFOMRATION	REMARKS
Superstructure Specialist (e.g. Precast, PPVC, etc.)		Element Mark	
		Element Type	
		Element Dimensions	
		Element Offset	
		Element X-Easting	
		Element Y-Northing	
		Material Grade	
		Element Classification	
		Remarks Status	
Critical Connections		Element Mark	
		Element Type	
		Element Dimensions	
		Element Offset	
		Material Grade	
		Element Classification	
		Remarks Status	
Column	• Model the structural column individually for each storey • Model the columns from SFL to SFL of floor above • Model the stumps (portion between the pile cap/footing and level 1 column) separately • Include Drop Panel, Corbel, etc (for precast columns) • Use library/objects for non-standard columns. Avoid using model-in-place	Column Mark	
		Column Type	
		Column Diamater / Size	
		Column Offset	
		Column Rotation	
		Construction Method	
		Loading (kN)	

ELEMENT	MODELLING REQUIREMENT	CORE INFOMRATION	REMARKS
		Concrete / Steel Grade	
		Element Classification	
		Remarks / Status	
Superstructure Walls	• Model the structural walls from SFL to the SFL of floor above • Coordinate location, alignment, and extents of structural wall with Architectural Model • Coordinate all openings with Architectural Model • Coordinate major openings through wall with MEP model	Wall Mark	
		Wall Type	
		Wall Thickness	
		Wall Offset	
		Wall Opening Size	
		Material Grade	
		Element Classification	
		Remarks/Status	

3 2D VIEWS, SCHEDULES, AND LEGENDS [INFORMATION FORMAT REQUIREMENTS]

Tender Information shall be presented through the following views and schedules.

NOTE:

- BIM View Requirements indicated below are as per Regulatory Submission Requirements. Refer to Code of Practice for BIM e-Submission for details.
- There are no additional views required for tender over and above the Submission Requirements apart from BIM Schedules.

BIM VIEW REQUIREMENTS	SCHEDULES
• 3D Model • Site Layout and Subterranean • General Notes* • Typical Details* • Foundation / Substructure Layout • Framing / Superstructure Layout • Structural Detailing / Schedules • Specialty Works*	• Pile Cap Schedule • Column Schedule • Beam Schedule • Floor Schedule • Wall Schedule • Truss Schedule

**Part of drafting views*

Schedules

Schedules shall be prepared for easy auditing of Core Information embedded inside each element and to facilitate extraction of necessary quantities in the correct unit of measurement.

The following are the list of schedules that must be extracted from the Structural BIM model.

These schedules shall include, but are not limited to, the minimum embedded Core Information as shown.

a. Pile Schedule

For REBAR RATIO, refer to EC2 provisions, including Singapore National Annex.

PILE SCHEDULE							
MARK	TYPE	SIZE / DIAMETER	EMBEDMENT LENGTH	MATERIAL GRADE	REBAR RATIO	REMARKS / STATUS	COUNT
A	600 BP	600					35

b. Pile Cap Schedule

PILE SCHEDULE						
TYPE / MARK	LENGTH	WIDTH	DEPTH	CONCRETE GRADE	REMARKS / STATUS	COUNT
PC1A	1000	1000	800		New	35

c. Column Schedule

TYPE of column shall be defined in the Type Mark which shall include the material/construction method + column size. Column size must be consistent with that of actual column geometry.

COLUMN SCHEDULE					
MARK	TYPE	LENGTH / VOLUME	CONCRETE GRADE	REMARKS / STATUS	COUNT
C1	PreCast 350 x 1000	0.41 cu.m.	C50	New	35

d. Beam Schedule

MARK shall distinguish Grade Beams
TYPE of beam shall be defined in the Type Mark which shall include the material/construction method + beam size. Beam size must be consistent with that of actual beam geometry.

BEAM SCHEDULE					
MARK	TYPE	LENGTH / VOLUME	CONCRETE GRADE	REMARKS / STATUS	COUNT
B1-3	Cast In-Situ 350 x 1000	0.41 cu.m.	C50	New	35

e. Slab Schedule

MARK shall distinguish Slabs on Grade
TYPE of wall shall be defined in the Type Mark which shall include the material/construction method + wall thickness. Slab thickness must be consistent with actual slab geometry thickness

SLAB SCHEDULE					
MARK	TYPE	THICKNESS	CONCRETE GRADE	REMARKS / STATUS	COUNT
S1-1	Cast In-Situ 250	250	C50	New	15

f. Wall Schedule

MARK shall distinguish Retaining Walls
TYPE of wall shall be defined in the Type Mark which shall include the material/construction method + wall thickness. Wall thickness must be consistent with actual wall geometry thickness

WALL SCHEDULE					
MARK	TYPE	THICKNESS	CONCRETE GRADE	REMARKS / STATUS	AREA
W1	Precast 200	250	C35	New	3513.5
RW2	Cast In-Situ 250	250	C35	New	532.4

MEP REQUIREMENTS

5 GENERAL REQUIREMENTS

This section describes the approach to the communication of tender information for MEP systems which typically consist of the following:

Routings

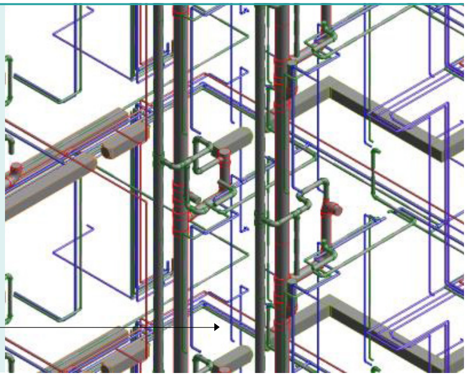
Routings include items such as as pipes, ducts, cable trays, trunking, which are measured by length, as well all fittings.

a. The count and type of fittings in each routing may be subject to change depending on construction coordination
b. Ensure that routings are modelled to correct nominal size, including insulation.
c. Pipe material shall be indicated in the Type Name
d. Cables, conduits, lightning tape need not be modelled.
e. Routings shall be sufficiently coordinated i.e.:
   - Avoids critical clashes with structure
   - Located and coordinated in their designated service shaft

ROUTINGS

Main Reference:
Pipes, ducts, cable trays, trunking as well as all fittings as modelled objects

150 mm uPVC Sanitary Drain Pipe



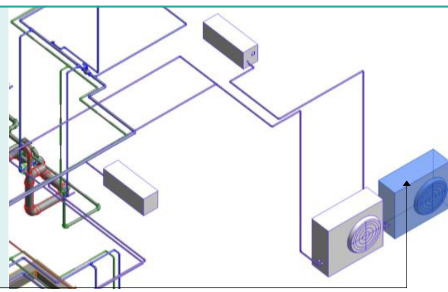
Equipment

MEP major equipment such as Cooling Tower, Chillers, AHUs, generators, pumps, etc., are measured by count in the model and shall reference to single line diagrams and performance specifications (which are also part of Core Information).

a. Ensure that equipment designation or mark is correctly embedded as Core Information and that it is consistent with that in the specifications and single line diagrams.
b. Ensure that counts in the model are consistent with in the single line diagram.
c. Ensure that all other performance specification Core Information is consistent with that in the general notes.

EQUIPMENT

Main Reference:
Equipment as modelled elements in the model



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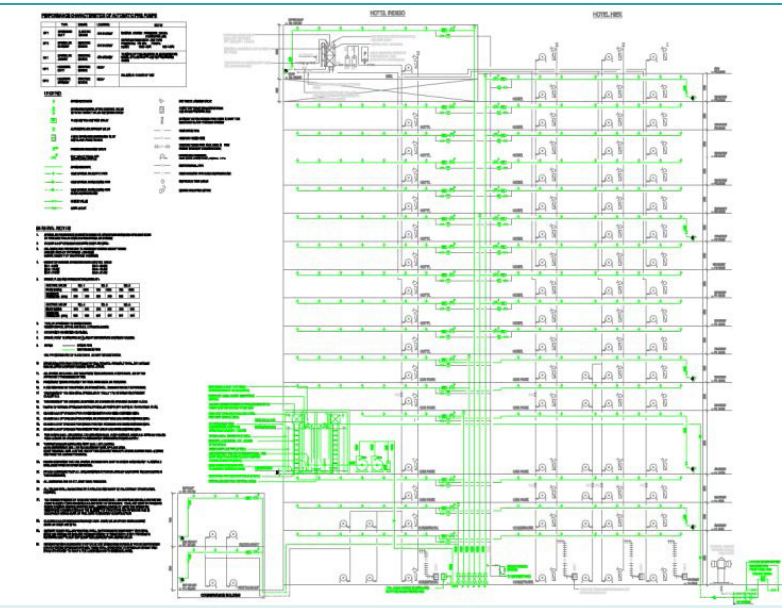


EQUIPMENT

Main Reference:
Single line diagrams, general notes, and specifications

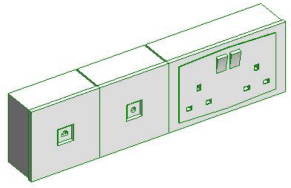
Accessories, Devices, Fixtures

Accessories, devices, fixtures such as lighting fixtures, valves, detectors, sprinklers, etc. are measured by count (e.g. number of each type of lighting) and shall reference to single line diagrams and performance specifications.

a. Ensure that type is clearly indicated in element name and that it is consistent with specifications.
b. Ensure that counts in the model are correct.
c. Ensure that fixture mark (if applicable) is correctly embedded as Core Information and that it is consistent with that in the specifications and single line diagrams.
d. Model to standard mounting heights and distances, if known.

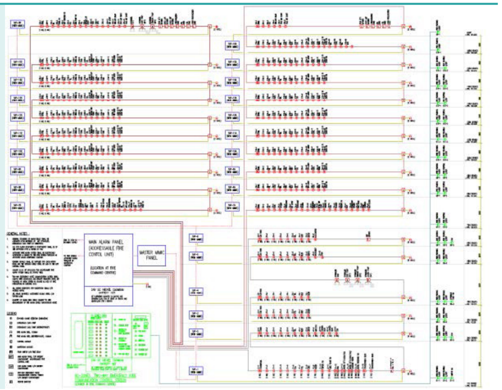
ACCESSORIES, DEVICES, FIXTURES

Main Reference:
Accessories, devices, fixtures, as modelled elements



ACCESSORIES, DEVICES, FIXTURES

Main Reference:
Single line diagrams, general notes, and specifications



6 MODELLING REQUIREMENTS AND CORE INFORMATION FOR MEP OBJECTS

The Core information includes but are not limited to the below listed for Tender purposes. Items in gray are Core Information as part of MEP e-Submission requirements.

- Fire Protection
- ACMV
- Plumbing and Sanitary
- Electrical
- Lightning Protection
- City Gas

2.1 Fire Protection

ELEMENT	MODELLING REQUIREMENT	CORE INFOMRATION	REMARKS
Sprinklers • Concealed • Exposed • Etc.	• Sprinkler objects need not be over modelled. • Ensure that sprinkler type is indicated correctly in the object name and that the correct sprinkler type is used.	Temperature Rating	
		Sprinkler Type	
		K Factor	
		Hazard Group	
		Nominal Size	
		System	

ELEMENT	MODELLING REQUIREMENT	CORE INFOMRATION	REMARKS
Pipes & Fittings	• Model to correct nominal diameter. • Model to consider clearance for installation and maintenance. • Indicate pipe material in Type Name. • Use correct fittings of standard overall size. • Fire rated-box up may be modelled using 'ducts' as workaround.	Nominal size	
		System	
		Type	
		Insulation Type (& fire rating)	For fire-rated box up
Pipe Accessories • Valves • Meters • Flow Switch	• Ensure consistency with single line diagrams.	Nominal size	
		System	
		Type	
Mechanical Equipment • Fire Sprinkler Pump • Fire Alarm Panels • Sub Alarm Panels	• Model or locate equipment with sufficient required clear access for maintainability. • Model equipment to correct design size, if known (or model to standard sizes).	Type	
		System	
		Mark / Designation	
		Pump Flow Rate	For pumps
		Pump Head	For pumps
Breeching inlet, Fire Hydrant and Hose Reels	• Location shall be provided by Archi, but modelled by MEP • Model correct diameter of inlet	Type	
		System	
		Design Pressure	
		Design Flow Rate	
Sprinkler Tank	• Model or locate equipment with sufficient required clear access for maintainability. • Model equipment to correct design size, if known (or model to standard sizes).	Effective Capacity	
		Width Tank Material	
		Type	
		Size	If specified
Fire Alarm Devices • Fire Alarms • Heat Detector • Smoke Detector • Break glass push button	• Model to standard size and location, if known. • Model to standard mounting heights and distances. • Extinguishers are modelled by Archi as symbols.	Type	
		System	
		Mark	

2.1 ACMV

ELEMENT	MODELLING REQUIREMENT	CORE INFOMRATION	REMARKS
Air Terminals • Grilles • Diffusers • Registers	• Model to correct design size of air terminal, if known. • Arrangement of all air terminals as per finalized Reflected Ceiling Plan fixture setting out to be coordinated during construction stage with Archi input • Height to be coordinated in construction with Archi input.	Type	
		System	
		Design Size	
		Design Air Flow	
Ducts & Duct Fittings • Rectangular • Oval • Flex* by contractor	• Model duct to take into consideration sufficient clearance for installation, brackets, and maintenance. • Model ducts to correct outside size including nominal thickness of duct insulation and fire rate insulation. • Use insulation type to indicate fire rating. • Use correct fittings as per specified. Model fittings to standard sizes. • Fire rating of the wall must be verified from Archi, as the in-line fire rating must be the same.	Type	
		Nominal Size	
		Insulation Thickness	
		Fire rating	To indicate in insulation and insulation type
		System	
Duct Accessories • Dampers • Filters • Silencer	• Model dampers in their exact locations. • Indicate Duct Access Panels as 2D symbols.	Type	
		System	
		Size	
		Fire rating	For fire dampers. To be provided by architect
Mechanical Equipment • AHU • Fans • FCU • Cooling Tower • Chiller • Control Panels • Water Pump • Heat Recovery Unit • Sprinkler Tank	• Model or locate mechanical equipment with sufficient required clear access for maintainability • Model mechanical equipment to standard size, or specified size if known	Type	
		System	
		Mark / Designation	
		Air Flow	For fans FCU and AHU
		Power Input	For fans
		Total Cooling Capacity	For cooling tower, AHU, FCU & chiller

