Building Information Modelling (BIM) Training

https://ibse.hk/BIM-Training/

3.1 Construction coordination

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Jun 2025

Contents

- Construction planning
- Virtual construction model
- Potential benefits
- BIM-based coordination
- Examples of coordination issues

Construction Project Management

(Source: https://www.fieldwire.com/blog/top-challenges-for-construction-project-managers/)

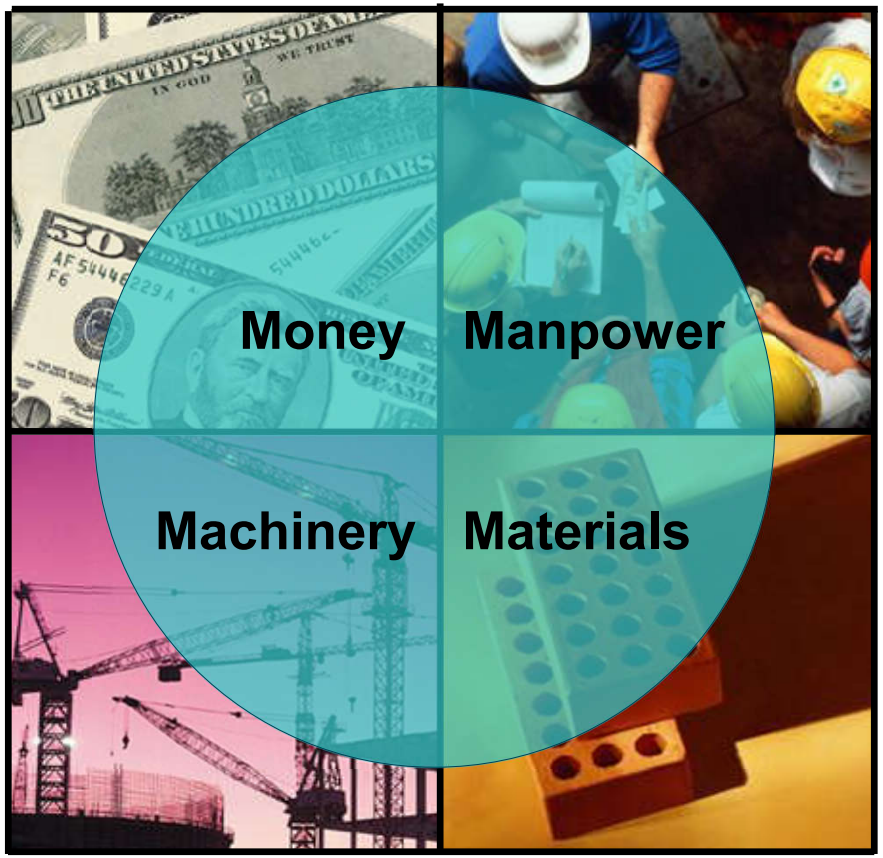
Problem Definition

- **Design**
  - No direct cost feedback on design decisions
  - Coordination of trades
- **Sub Contractor Cost**
  - Missing / Incorrect Design Information
  - Inability for reusing data for shop drawings
  - Field rework required for prefabricated components
  - Padding to compensate risks
  - Poor subcontractor work flow – “Starts and Stops”
  - Inadequate quantity information for planning
- **Construction**
  - Lack of owner trust – difficulties in communicating cost and schedule issues
  - Production control is based on subjective information
  - Frequent starts and stops
  - Estimating is time consuming and occasionally inaccurate
- **Facility Management**
  - Insufficient as-built project documentation
  - Renovation, addition and demolition planning is time consuming

(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Objectives

- Winning the bid
  - Fast design feedback loop
  - Fast & accurate estimates
  - Value engineering
  - Constructability analysis
- Managing the 4 Ms
  - Money
  - Manpower
  - Machinery
  - Materials



(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Construction Planning

Model

- Constructability Analysis
- Drives Estimating
- Provides Locations
- Zone Planning
- Design to Build / Build to Design

Estimating

- Fast & Accurate
- Easy Updates – Linked
- Drives Sequencing

Sequencing

- Schedule Analysis
- Line of Balance
- Integrated Monte Carlo
- 4D Simulation
- Drives Procurement