ELEMENT	MODELLING REQUIREMENT	CORE INFOMRATION	REMARKS
		Sensible Cooling Capacity	For AHU & FCU
		Condenser Water Flow Rate	For cooling tower
		Power Input	For cooling tower, AHU, chiller, FCU
		Chilled Water Flow Rate	For chiller
		Static Pressure	For AHU
		Effective Capacity	For Sprinkler Tank
		Tank Material	For Sprinkler Tank
		Pump Flow Rate	For Pumps
Chiller / Refrigerant Pipes & Fittings	• Model to correct nominal dimension, including insulation thickness • Model to consider clearance for installation and maintenance. • Use correct fittings as per specified. Model fittings to standard sizes.	Type	Pipe Material
		System	
		Nominal Size	
		Insulation Thickness	
Pipe Accessories • Valves • Meters	• Ensure consistency with single line diagrams.	Nominal size	
		System	
		Type	

: 2.3 Plumbing and Sanitary

ELEMENT	MODELLING REQUIREMENT	CORE INFOMRATION	REMARKS
Inspection Chambers, Silt Traps, Waste sumps, Dilution Tanks	• Create IC/manhole family to designed invert levels, top levels, etc. • Insert family to designed location. • Model pipe connections to chamber/tank to its exact location. • Model special connections such as backdrops, tumbling bays, etc. • The system need not be connected between the tank and the pipe.	Top Level	
		Invert Level	
		Depth	
		Identity Mark	
Plumbing Fixtures • Floor Waste & Floor Trap • Bibs and Taps	• Not to model architectural fixtures such as Water Closet, Lavatories, but to link from AR model, and to provide / model the connection. • Only all other fixtures such as floor wastes, traps, bibs and taps must be modelled by MEP.	Type	
		Size	
Pipes & Fittings	• Model to correct nominal dimension. • Model to correct slope • Model to consider clearance for installation and maintenance. • Use correct fittings as per specified. Model fittings to standard sizes.	Type	
		Nominal Size	
		Slope	
		System	
Equipment • Water Tanks • Hydro-pneumatic tank • Pumps • Control Panels • Water Heaters • Pressure Vessel	• Model or locate equipment with sufficient required clear access for maintainability. • Model equipment to correct design size, if known.	Type	
		System	
		Mark / Designation	
		Pump Flow Rate	For pumps
		Power Input	For pumps
		Effective Capacity	For tanks & heater
		Tank Material	For tanks
Pipe Fittings & Accessories • Valves • Meters	• Ensure consistency with single line diagrams.	Nominal size	
		System	
		Type	

2.4 Electrical

Electrical includes the following sub-trades:

- Lighting
- Power
- Data
- Telephone
- Security

ELEMENT	MODELLING REQUIREMENT	CORE INFOMRATION	REMARKS
Lighting Fixtures		Count Type	Indicate no. of lamps & type lighting, wattage
Cable Containment & Fittings • Cable Trays • Cable Ladders • Underfloor trunking • Trunking	• Model using correct cable tray type and fittings. • For cable trays and trunking assuming to share same hanger, align bottom or sides of trays. • Model to consider clearance for installation and maintenance. • Duct may be used as trunking workaround as long as system is modified.	System	
		Type (material)	
		Overall Size	
Electrical Equipment • DB • Generator • Panels • Control Panels • Transformers • HT Switchgear • LV switchboard	• Model or locate electrical equipment with sufficient required clear access for maintainability. • Model electrical equipment to correct overall size, if known.	Type	
		System	
		Designation	
		Capacity*	

ELEMENT	MODELLING REQUIREMENT	CORE INFOMRATION	REMARKS
Electrical & Communication Devices and Fixtures • Switches • Speakers • Card Access Readers • Call Panels & Buttons • Isolators • FTP • CCTV, cameras • Data Points • Servers • Socket outlets	• Model devices and fixtures to standard sizes. • Model devices to exact height and location.	Type	
		Size*	
		System	

** If known*

2.5 Lightning Protection

ELEMENT	MODELLING REQUIREMENT	CORE INFOMRATION	REMARKS
Lightning Pit		System	
		Type	
Test Link Box		System	
		Type	
Lightning metal tape	May be indicated through 2D lines in plan		

2.6 City Gas

ELEMENT	MODELLING REQUIREMENT	CORE INFOMRATION	REMARKS
Gas Box Up	• May be modeled as a duct, so long as it is changed to correct system type.	Type	Indicate material
		Size	
		System	
Pipes & Fittings	• Model or locate equipment with sufficient required clear access for maintainability. • Model equipment to correct design size, if known.	Type	Pipe material
		Nominal Size	
		System	
Equipment Gas water heater	• Model or locate equipment with sufficient required clear access for maintainability. • Model equipment to correct design size, if known.	Type	Pipe material
		Marks / Designation	
		Capacity	
Pipe Fittings & Accessories • Valves • Meters	• Ensure consistency with single line diagrams.	Nominal size	
		System	
		Type	

7 2D VIEWS, SCHEDULES, AND LEGENDS [INFORMATION FORMAT REQUIREMENTS]

Tender Information shall be presented through the following views, schedules, and 3D views:

2D VIEWS	BIM-GENERATED SCHEDULES	3D VIEWS
• Site and Location Plans • General Notes and Specifications • Single line diagrams • Plans and Layouts • Standard details	• Equipment Schedule • Lighting Fixture Schedule • Electrical Equipment Schedule • Sprinkler Pump Schedule • Plumbing Fixture Schedule • Pipe Schedule • Pipe Fitting Schedule • Sprinkler Schedule • Duct Schedule • Duct Fitting Schedule	• Part 3D model of each floor

2D Views

- Single Line Diagrams

  - Single Line Diagrams may be created using a 2D platform and linked or imported into the BIM model views
  - Ensure that information inside of the Single Line Diagrams are consistent with that in the model, especially for equipment/fixture/device marks and counts

- Floor Plans

  - Floor plans such as 1st Storey Fire Protection Layout, etc., must be generated from the BIM model.
  - Floor plans must show layout and routing as modelled, except for non-modelled elements such as Lightning Tape, which may be represented through 2D lines.
  - Annotation is not necessary provided core information is correct and complete.

- Standard Details

  - Standard details may be created using a 2D platform and linked or imported into the BIM model views.

- General Notes and legends

  - General notes and legends may be created using a 2D platform and linked or imported into the BIM model views.
  - Ensure that information inside of General Notes are consistent with Core Information embedded inside modelled elements, especially performance specification of equipment.

Schedules

Schedules shall be prepared for easy auditing of Core Information embedded inside each element and to facilitate extraction of necessary quantities in the correct unit of measurement.

These schedules are purely for auditing of Core Information and may or may not be separate from the schedules that function as design specifications for items such as equipment, panels, etc.

The following are the list of schedules that must be extracted from the Structural BIM model.

These schedules shall include, but are not limited to, the minimum embedded Core Information as shown.

Refer to the chapter on General Requirements for Object Naming Conventions.

Fire Protection:
- Equipment Schedule
- Pipe Schedule
- Pipe Fitting Schedule
- Pipe Accessory Schedule
- Sprinkler Schedule
- Fire Alarm Device Schedule

ACMV:
- Equipment Schedule
- Pipe Schedule
- Pipe Fitting Schedule
- Pipe Accessory Schedule
- Duct Schedule
- Duct Fitting Schedule
- Duct Accessory Schedule
- Air Terminal Schedule

Plumbing and Sanitary:
- Equipment Schedule
- Pipe Schedule
- Pipe Fitting Schedule
- Pipe Accessory Schedule
- Plumbing Fixture Schedule

Electrical:
- Electrical Equipment Schedule
- Electrical Fixture / Devices Schedule
- Lighting Fixture Schedule
- Cable Tray Schedule
- Cable Tray Fitting Schedule

City Gas:
- Pipe Schedule
- Pipe Fitting Schedule
- Pipe Accessory Schedule
- Equipment Schedule

The abovementioned schedules shall contain the minimum core information below:

j. Equipment Schedule

- TYPE of equipment must be clear in the Object Name.
- MARK refers to equipment designation which must be consistent with the single line diagrams and specifications

EQUIPMENT SCHEDULE			
SYSTEM	TYPE	MARK	COUNT
CHWS 1	ABC-ACMV_WallMountFCU	CWP/15	1

k. Fire Alarm Devices Schedule

- TYPE of device must be clear in the Object Name.

FIRE ALARM DEVICE SCHEDULE	
TYPE	COUNT
ABC-FS_FireAlarmBell	22

l. Lighting Fixture Schedule

- TYPE of light including number of light, wattage, and type of lamps must be reflected in the object name + type name.

LIGHTING FIXTURE SCHEDULE	
TYPE	COUNT
ABC-ES_WallMountedLights: 1 x 28W T5 IP65 wm	65

m. Plumbing Fixture Schedule

- TYPE of plumbing fixture must be clear in the Object Name.

PLUMBING FIXTURE SCHEDULE	
TYPE	COUNT
ABC-PS_FloorTrap	12

n. Electrical Equipment Schedule

- TYPE of Electrical Equipment must be clear in the Object Name.
- MARK refers to equipment designation which must be consistent with the single line diagrams and specifications

ELECTRICAL EQUIPMENT SCHEDULE		
TYPE	MARK	COUNT
ABC-ES_DBs: DB-UNIT	5	1

o. Electrical Devices & Fixtures Schedule

- TYPE of Electrical Device or Fixture must be clear in the Object Name.
- Depending on the BIM software, Electrical Devices and Fixtures have more specific schedules to include:

* Communication Devices Schedule
* Electrical Fixtures Schedule
* Security Devices Schedule
* Lighting Devices Schedule

ELECTRICAL DEVICE SCHEDULE	
TYPE	COUNT
ABC-ES_Ceiling Speaker	12
ABC-EL_Proximity Card Access Reader	3
ABC-ES_CCTV Camera: Dome Camera	22
ABC-ES_1G Switch: 1G 2Way Switch Flush	230

p. Pipe Schedule

- TYPE of Pipe, which is the material, must be clear in the Type Name.
- INSULATION TYPE shall describe the type of insulation for the pipe, especially if fire rated.

PIPE SCHEDULE				
TYPE	SIZE	SYSTEM	INSULATION TYPE	INSULATION THICKNESS
Copper Pipe	50?			25 mm

q. Pipe Accessory Schedule

PIPE ACCESSORY SCHEDULE		
TYPE	SIZE	COUNT
ABC-PS_Ball Valve	32□	56

r. Pipe Fitting Schedule

- TYPE of Pipe Fitting must be clear in the Object Name.
- SIZE refers to nominal size. This is an automatic entry for every auto-creation of fittings when routing.

PIPE FITTING SCHEDULE			
TYPE	SIZE	SYSTEM	COUNT
ABC-PS_Elbow Fitting	32□ - 32□		54

s. Sprinkler Schedule

- TYPE of Sprinkler, whether concealed, side mounted, etc. must be clear in the Object Name.

SPRINKLER SCHEDULE					
TYPE	TEMPERATURE RATING	DIAMETER	K FACTOR	SYSTEM	COUNT
ABC-FP-Concealed Sprinkler	68d C	32mm			1253

t. Duct Schedule

- TYPE of duct, whether round, rectangular, etc. is indicated in Type Name

DUCT SCHEDULE				
TYPE	SIZE	SYSTEM	INSULATION / LINING TYPE	INSULATION / LINING THICKNESS
Rectangular duct	750mm x 200mm	SAD		25 mm