Procurement

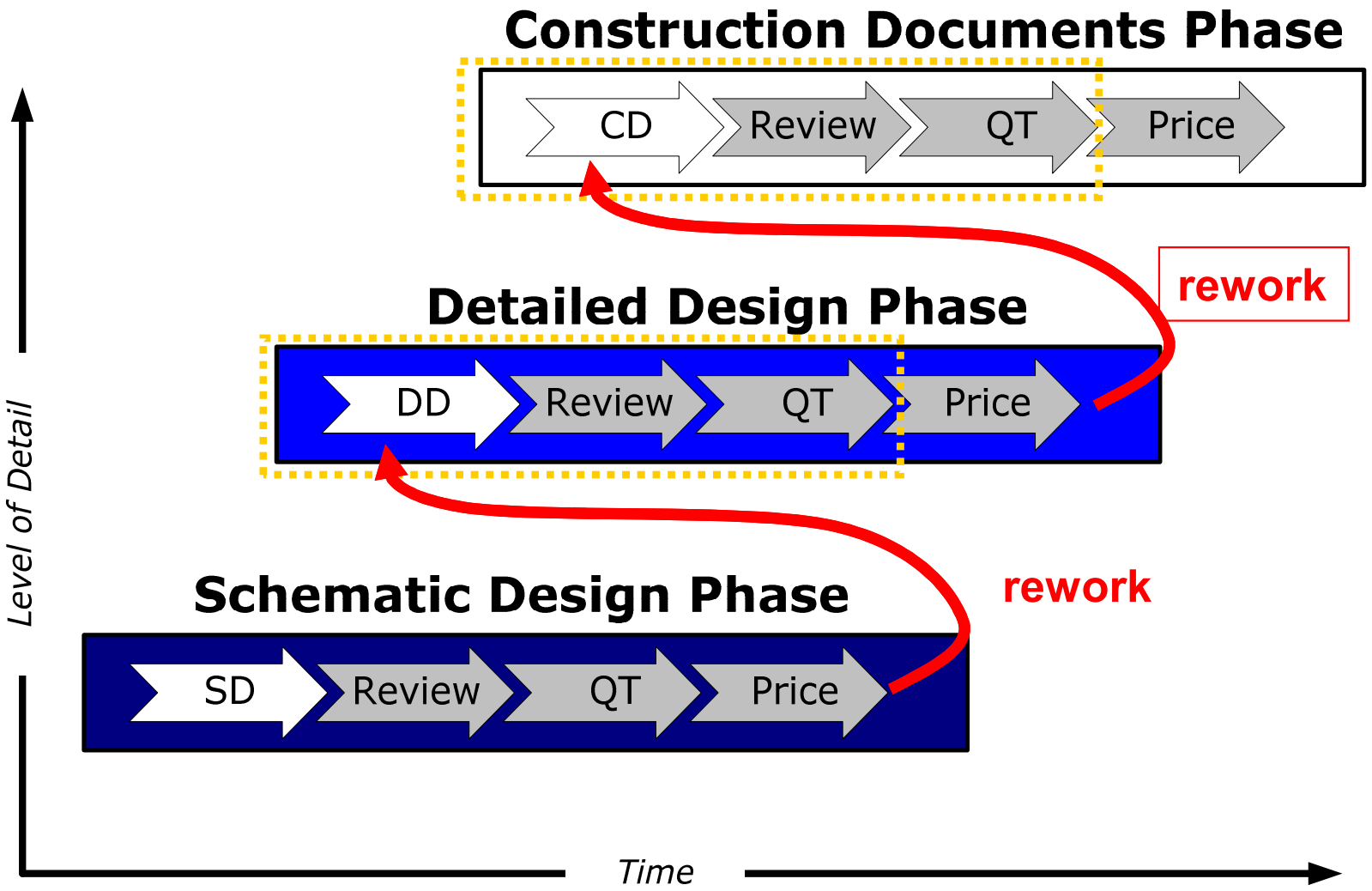
- Data Mining for Supplier Negotiations
- Tracking of High Risk, Long Lead Items
- Integrated with the Project Schedule
- Drives Site Management Process