u. Duct Fitting Schedule

- TYPE of duct fitting must be clear in Object Name

TYPE	SIZE	SYSTEM
Rectangular elbow - mitered	750mm x 200mm – 750mm x 200mm	FAD

v. Duct Accessory Schedule

- TYPE of duct accessory and size must be clear in Object Name and Type Name

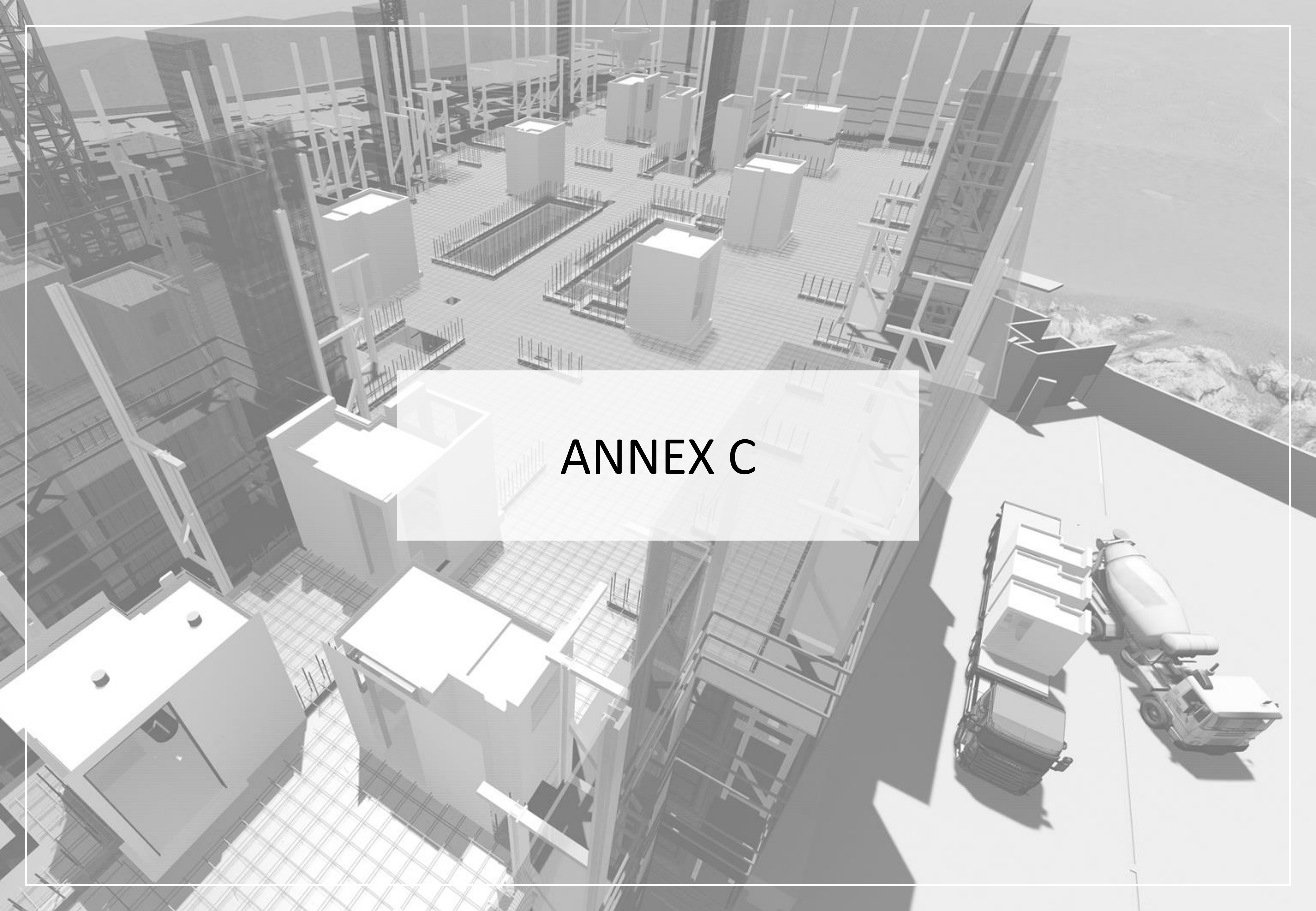
DUCT ACCESSORY SCHEDULE				
TYPE	SIZE	SYSTEM	MARK	COUNT
ABC-ACMV_Axial Fan: 150	150⍰	EAD	EF/BATH 1/1	76

w. Air Terminal Schedule

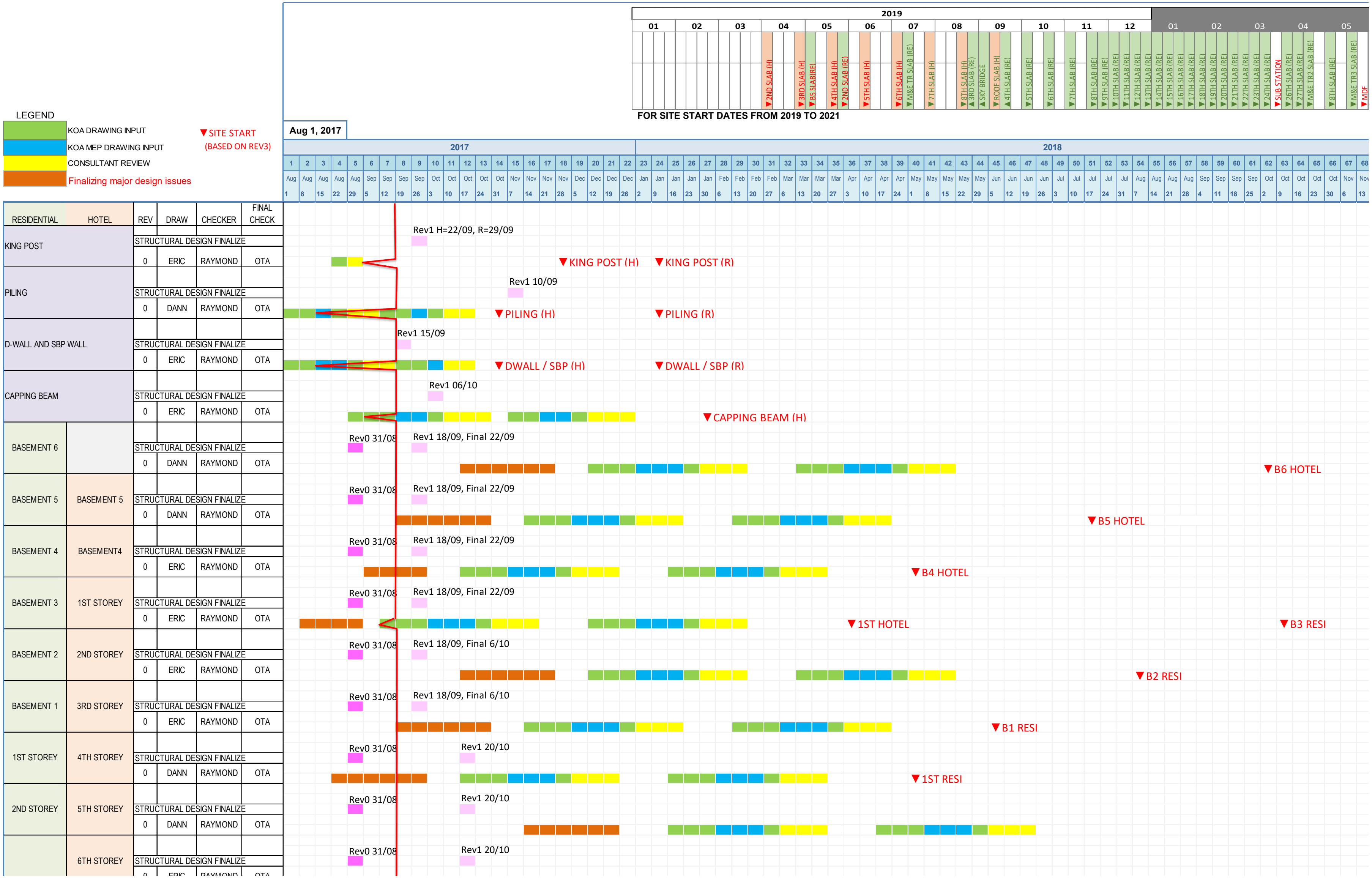
- TYPE of duct fitting must be clear in Object Name and Type Name

AIR TERMINAL SCHEDULE			
TYPE	SIZE	SYSTEM	COUNT
ABC-ACMV_Exhaust Air Terminal: 150 x 150	150 x 150	SAD	45

ANNEX C

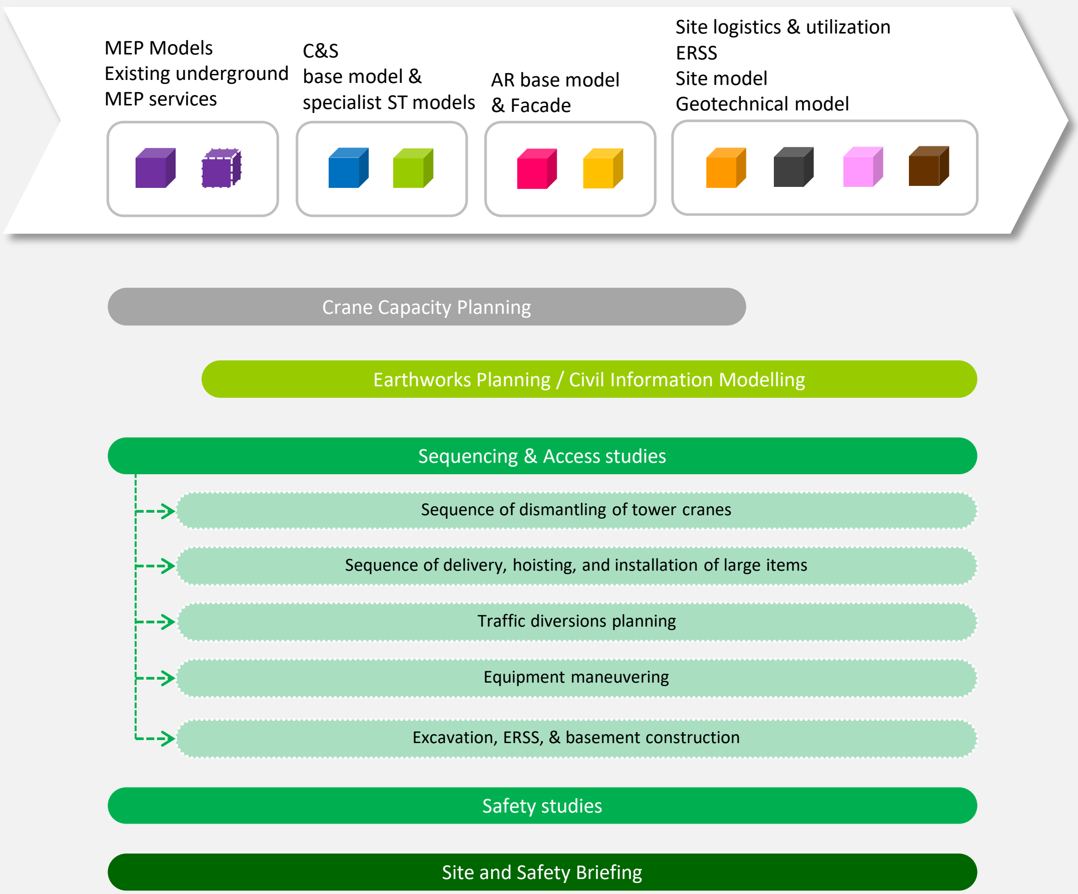


ANNEX C1: VDC SCHEDULE SAMPLE



ANNEX C2: **USE CASE 1** SITE LOGISTICS & PLANNING

BIM PRODUCTS



	MEP Model (proposed & existing) MEP Subcontractor	ST Model & Specialist ST Main Contractor, ST Specialist Contractor
Crane hoisting & capacity planning	▪ Equipment to be hoisted cooling tower, genset, transformer, etc. with tagged weight	▪ PRECAST: All precast components, modelled to exact fabrication details in terms of overall geometry and dimensions ▪ PPVC / PBU: Concrete shell of final coordinated profile, modelled to exact fabrication details in terms of overall geometry and dimensions (located in exact locations) ▪ STEEL: All steel structural members, modelled to exact details in terms of overall geometry, profile, and dimensions
Site Logistics & Utilization Planning & Modelling	▪ All existing underground services as per verified as-built ▪ All proposed underground services to coordinated depths and sizes	▪ Organize the model according to work zones / sequence / phase
Earthworks Planning	▪ All existing underground services as per verified as-built ▪ All proposed underground services to coordinated depths and sizes	▪ All underground structural components (piles, foundation, basement structures) ▪ All civil works
Sequencing & Access Studies	▪ MEP equipment for hoisting: cooling tower, genset, transformer, etc. to **actual** overall size (for hoisting sequencing)	▪ Split the model according to work zones / sequence / phase ▪ Model temporary supports and openings where required
Safety Studies		▪ Split the model according to work zones / sequence / phase ▪ Model temporary supports and openings where required
Site Briefing		

ANNEX C2: **USE CASE 1** SITE LOGISTICS & PLANNING

AR Model / Façade Model	Site Logistics & Utilization	ERSS	Site Model	Earthworks, Geotechnical Model	ACTIVITIES
Main Contractor, Façade Contractor	Main Contractor	Main Contractor	Main Contractor	Main Contractor	
▪ Model to exact modulation and location of panels	▪ Intelligent object crane / crane with reach radii integrated in				Crane hoisting & capacity planning
	▪ Construction equipment ▪ Temporary facilitates ▪ Temporary structures ▪ Internal access roads, ramps, etc.		▪ Surrounding buildings, roads, trees, structures, etc.	▪ Model earthworks by stage ▪ **may be modelled inside of site utilization model or done separately	Site Logistics & Utilization Planning & Modelling
▪ Organize the model according to work zones / sequence / phase	▪ Working platforms, construction equipment (excavators, concrete placing boom, etc.), hoarding, safety barriers, ECM to exact overall sizes and dimension	▪ Soldier piles, raking struts, braces, soil nails, diagonal struts, etc. (components depending on and as per ERSS design)	▪ All adjacent structures, roads, buildings, drains, etc.		Earthworks Planning
▪ Organize the model according to work zones / sequence / phase		▪ Soldier piles, raking struts, braces, soil nails, diagonal struts, etc. (components depending on and as per ERSS design)	▪ All adjacent structures, roads, buildings, drains, etc.		Sequencing & Access Studies
▪ Organize the model according to work zones / sequence / phase	▪ Safety barriers, other safety measures	▪ Soldier piles, raking struts, braces, soil nails, diagonal struts, etc. (components depending on and as per ERSS design)			Safety Studies
					Site Briefing