Site Management

- Short Lead Procurement
- Site Planning for Materials, Equipment & Locations

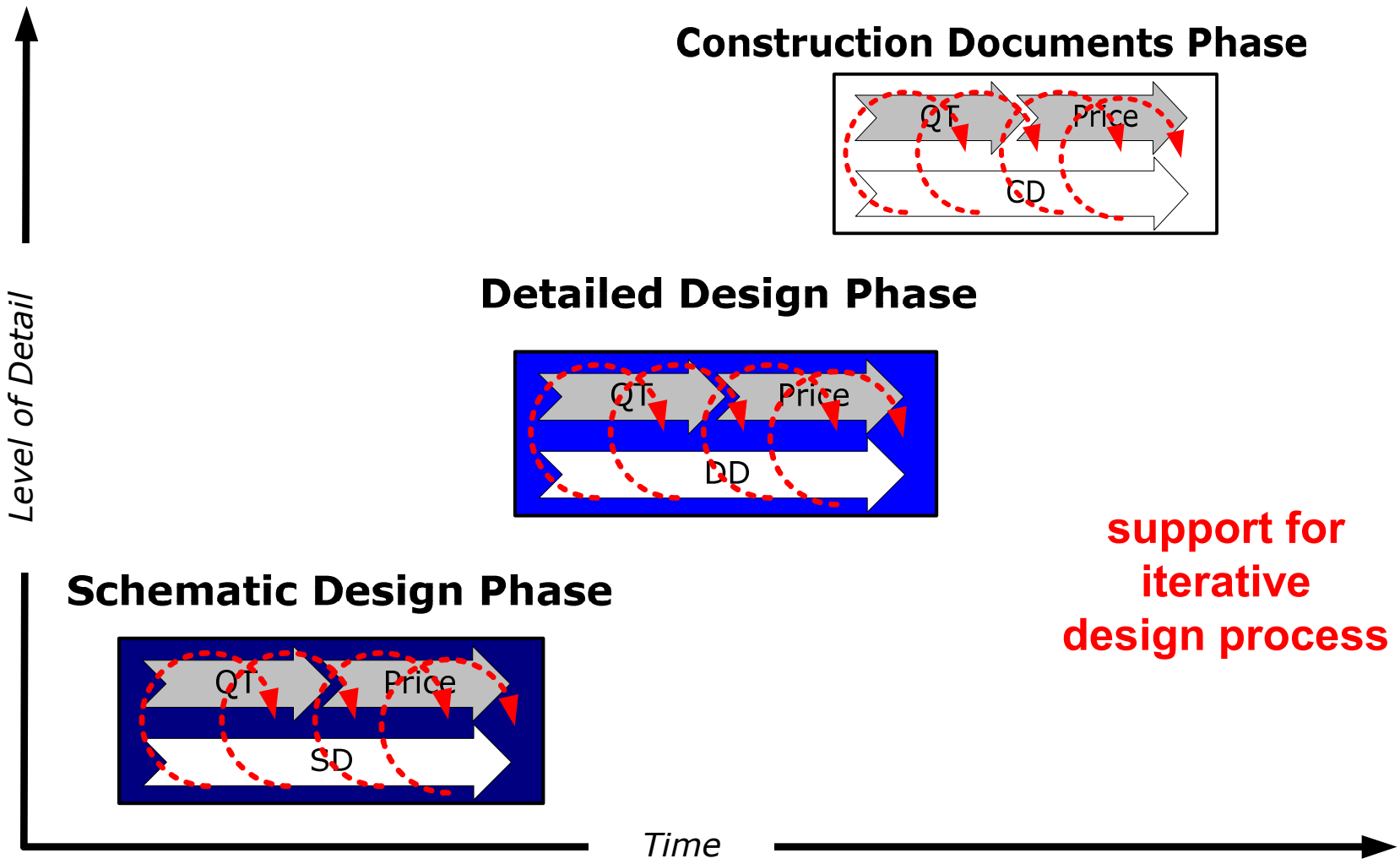
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Traditional Design Process