Site Logistics Model

OBJECTS	MODELLING TECHNIQUE	CORE INFORMATION
CRANES tower crane, mobile cranes	Model to correct height, boom length, and location Model foundation of tower crane to correct size and location May build mass of tower crane coverage Obtain info from supplier	
VEHICLES lorries, concrete trucks, excavators, etc.	Model to actual overall size May build mass of collapse zone	
MACHINERY piling rig, concrete placing boom, ground equipment	Model to actual overall size (height and radius) May build mass of collapse zone	
TANK / SILO	Model to actual overall size May build mass of collapse zone	
SITE OFFICE	Model to overall size and height	
HOARDING AND ACCESS GATES	Model to actual height (may use wall or railing for modelling)	
TEMPORARY ROAD	Model to actual width, turning radius, gradient May model as floor	
WASHING BAY	Model to actual overall size	
ECM TANK	Model overall size	
PASSENGER / MATERIAL HOIST	Model overall size (according to catalog)	
ECM DRAIN	Model to exact overall size and depth	
SAFETY PROTECTION (barriers)	May model using railing (no need to be detailed)	
TOPOGRAPHY	Model by excavation stage May use specialized earthworks software May also model using massing and voids	
CONSERVED TREES	Model to actual location	

Surrounding Site Model

OBJECTS	MODELLING TECHNIQUE	CORE INFORMATION
TOPOGRAPHY	Depending on the stage of construction when planning traffic diversion, topo may refer to existing topography or survey data	
EXTERNAL ROADS & SIDEWALKS	Follow elevation of roads (obtain info).	
EXISTING SURROUNDING BUILDING	Model surrounding buildings as massing only. If there are any existing buildings which may interface with new construction, model from as-built or preferably from 3D scan data.	
UNDERGROUND LINKS	Model from as-built documents or from 3D scan data (preferred) especially if there are interfaces or connection to new construction	
OVERHEAD BRIDGES (pedestrian and road bridges)	Model from as-built documents or from 3D scan data (preferred) especially if there are interfaces or connection to new construction	
TREES	Model trees to actual location	

Structural Base Model

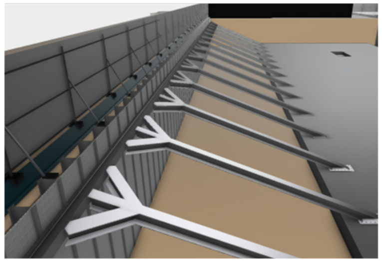
OBJECTS	MODELLING TECHNIQUE	CORE INFORMATION
ALL STRUCTURAL ELEMENTS	Split the model by location, work zones, and/or phases. This is best done using non-destructive splitting functions in some 4D software	Location / zone / phase
TEMPORARY OPENINGS	Model in temporary openings to overall size	
TEMPORARY SUPPORTS	Where necessary, model temporary supports such as king posts, support trusses, etc.	Indicate “temporary” so as not to create confusion
ALL STRUCTURAL ELEMENTS	Split the model by location, work zones, and/or phases. This is best done using non-destructive splitting functions in some 4D software	Location / zone / phase

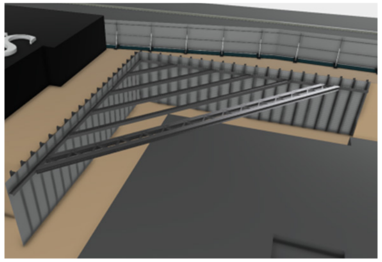
Earthworks Model

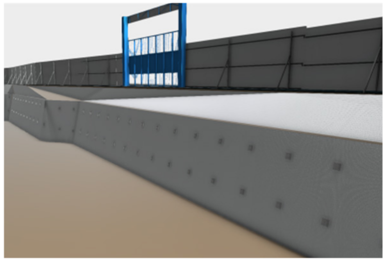
OBJECTS	MODELLING TECHNIQUE	CORE INFORMATION
ACTUAL TOPO	Model existing topo as per survey	
EARTHWORKS	Capture all earthworks (excavation, fill) by detailed stages, according to depth and volume of excavation Capture angles of slopes Split earthworks by sequence of work (may be done in 4D planning software)	Task ID to link for 4D planning
EARTH RAMPS	Model temporary earth access ramps to slope and overall dimensions	Task ID to link for 4D planning

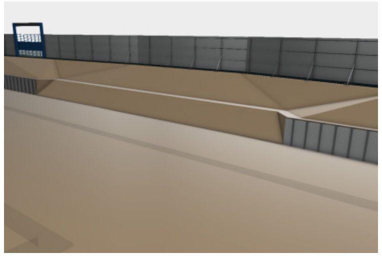
ERSS Model

OBJECTS	MODELLING TECHNIQUE	CORE INFORMATION
SOLDIER PILES	Model to exact overall size and location	Task ID for 4D sequencing
RAKING STRUTS	Model to exact overall size, shape, and angle.	Task ID for 4D sequencing
SOIL NAILS	Model as per designed level by level installation	Task ID for 4D sequencing
DIAGONAL STRUTS	Model to exact overall size and spacing of members	Task ID for 4D sequencing
DIAPHRAGM WALL	Model to exact overall size and location	Task ID for 4D sequencing
CBP	Modelled to design intent diameter and lengths	Task ID for 4D sequencing

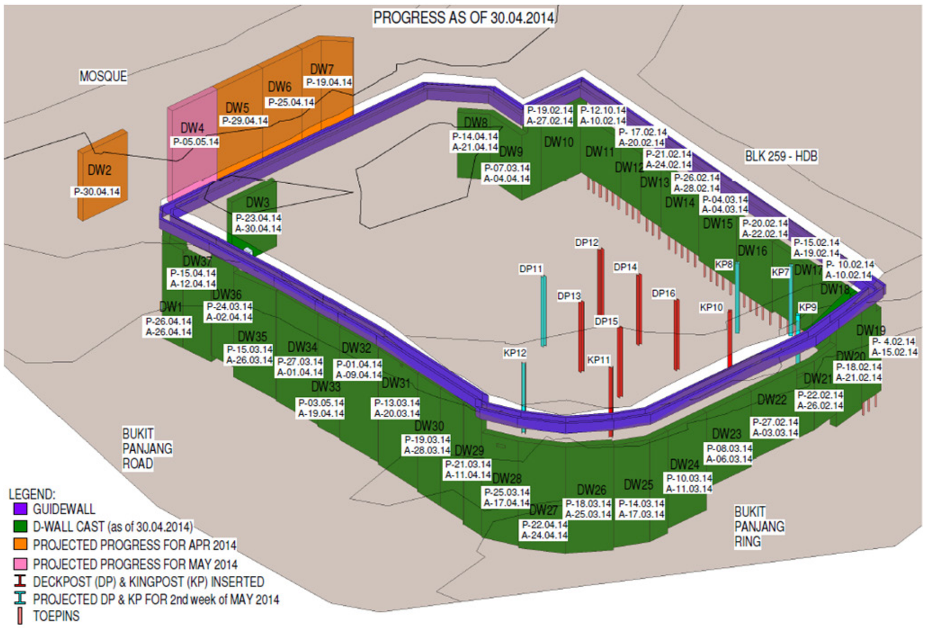

Raking struts


Diagonal struts

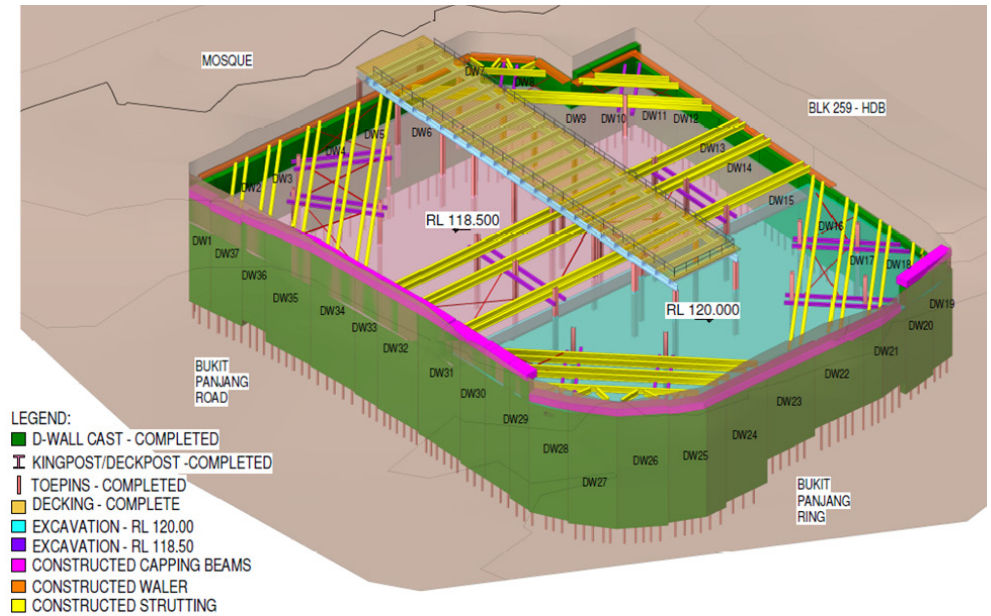

Soil nails


Soldier piles

Sample Progress Reporting for Underground Works and ERSS



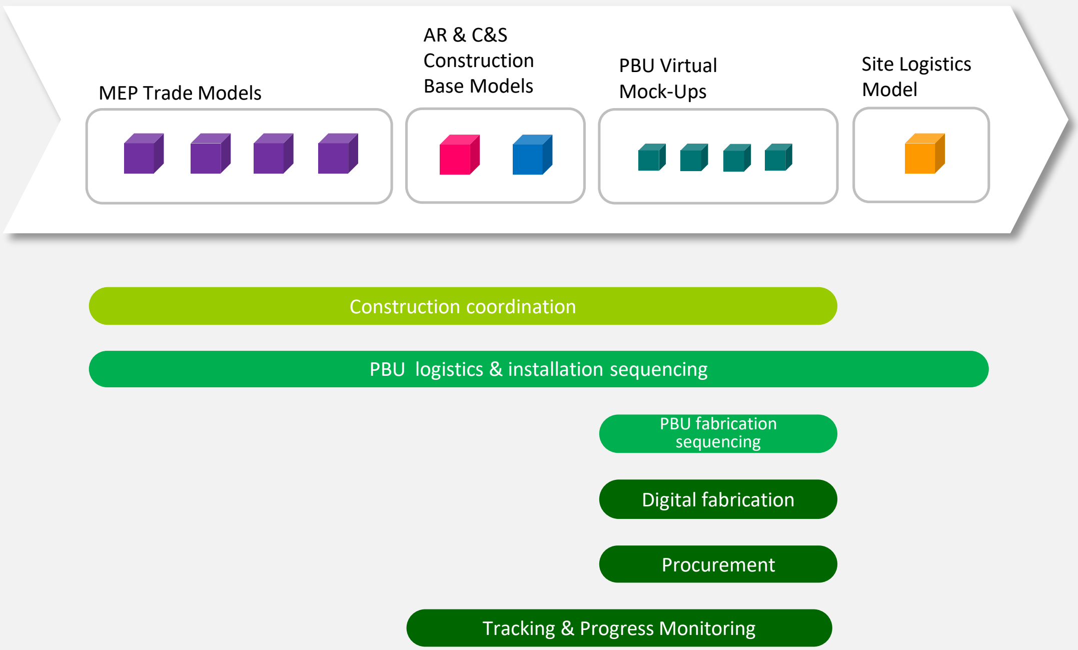
Progress report of D-wall and capping beam construction



Progress report of strutting and decking works

ANNEX C3: **USE CASE 2** PBU INSTALLATION

BIM PRODUCTS



ACTIVITIES	AR CONSTRUCTION MODEL Main Contractor
Construction Coordination	▪ Final FFL levels and coordination with structural SFL, considering finish thickness ▪ Wall setting out
PBU Virtual Mock-Up Development	
PBU logistics & installation Sequencing	FOR NON-CRITICAL PBU ▪ Walls and other architectural partitions to be phased according to which areas to install later after PBU installation
Procurement	
Fabrication & BIM to Field	
Tracking & Progress Monitoring	All structural elements to be organized by zone and sequence for ease of progress updating

ANNEX C3: **USE CASE 2** PBU INSTALLATION

ST CONSTRUCTION MODEL	MEP TRADE MODELS	PBU VIRTUAL MOCKUP	SITE LOGISTICS	ACTIVITIES
Main Contractor	MEP Subcontractors	Main Contractor	Main Contractor	
▪ Final SFL levels and coordination with architectural FFL, considering finish thickness ▪ Coordinated sizes and locations of all structural members	▪ Actual size of critical items in PBU unit such as water heater tank ▪ Aligned MEP vertical stack	▪ Finalized concrete profile ▪ Fixtures, bathroom accessories, cabinetry, casework inside of PBU unit ▪ Material finishes, including exact size, modulation, and alignment ▪ Doors, windows, glass screens ▪ Coordinated FFLs of PBU with main floor level considering thickness of finishes ▪ Ceiling and access panels		Construction Coordination PBU Virtual Mock-Up Development
FOR NON-CRITICAL PBU ▪ Structural Walls and structural elements to be phased according to which areas to install later after PBU installation FOR CRITICAL PBU ▪ All other structural elements to be phased according to correct sequence of installation in relation to PBU installation	▪ Critical MEP connections to be organized according to work sequence	▪ Exact coordinated overall size and locations	▪ Critical temporary structures: jump forms, surrounding scaffold platforms etc. that may obstruct installation ▪ Delivery trucks and trolleys ▪ Cranes and hoisting platforms ▪ Storage area	PBU logistics & installation Sequencing
		▪ Exact coverage and extent of finishes. Indicate tile layout and modulation to determine cut pieces ▪ Correct counts and model numbers of fixtures and accessories ▪ Correct sizes and type marks of doors and windows		Procurement
		▪ Accuracy and completeness of all components to be pre-fabricated		Fabrication & BIM to Field
▪ All structural elements to be organized by zone and sequence for ease of progress updating		▪ Unique IDs of each PBU to easily track individual status ▪ Status tags: date of delivery, date of installation, date of fabrication, etc.		Tracking & Progress Monitoring