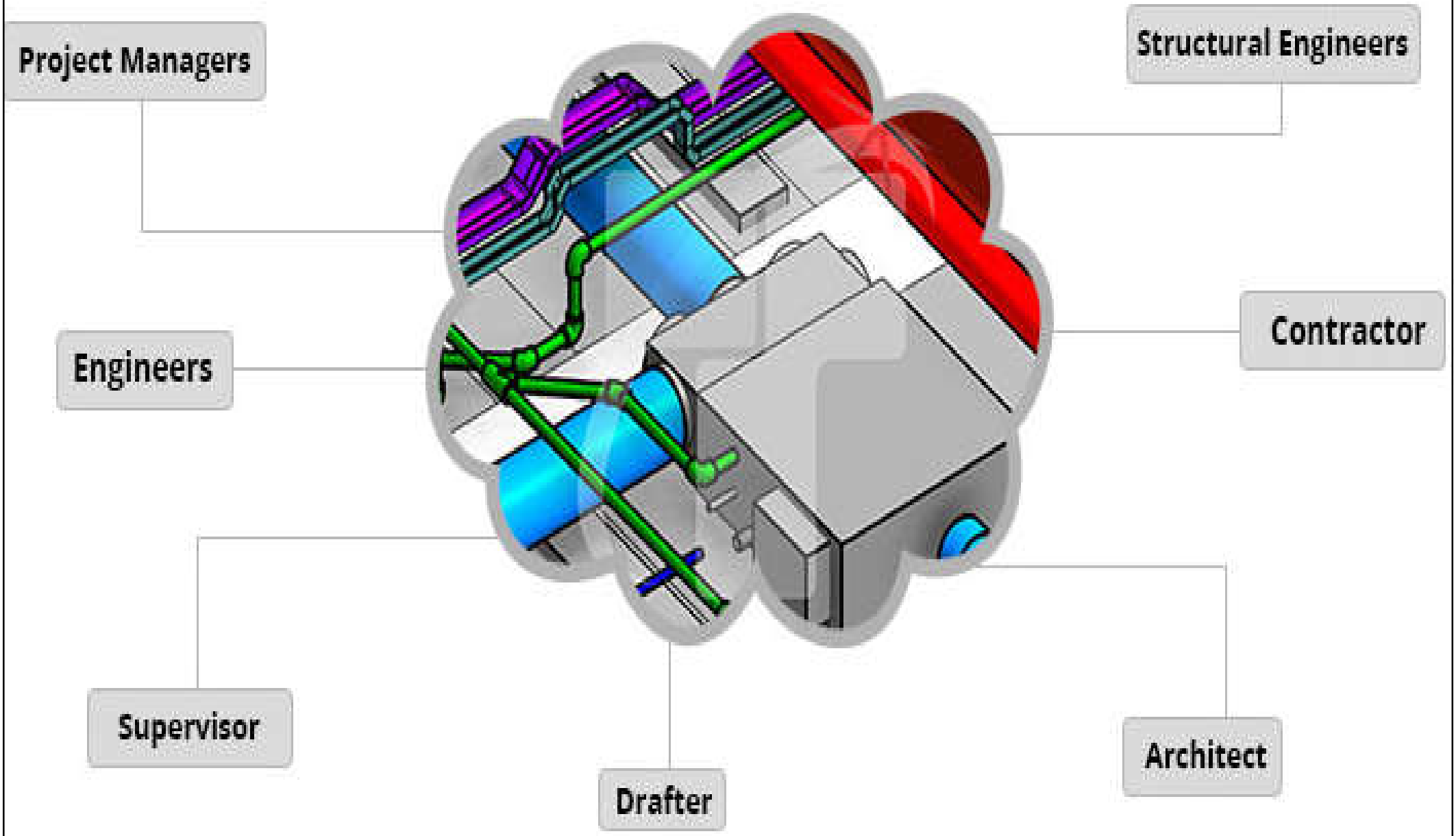
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