ANNEX C3: **USE CASE 2** PBU INSTALLATION

	MAIN CONTRACTOR	SUBCONTRACTORS	SPECIALIST CONTRACTORS	CLIENT	CONSULTANT
Construction Coordination / PBU Virtual Mock-Up Devt.	• Develop virtual mockup • Ensures all models are updated in terms of completeness, final sizes, locational and dimensional accuracy of embedded services	• Identify issues and conflicts within their own trade and escalate to main contractor • Update individual trade model completeness, locational and dimensional accuracy of embedded services of their own trade • Update based on resolved issues	• Identify issues related to fabrication and escalate to main contractor or/and propose better solution • * Develop/ update virtual mock-up / fabrication model from design-intent or construction-intent model to incorporate fabrication details and fabricator's domain knowledge	• Ensure that coordination does not deviate from design and marketing requirements.	• Ensure that coordination does not deviate from design intent • Ensure that all authority compliance are being met • Review coordination issues • Approve final prototype
PBU logistics & installation Sequencing	PM, SITE MANAGER, PLANNER • Identify and Initiates development of virtual planning / sequencing • Define construction sequence • Identifies critical temporary works that must be considered • Endorse virtual sequence SAFETY OFFICER • Identify safety risks in planning • Provides safety requirements input BIM MODEER/ COORDINATOR • Does simulation • Identifies what needs to be modelled and to what level of detail according to inputs above • Coordinates with planner with regards to level of detail of sequence	STRUCTURAL SUBCONTRACTOR • End user of plan • Review of workable or can be carried out			
Procurement: SEE QUANTITY TAKEOFF p 67					
Fabrication & BIM to Field: SEE DIGITAL FARICATION p 68					
Tracking & Progress Monitoring	PLANNER • Gather, double check, and keep track of status data day by day • Track reason of delay PROJECT MANAGER • Endorse accuracy of information provided by the planner • Plan out how to mitigate delays BIM MODEER / COORDINATOR • Update the progress model in terms of actual accomplishment data from planner • Inform of any identified delay	• Provide info on what they will and what they did install / execute	• Provide timeline from mould prep to production		

PBU Virtual Mockup: Architectural Elements

OBJECTS	MODELLING TECHNIQUE	CORE INFORMATION
WALL	Model wall finish only. Tiles be represented by lines / patterns but the layout must be exact as per design requirement and consideration of optimization of tile setting out.	Size of tiles Thickness of tiles Tile model number
FLOOR	Model floor finish only. Tiles be represented by lines / patterns but the layout must be exact as per design requirement and consideration of optimization of tile setting out.	Size of tiles Thickness of tiles Tile model number
CABINETRY	Model overall dimensions only. Capture alignment of compartments to tiles.	Cabinet type Overall dimension
BATHROOM ACCESSORIES Mixer, towel holders, toilet paper holder, shower head	Model to overall dimensions only. Capture alignment of each component to tiles.	Model number as per approved
GLASS SCREENS	Model to overall dimensions only. Capture alignment to wall and floor tiles.	Size Thickness height
TOILET FIXTURES	Floor trap location to located as per exact as per tile setting out, etc.	Model number size
DOORS AND WINDOWS	Type of window and door (swing), setting out must be aligned to wall tiles.	Type size
CEILING	Exact design intent height. Access panel location and size as determined by MEP coordination. May need to model as per modulation. May need to model frame.	Height Type Material

PBU Virtual Mockup: Structural Elements

OBJECTS	MODELLING TECHNIQUE	CORE INFORMATION
WALLS	Model MEP service recesses and openings into structure to final coordinated location and sizes Model receiving chamfers	Opening / recess size and location
SLAB	Model MEP service recesses and openings into structure to final coordinated location and sizes	Opening / recess size and location
REBAR	* Good to have: coordinated as per MEP penetrations, embedded services and openings	Rebar size and spacing

PBU Virtual Mockup: MEP Elements

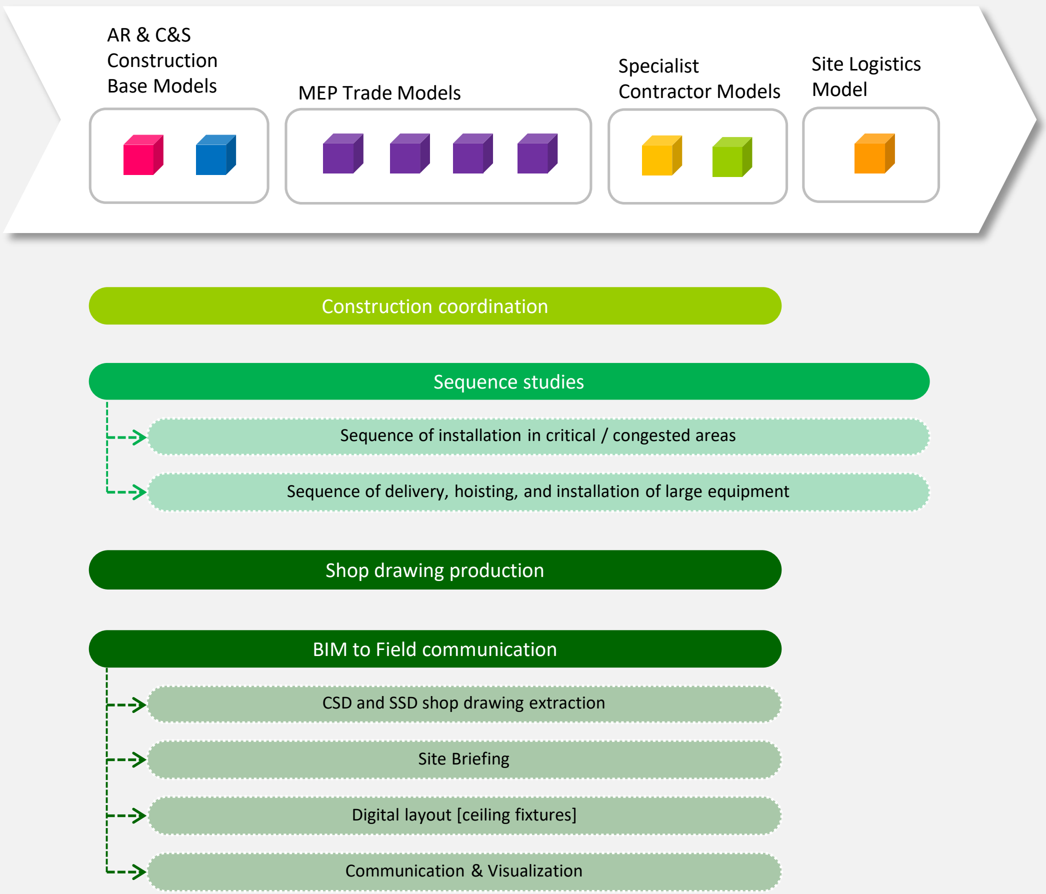
OBJECTS	MODELLING TECHNIQUE	CORE INFORMATION
TRAPS	Actual pipe size and fittings	
FITTINGS	Model to correct overall type, overall size and detail	
HEATER DRUM	Model to actual approved overall size	
CONDUITS?	Actual pipe size and fittings	
ACMV pipes	Model to actual size and insulation thickness	

Site Logistics Model

OBJECTS	MODELLING TECHNIQUE	CORE INFORMATION
CRITICAL TEMPORARY STRUCTURES	To appropriate level of detail required for planning	
Storage area	Identify storage area (outline / massing) (consider space between PBUs)	
Loading / unloading area	Identify area (outline)	
Delivery trailer	Length, width, height	
Access roads	Width, radius	
Tower crane	Specific to actual height, according to chosen brand. Consider lifting clearance. Model frame (and clutch if applicable) to correct overall height and extents	
Safety scaffolds	Height, model as one plane (external outermost outline)	
Jump forms if applicable	Massing, consider width of the platform and height of the jump form	
Trolley	Consider height of trolley when animating	
Placing boom (if applicable)		

ANNEX C4: **USE CASE 3** MEP INSTALLATION

BIM PRODUCTS



ACTIVITIES	AR Construction Model Main Contractor	ST Construction Model Main Contract
AR and C&S Pre Coordination	▪ Ceiling, ceiling height and details ▪ Fire compartmentalization ▪ Design intent of rooms ▪ Room layout and function (whether naturally or mechanically ventilated)	▪ All critical structural elements in terms of sizing, location of all structural members. ▪ Plinths and stumps
Individual Trade Modelling		
Inter-trade coordination	▪ Ceiling, ceiling height and details ▪ Fire compartmentalization ▪ Design intent of rooms ▪ Room layout and function (whether naturally or mechanically ventilated)	▪ All critical structural elements in terms of sizing, location of all structural members. ▪ Plinths and stumps
Sequencing Studies	▪ Walls, temporary openings through walls	▪ Structural components as per final coordinated sizes ▪ Temporary structural support*
BIM to Field		

ANNEX C4: **USE CASE 3** MEP INSTALLATION

MEP TRADE MODELS	FACADE	CASEWORK	STEEL STRUCTURE	SITE LOGISTICS	ACTIVITIES
	▪ Final sizes and location of actual components as per installation details that may affect coordination	▪ Model entry point of services ▪ Setting out (height, layout) ▪ Overall size	▪ Overall size and location of major steel components		AR and C&S Pre Coordination
▪ Model all items that are required for coordination. ▪ Model routings to exact final sizes, including insulation. ▪ Use actual fittings ▪ Consider space for maintenance, installation, and brackets ▪ Model brackets for congested areas where necessary ▪ Model fixtures and equipment to correct overall size as per approved specifications ▪ Update connectors to final sizes and locations as per approved specifications of component	▪ Final sizes and location of actual components as per installation details that may affect coordination	▪ Model entry point of services ▪ Setting out (height, layout) ▪ Overall size	▪ Overall size and location of major steel components		Individual Trade Modelling
	▪ Final sizes and location of actual components as per installation details that may affect coordination	▪ Model entry point of services ▪ Setting out (height, layout) ▪ Overall size	▪ Overall size and location of major steel components		Inter-trade coordination
▪ All systems to be sequenced ▪ Hangers and supports (if critical to coordination and planning)	▪ Building envelope, façade strengthening steel structure support, slab edge		▪ All steel structure components and detail connection	▪ Scaffolds, scissor lifts, working platforms (if critical to planning)	Sequencing Studies
▪ MEP equipment as per actual overall size and equipment weight as core information	▪ Building envelope, façade strengthening steel structure support, slab edge		▪ All steel structure components and detail connection	▪ Lifting cranes ▪ Temporary works that may affect hoisting clearance*	BIM to Field

ANNEX C4: **USE CASE 3** MEP INSTALLATION

	MAIN CONTRACTOR	MEP SUBCONTRACTORS	SPECIALIST CONTRACTORS	CLIENT	CONSULTANT
AR and C&S Pre Coordination	• Update architectural and structural models to capture coordination details and information required for MEP coordination • Identify which trades and information must be needed up front if they are needed of coordination • Lead coordination works, identify, and escalate issues		• Provide early information of actual components • * model own trade (if possible) as per final approved sizes / installation details • * Continuous update of model and coordination	• Provide early information of the intended space including all equipment, required ceiling height, required acoustic rating, and all else that may affect coordination • Facilitate early on board of main contractor, subcontractor, specialist contractors who are needed for early information and coordination	• Provide early information and confirmation on details that may affect coordination such as ceiling modulation, architectural fixture type and location, etc.
Setup and Coordination Kick-off Meeting	• Develops and issue template • Establish standards, modelling guidelines • Brief on BEP • Pre identify and highlights potential critical areas	PROJECT MANAGER • Ensure that downstream people conforms to standards and requirements • Raise issues and queries BIM COORDINATOR • Need to understand and conform to templates and standards			• Explain and highlight MEP design intent to all parties involved • Explain MEP zoning and compartmentalization of spaces • Highlight all other critical areas or issues
Individual Trade Modelling	• Manage model development and update of all MEP models and ensure compliance with schedule • Ensure all trades comply with BIM standards, requirements, and deliverables • Review QA/QC of each trade model prior to model sharing	• Develop trade model and update model throughout coordination period • Ensure models are well-developed to consider accuracy, completeness, clearances, tolerances, and integration of trade knowledge • Ensure compliance to BIM standards, requirements, and deliverables as set out by Main Contractor • Model within designated or allocated space • Perform QA/QC and intra-trade coordination checks prior to model sharing • Timely submission of models for sharing and coordination as per schedule			• Provide early information of design requirements that may affect coordination (e.g. catwalk required for maintenance, running services passing through critical areas) • Approve coordinated model
Inter-Trade Coordination: see Chapter 3					
Sequencing Studies		• Overall individual trade planning that tie with main contractor planning • Suggest methodology and sequencing with main contractor • Provide and discuss with main contractor & consultant on the equipment delivery schedule			
BIM to Field: see pp 67-69					

MEP Trade Model Quality Check: General

Description	Pass	Fail	N.A.	Remarks
GENERAL FILE CHECK				
Model in agreed version				
Model interoperability with IFC				
File size under 100 MB				
All unused families and links purged				
Based on contract documents				
Compliance with view naming and organization				
Compliance with file naming convention				
CONTROL ELEMENTS CHECK				
Aligned coordinated systems				
Levels are aligned				
Grids are aligned				

MEP Trade Model Quality Check: MEP Specific

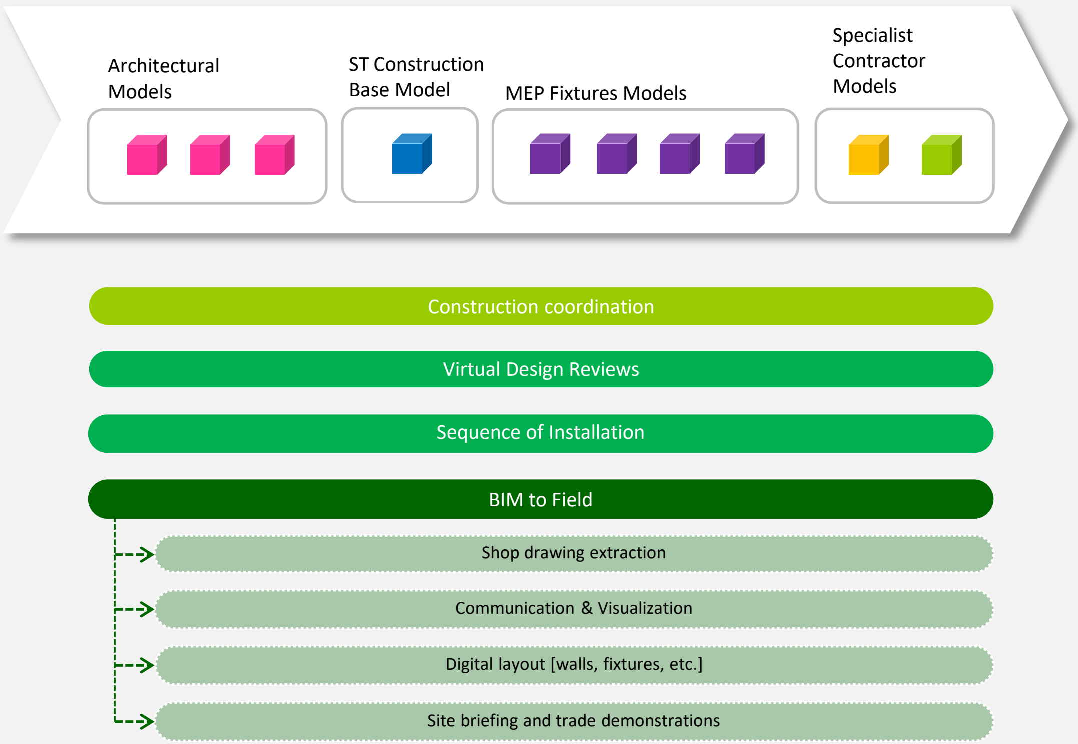
Description	Pass	Fail	N.A	Remarks
MODELLING REQUIREMENT				
Continuity of routing				
Correct systems assigned				
Completeness of elements				
Correct overall size of elements as per submittal approvals				
Use of correct fixtures, fitting, devices				
Installation and maintenance space provided				
Components are modelled using correct objects				
Compliance with system colours				
Alignment of vertical services				
PRE-COORDINATION INTERFERENCE CHECKS				
Clash free from structure				
Clash free from ceiling and walls				
Runs within allocated / designated space				
No duplicate or overlapping components, no clash within own trade				

Coordination Matrix

	ARCHITECTURAL					STRUCTURAL						MEP								
	Ceiling	Rated Walls	Floors	Casework	Furnishings	Structural Foundation	Structural Column	Structural Framing	Structural Wall	Slab	Steel & Pre-Cast	Mechanical Ductwork	Mechanical Piping	Mechanical Equipment	Mechanical Fixtures	Plumbing Piping	Electrical Equipment	Electrical Fixtures & Devices	All equipment with clearances	Specialty Equipment
Mechanical Ductwork	**1**	**2**					**3**	**3**	**3**	**3**	**3**									
Mechanical Piping	**1**	**2**					**3**	**3**	**3**	**3**	**3**									
Mechanical Equipment												**13**								
Mechanical Fixtures												**13**								
Plumbing Piping																				
Electrical Equipment											**10**	**11**	**11**	**6**	**6**	**12**				
Electrical Fixtures & Devices				**7**	**8**						**10**	**11**	**11**	**6**	**6**	**12**				
All equipment with clearances		**4**					**5**	**5**	**5**		**5**									
Specialty Equipment											**9**									

ANNEX C5: **USE CASE 4** ARCHITECTURAL FIT-OUT

BIM PRODUCTS

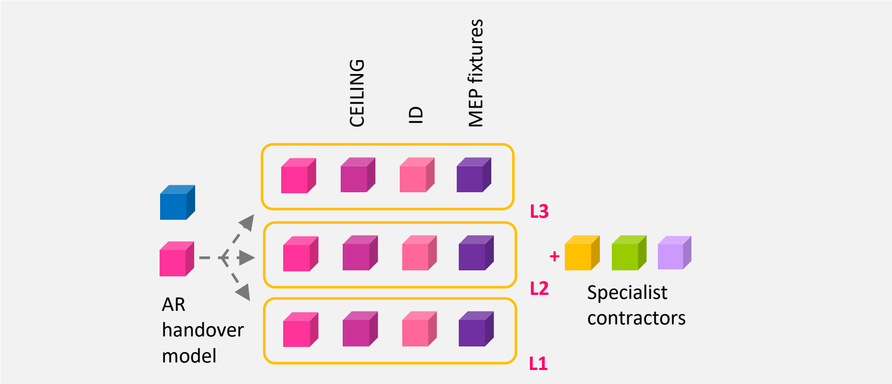


ACTIVITIES	AR CONSTRUCTION MODEL	RESIDENTIAL UNIT MOCKUP
Model update & virtual mock-up development Construction Coordination	BASE MODEL ▪ Wall core and wall finish ▪ Floor finishing ▪ Doors and windows ▪ Roller shutters, including shutter box above ceiling ▪ Glass partitions / internal glazing ▪ Clear space requirement for authority compliance CEILING ▪ All ceilings including coves, flat ceiling, ceiling details, etc ▪ Show setting out and modulation of ceiling ▪ Access panels ▪ Any special sub-framing for ceiling support INTERIOR DESIGN ▪ Furniture (fixed and loose) ▪ Appliances ▪ Cabinetry ▪ Casework ▪ Projector screens ▪ ID finishing to wall, e.g. wall paneling, tiling, etc. ▪ Architectural switches e.g. auto door switches, roller shutter switches control panels	ALL ELEMENTS INSIDE TYPICAL UNIT MOCK-UP ▪ Wall core and wall finish ▪ Floor finishing ▪ Glass partitions / internal glazing ▪ All ceilings including coves, flat ceiling, ceiling details, etc ▪ Furniture (fixed and loose) ▪ Appliances ▪ Cabinetry ▪ Casework ▪ ID finishing to wall, e.g. wall paneling, tiling, etc. ▪ Furniture ▪ Appliances ▪ Doors and windows ▪ Fixtures
Virtual Design Reviews	▪ Show actual material finishes, modulation of tiles and ceiling, look and layout of furniture, etc.	▪ Show actual material finishes, modulation of tiles and ceiling, look and layout of furniture, etc.
Sequence of Installation	▪ All items critical for sequencing studies	▪ All items critical for sequencing studies
BIM to Field	▪ ensure that scopes of work by each trade are indicated clearly ▪ Show “clear zones”” for owner-supplied fixtures or items	▪ ensure that scopes of work by each trade are indicated clearly ▪ Show “clear zones”” for owner-supplied fixtures or items

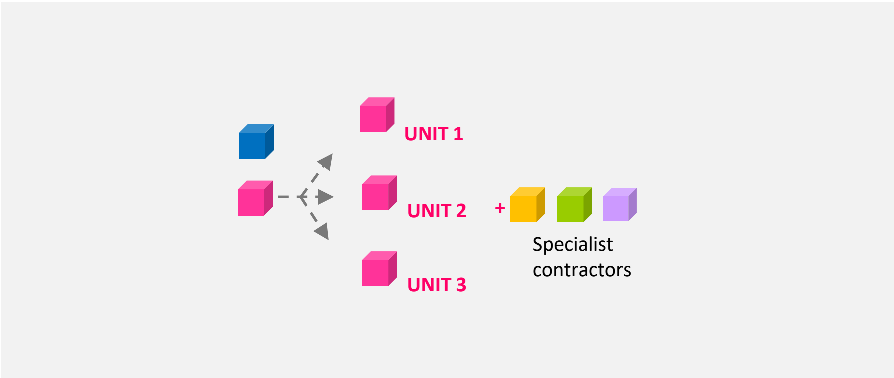
ANNEX C5: **USE CASE 4** ARCHITECTURAL FIT-OUT

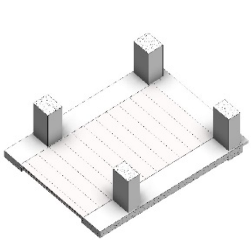
Structural	MEP Model	ID Subcontractors Model	Façade Model	Steel Structure	ACTIVITIES
Main Contractor	MEP Subcontractor	ID Subcontractor	Façade Contractor	Steel Contractor	
▪ Final coordinated sizes of all structural elements ▪ Final coordinated levels ▪ Final coordinated structural openings	All exposed MEP Fixtures ▪ Lighting fixtures ▪ Dimmers ▪ Thermostats ▪ Switches ▪ Socket outlet *fixtures may also be modelled separately from main MEP TRAIDE MODELS ▪ SOB locations, whether cast in or screed	▪ Furniture (fixed and loose) ▪ Cabinetry to actual layout and overall height ▪ Casework ▪ System furniture with exact location of service entry ▪ ID finishing to wall, e.g. wall paneling, tiling, etc. ▪ Architectural switches e.g. auto door switches, roller shutter switches control panels	▪ Façade model showing glass, backpan areas	▪ Any special steel structure support requirement	Model update & virtual mock-up development Construction Coordination
	▪ Fixtures updated to actual size, location, and look	▪ Show actual material finishes, modulation of tiles and ceiling, look and layout of furniture, alignment of finish modulation with doors, windows, cabinetry, etc.			Virtual Design Reviews
▪ All items critical for sequencing studies	▪ All items critical for sequencing studies	▪ All items critical for sequencing studies	▪ All items critical for sequencing studies	▪ All items critical for sequencing studies	Sequence of Installation
		▪ ensure that scopes of work for this trade is indicated clearly ▪ Show “clear zones”” for owner-supplied fixtures or items			BIM to Field

Typical Modelled Components by Architectural Trade

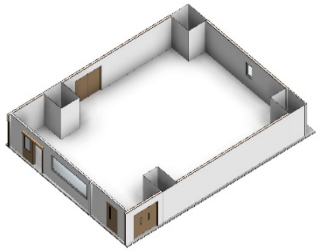


Typical Modelled Components of Residential Unit Mock-up

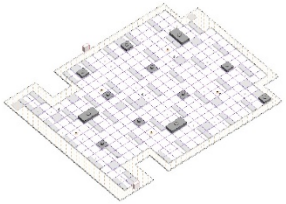




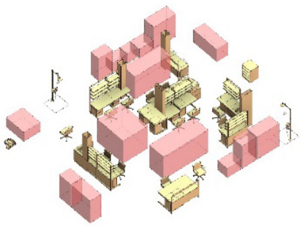
STRUCTURAL ELEMENTS



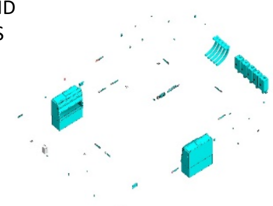
WALL PARTITIONS WITH FINISHES AND DOORS AND WINDOWS



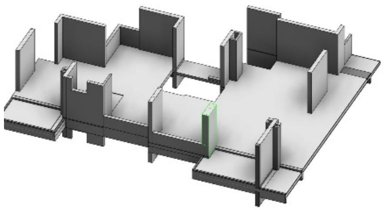
REFLECTED CEILING PLAN



CASEWORK – WORKSTATIONS, CABINETS, BASINS USER SPACE FOR FUTURE FURNITURE PROVISIONS

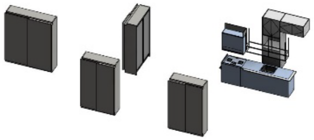


MEP FIXTURES AND EQUIPMENTS TO WALLS AND WORKSTATIONS

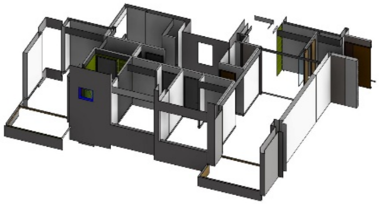


[STRUCTURAL ELEMENTS]

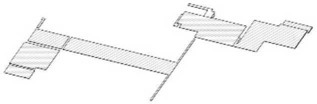
INTERIOR PARTITIONS AND WALL FINISHES



CASEWORK, CABINET, WARDROBES
APPLIANCES
FURNITURE



INTERIOR PARTITIONS
WALL FINISHES
DOORS & WINDOWS

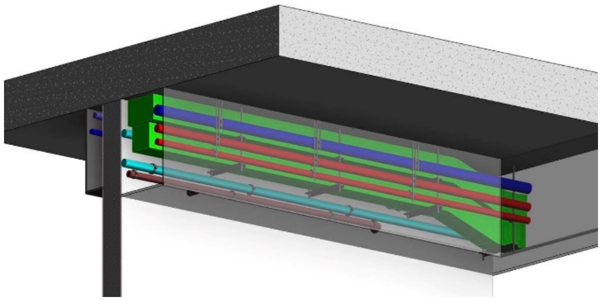


CEILING: CEILING BULKHEADS, COVES

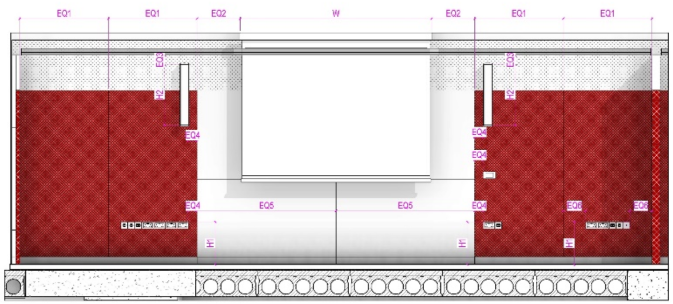
ANNEX C5: **USE CASE 4** ARCHITECTURAL FIT-OUT

	MAIN CONTRACTOR	SUBCONTRACTORS & SPECIALIST SUBCONTRACTORS	SUPPLIERS	CLIENT	CONSULTANT
Prepare schedule of information & make ready tasks: **SEE VDC SCHEDULE p 64**					
Model update & virtual mock-up development: SEE VIRTUAL MOCKUP DEVELOPMENT p 65					
Construction Coordination: SEE CHAPTER 3					
Virtual Design Reviews: SEE VIRTUAL REVIEWS p 66					
Sequence of Installation	PROJECT MANAGER, SITE ENGINEERS, PLANNERS • Overall planning and review • Determine methodology and sequencing BIM COORDINATOR / MODELLER • Create and update the model according to methodology and sequence • Create work sequences / animations where necessary SAFETY OFFICER • Provide safety requirement input • Does risk assessment	PROJECT MANAGER • Overall individual trade planning that tie with main contractor planning • Suggest methodology and sequencing with main contractor • Ensure sufficient resources to handle day to day work • Provide and discuss with main contractor & consultant on the equipment delivery schedule			
BIM to Field	• Extract construction drawings from latest approved models • Prepare models and virtual mock-ups for site reviews and mobile access • Ensure latest approved drawings and models are uploaded for reference on site • Arrange regular virtual reviews and briefings with subcontractors, all related RE's and RO's • Prepare the model for layout and layout on site based on model points	• Prepare shop drawings from approved coordinated model • Install as per latest approved drawings and models • Prepare presentation and perform trade demonstrations where necessary • To respond and take prompt action to any quality or defects issues	• Install as per latest approved drawings and models • Prepare presentation and perform trade demonstrations where necessary		• Participate in briefings and trade demonstrations to provide a look out items and issues to pay attention to • Highlight what they are more particular with in inspection

Sample Virtual Review Coordination Issues



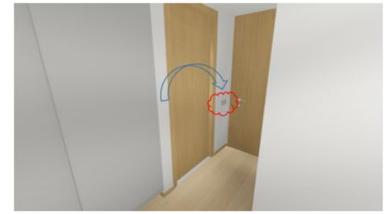
Coordination of MEP services inside of residential unit ceiling bulkhead



Coordination of M&E outlets, projects, whiteboard, and speakers with wall paneling alignment

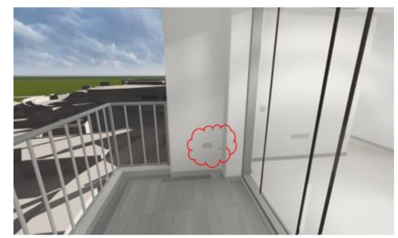
-On 21 Nov 2016, PTA requested to switch for bath 1 to shift to together with switch for master bedroom. CCDC to check.

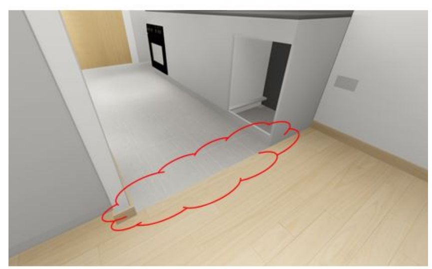
-On 28 Nov 2016, CCDC informed that switch can be shifted, but the change will have abortive work, need to chase groove on PBU wall to the new locatopn. PTA will check and revert back.



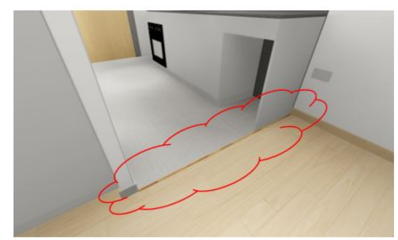
- On 14 Nov 2016, PTA commented, Ceiling at master bedroom as per HPK-Archi-RFI-151, to be added.

- On 14 Nov 2016, PTA commented, power socket at balcony to be adjusted to 450mm height

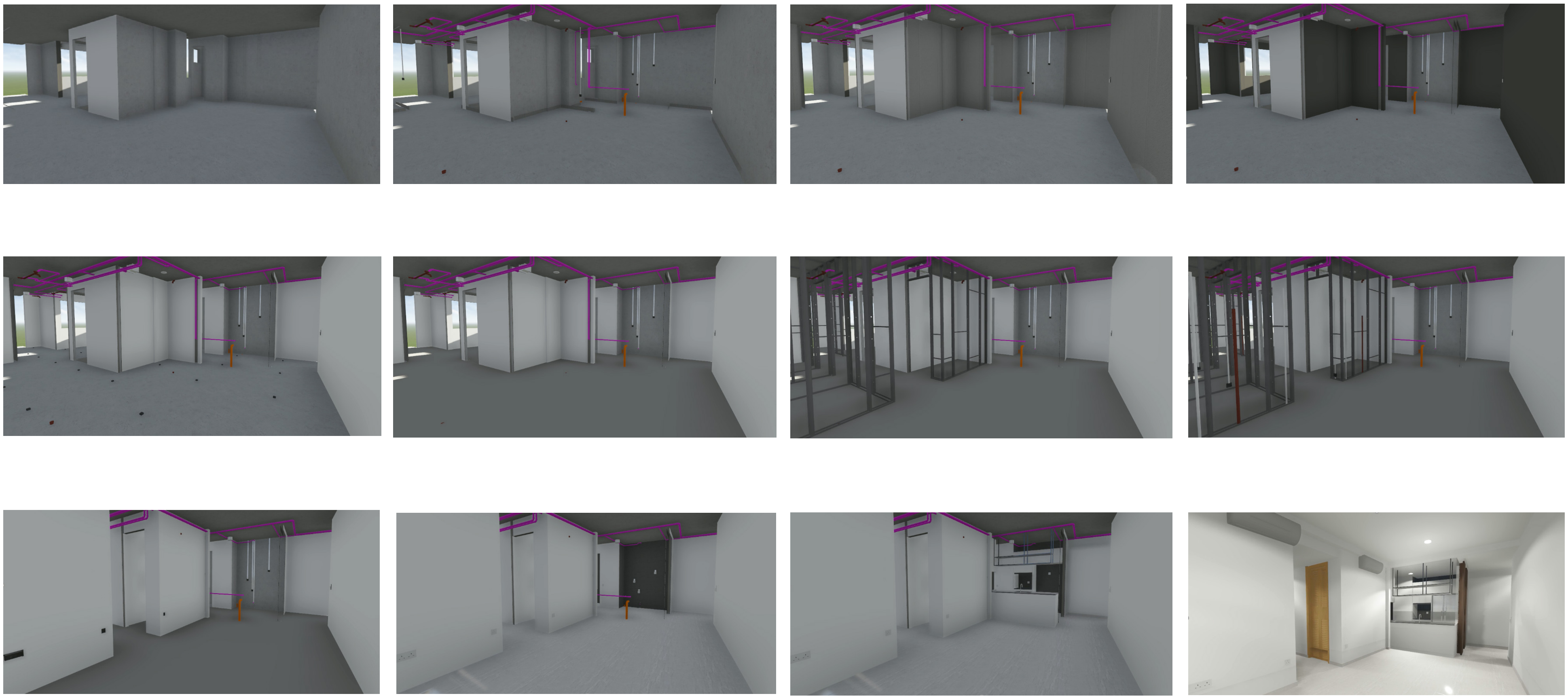




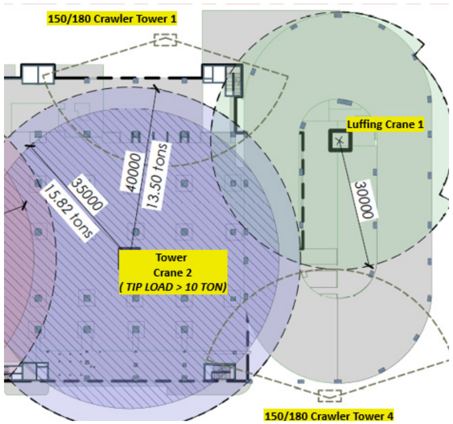
- On 14 Nov 2016, Developer & PTA commented, the termination between laminate floor & kitchen floor tile at bedroom 4 should use laminated end cap.
-On 21 Nov 2016, PTA commented, tiling shirting to be extended to wrap wardrobe dry wall to make
-On 28 Nov 2016, PTA commented whether can use smaller end cap. And CCDC confirmed in the meeting that 20mmm is smallest size after clarification with Weavepact

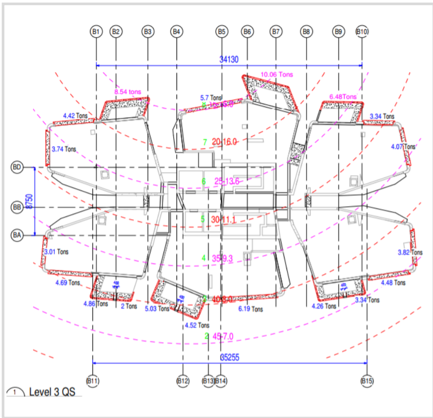


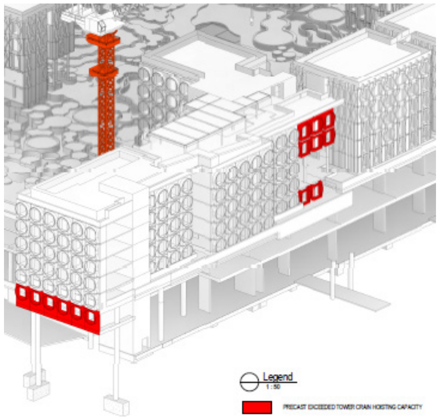
Sample Virtual Sequencing for Residential Unit Mock-up

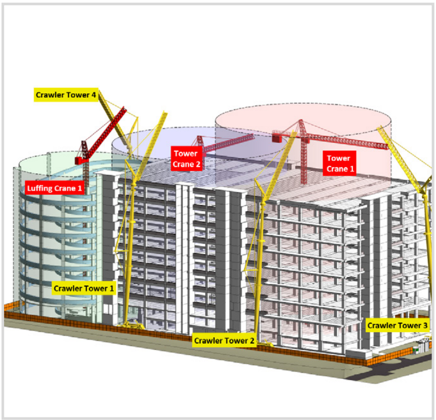


Crane Capacity Planning









STEP 1

Model in Tower Cranes / crane to exact planned location

- Build in reach radii into object

STEP 2

Identify and prep all items to be hoisted in the model

- Modelled to exact location
- Modelled to exact overall size, dimensions, details as per fabrication
- Apply formula or scripting to calculate weight from each object OR manually key in

STEP 3

MANUAL METHOD:

- Tag weight for each items so that this annotation shows up in the model
- Visually check if every component weight is within load capacity for that reach radius

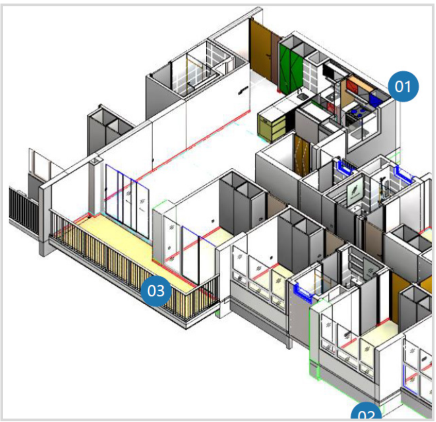
AUTOMATIC METHOD:

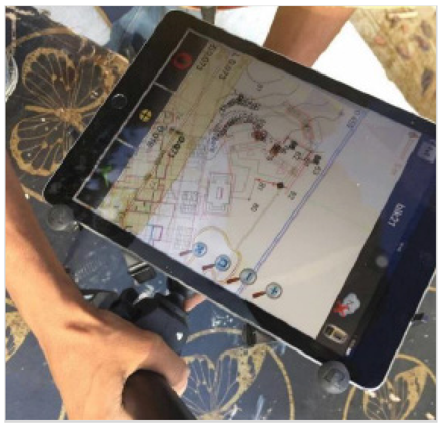
- Apply scripting to auto-detect and highlight items that are over weight

STEP 4

Adjust tower crane plan (add in more tower cranes) until all items (esp. heaviest or critical items) are within hoisting weight and reach

Digital Layout Workflow





STEP 1

Specify areas in the model to stake-out on site

- Ensure that model is fit for use for layout
- Select points in the model. Applicable items for layout may be:

STEP 2

- Upload points to the Cloud
- Retrieve points from controller

STEP 3

- Calibrate equipment with controller
- Set up and orient equipment on site

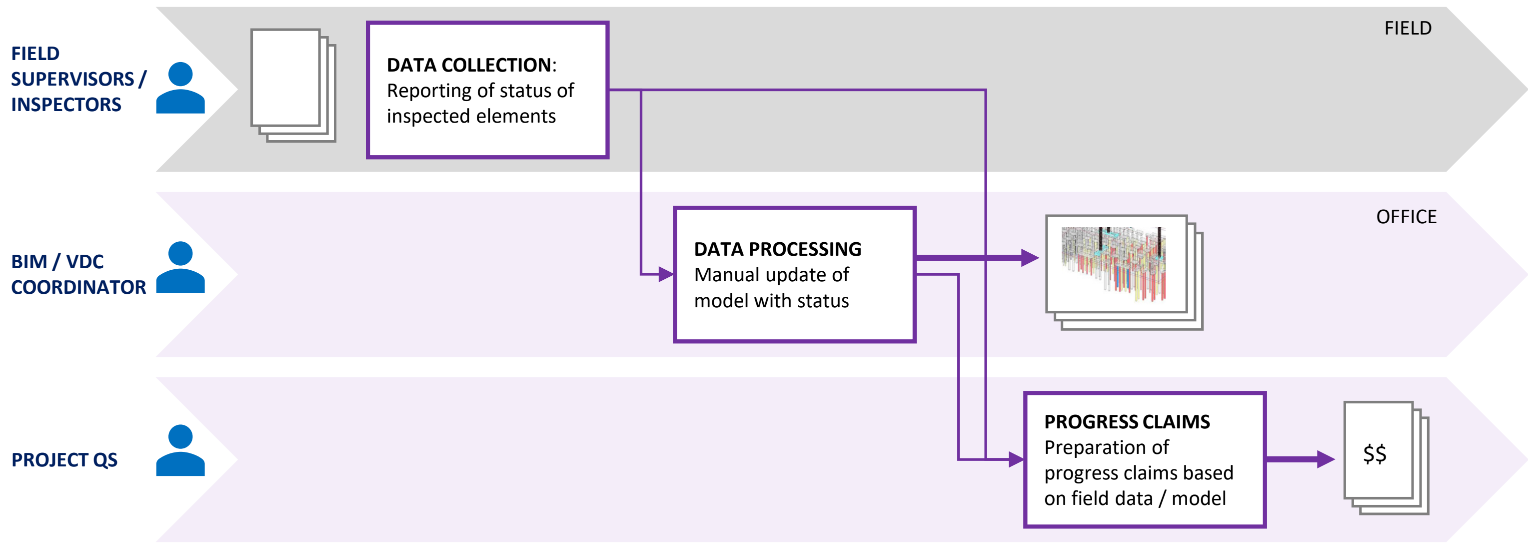
STEP 4

- Set out each point from the model on site

Progress Tracking & Monitoring Workflows

SEMI-INTEGRATED, MANUAL WORKFLOW

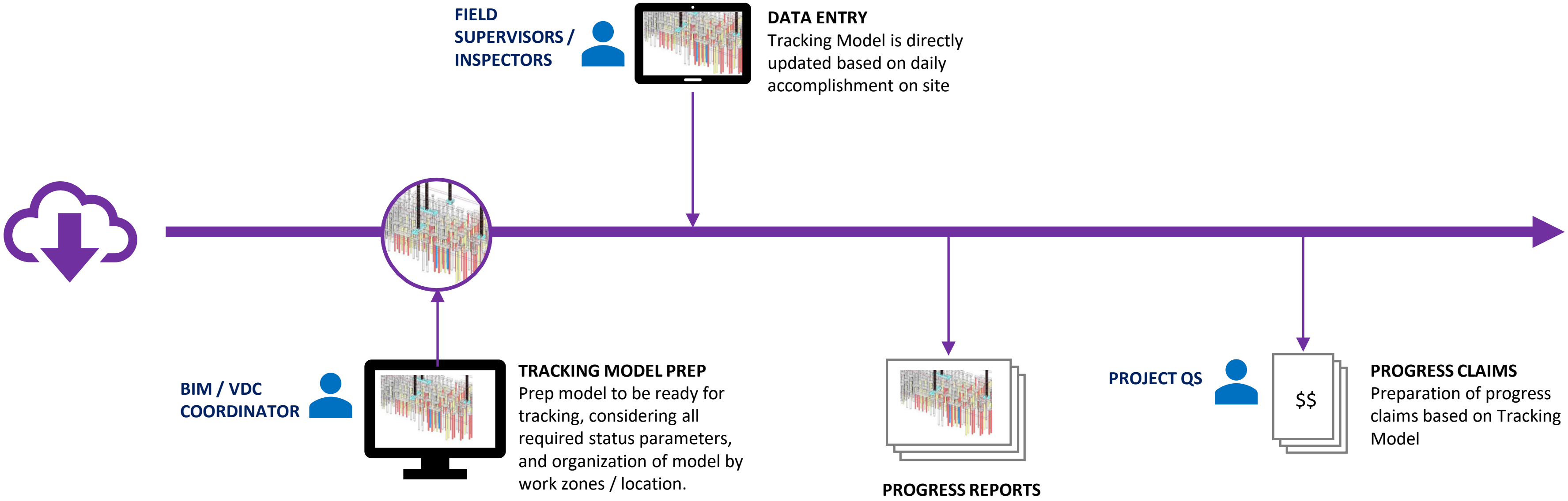
- Due to manual nature of tracking progress, data may be corrupted or inaccurate
- As volume of tracked data increases, updating model becomes more and more demanding for BIM coordinator



Progress Tracking & Monitoring Workflows

FULLY INTEGRATED, CLOUD-BASED WORKFLOW

- Streamlined, automated process
- Data visualization enables team to recognize redundancy of tracked data coming from field
- Eases requirement on constant model update



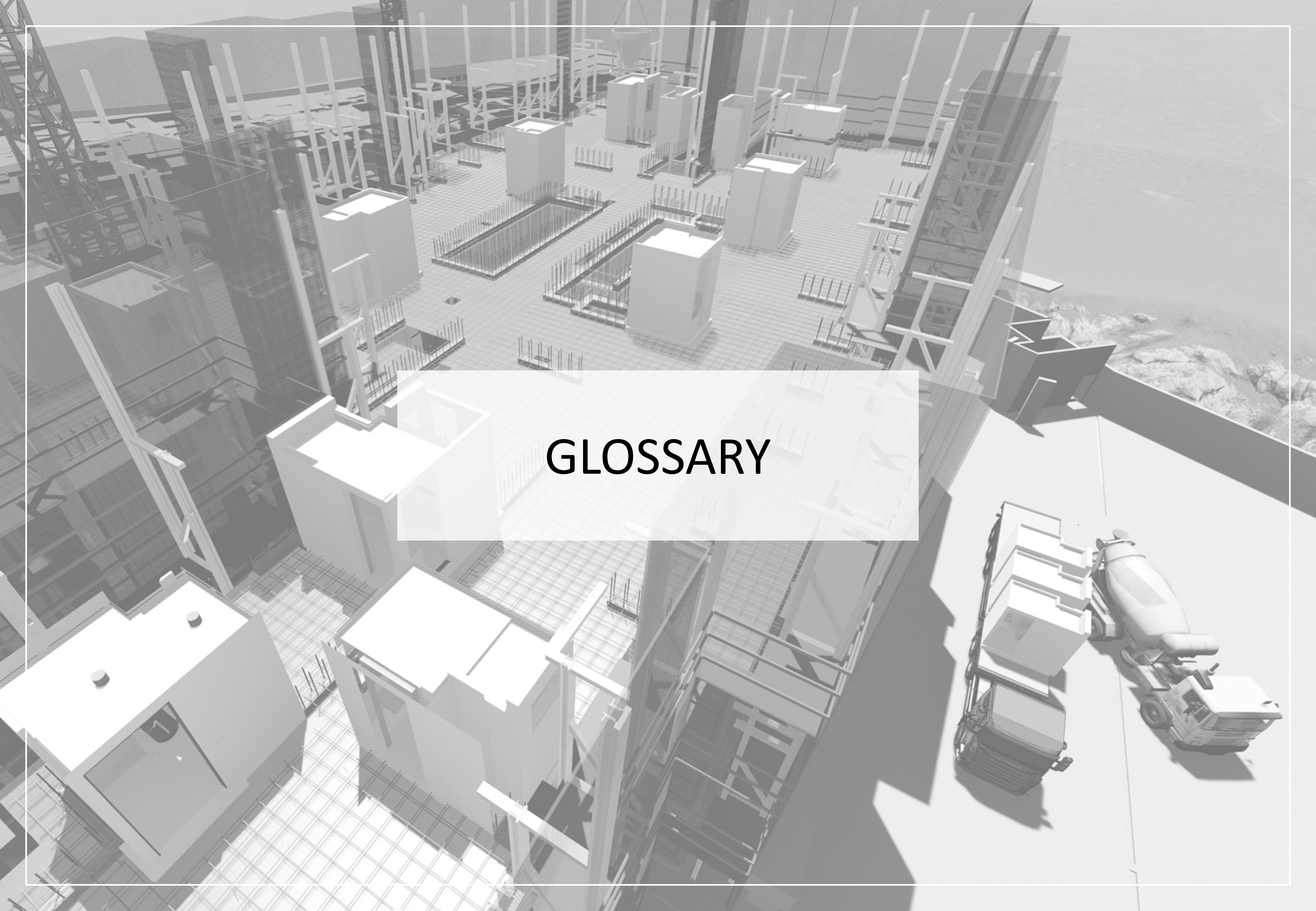
Trade Briefing & Demonstration Best Practices

The purpose of trade briefings and demonstrations is to brief the site team, including supervisors, REs, other subcontractors, on the methodology of installation of a specific trade so that all stakeholders are clear and can raise and clear all concerns and issues prior to first installation.

- ✓ Main contractor to organize trade briefing for major trades. Samples of these trades may be: Wall partition, ceiling, operable walls, MEP equipment, etc.
- ✓ Every trade will do presentation on their proposed step-by-step methodology
- ✓ Approved samples may be brought pertaining to their scope
- ✓ Trade briefing is to be done before the trade demonstration
- ✓ The first installation then becomes the trade demonstration. During the demonstration, the subcontractor / supplier explains what they are doing to ensure there is no miscommunication.
- ✓ Other subcontractors are to join these trade demonstrations to raise any site installation and sequencing interfacing with their individual trades
- ✓ Trade demonstration to be also attended by site staff, RE, RA, officers

The following images show a trade demonstration for ceiling installation.

GLOSSARY



Glossary of Terms and Acronyms

Activities
Activities are general tasks that need to be carried as part of accomplishing Critical Success Factors. Each activity or groups of activity must have a specific target against which performance may be measured.

BIM
Building Information Modelling. It is the process and technology used to create a Model

C&S
Civil and Structural

CDE
Common Data Environment (see page 23). This is a central information repository that can be accessed by all stakeholders in a project.

Core Information
Properties, attributes or parameters embedded in an object/element that shall be provided for use by the different project members for different purposes at different project stages.

Critical Success Factors
Essential tasks that that need to be performed or carried out in order to achieve a specific objectives.

E-Submission Model
A model that complies with all of the requirements for e-submission and is submitted to respective regulatory agencies.

Federated Model
A combined Building Information Model that has been compiled by linking or combining several different models into one

Goal
An overall desired result from all VDC efforts. It may be a project goal that is agreed upon in consensus with all stakeholders, or it can be an organizational goal to improve a company's business processes

Handover Model
A design intent model that is handed over to the awarded contractor for their visual reference and further development.

Information Model
Information models form the cornerstone of all VDC efforts as it is the repository of data that are required for all intended uses and analyses. As such, the validity of the data inside information models should be dictated by its suitability for use.

ICE
Integrated Concurrent Engineering. It is a methodology for effective, rapid, and reliable development of product and process design[1]

ICP
Intensive Collaboration Period. See Chapter 3.

KPIs
Key Performance Indicators. KPIs are quantifiable are metrics that reflects a goal or objective and how effectively a project team or company is achieving that goal or objective.

LBMS
Location Based Management System.

LEAN
Is a system of techniques that endeavors to maximize value through eliminating wastes and improving flow

LPS
Last Planner System.

Metrics
Are recorded measurements to track some aspect of your activities and measure the success or failure of the performance of that activity.

Model
A digital representation of the Project or part of the Project, and used to describe a two dimensional representation, three dimensional representation, as well as other data representations

Objectives
Objectives are more specific points of focus in order to carry out a goal. These aspects of focus help a project or organizational team concentrate their efforts and identify specific activities to be accomplished in alignment with their desired results.

PCP
Progressive Collaboration Period. See Chapter 3.

PPM
Project Production Management. Is a system and methodology that applies principles of production management in an building project.[1]

Tender Model
A design intent model that is fit for use for bidders during the tender period

Trade Model
Trade models are usually developed by the subcontractor or specialist contractor of that specific trade, and integrates the fabrication details and domain knowledge into the model.

VDC
Virtual Design and Construction. It is the management of BIM models as well as people and processes in order to achieve explicit project or organizational goals and to improve performance.

Virtual Mock-Up
These are models of isolated areas in the project and are developed to a very high level of detail and accuracy for the purpose of constructability and sequencing analysis, visualization and virtual reviews, and / or fabrication.

VDC Services
Are specific model uses for the information models to perform a unique task, usually relevant to the pre-identified activities and objectives.

[1] Centre for Integrated Facilities Engineering, Stanford University

OTHER BIM PUBLICATIONS

All documents related to BIM e-Submission and other BIM Guides can be downloaded from the CORENET website:
https://www.corenet.gov.sg

SINGAPORE BIM GUIDE

BIM ESSENTIAL GUIDES

BIM Essential Guide for Adoption in Organization

BIM Essential Guide for C&S Consultants

BIM Essential Guide for Execution Plan

BIM Essential Guide for MEP Consultants

BIM Essential Guide for Architectural Consultants

BIM Essential Guide for Contractors

BIM Essential Guide for Building Performance Analysis

BIM for DfMA Essential Guide

BIM Essential Guide for Land Surveyors

CODES OF PRACTICE FOR BIM E-SUBMISSION

General Requirements

Architectural Requirements

Civil and Structural (C&S) Requirements

Mechanical, Electrical & Plumbing (MEP) Requirements

REFERENCES:

- https://www.leanconstruction.org/
- https://cife.stanford.edu/
- Andersson, L., Farrell, K., Moshkovich, O., & Cranbourne, C. (2016). Implementing virtual design and construction using BIM: current and future practices. London: Routledge, Taylor & Francis Group.
- Damelio, R. (2011). The Basics of process mapping. New York: CRC/Productivity Press

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For more information and feedback on the
Code of Practice for Virtual Design and Construction,
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