New Design Process



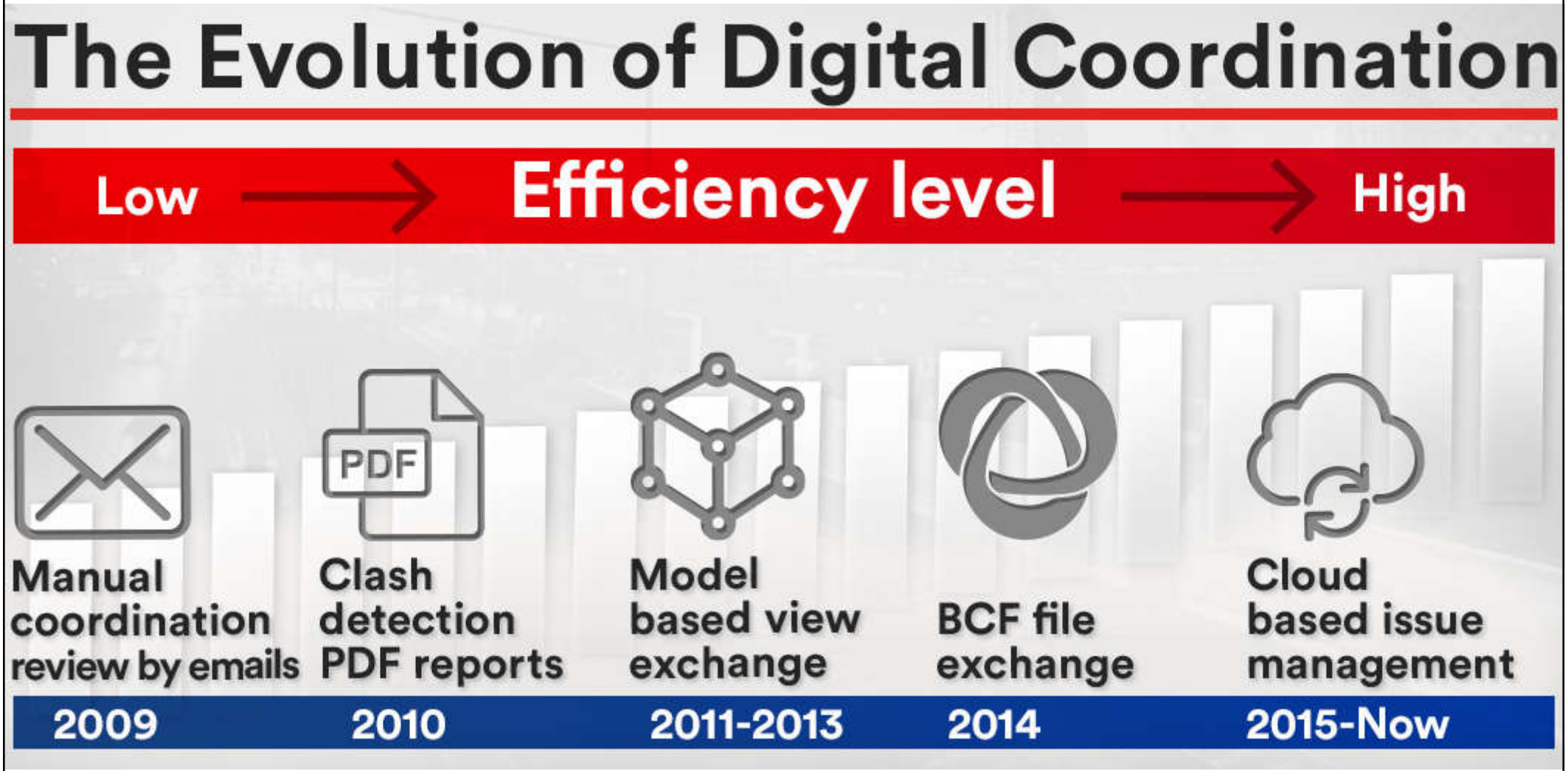
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

How does BIM enhance coordination on large projects?



(Source: https://www.teslaoutsourcingservices.com/blog/how-does-cloud-based-bim-enhance-coordination-on-large-projects/)

The evolution of BIM coordination



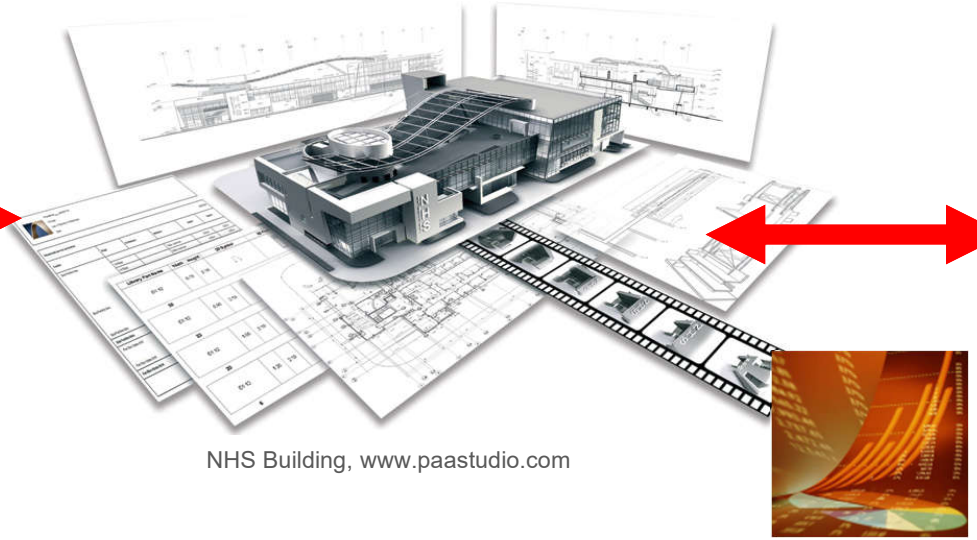
(Source: https://bimtrack.co/blog/blog-posts/from-confusion-to-collaboration-my-journey-through-the-evolution-of-bim-coordination)

The Virtual Construction Model (5D)

Time (4D)

BIM Model (3D)

Cost (5D)



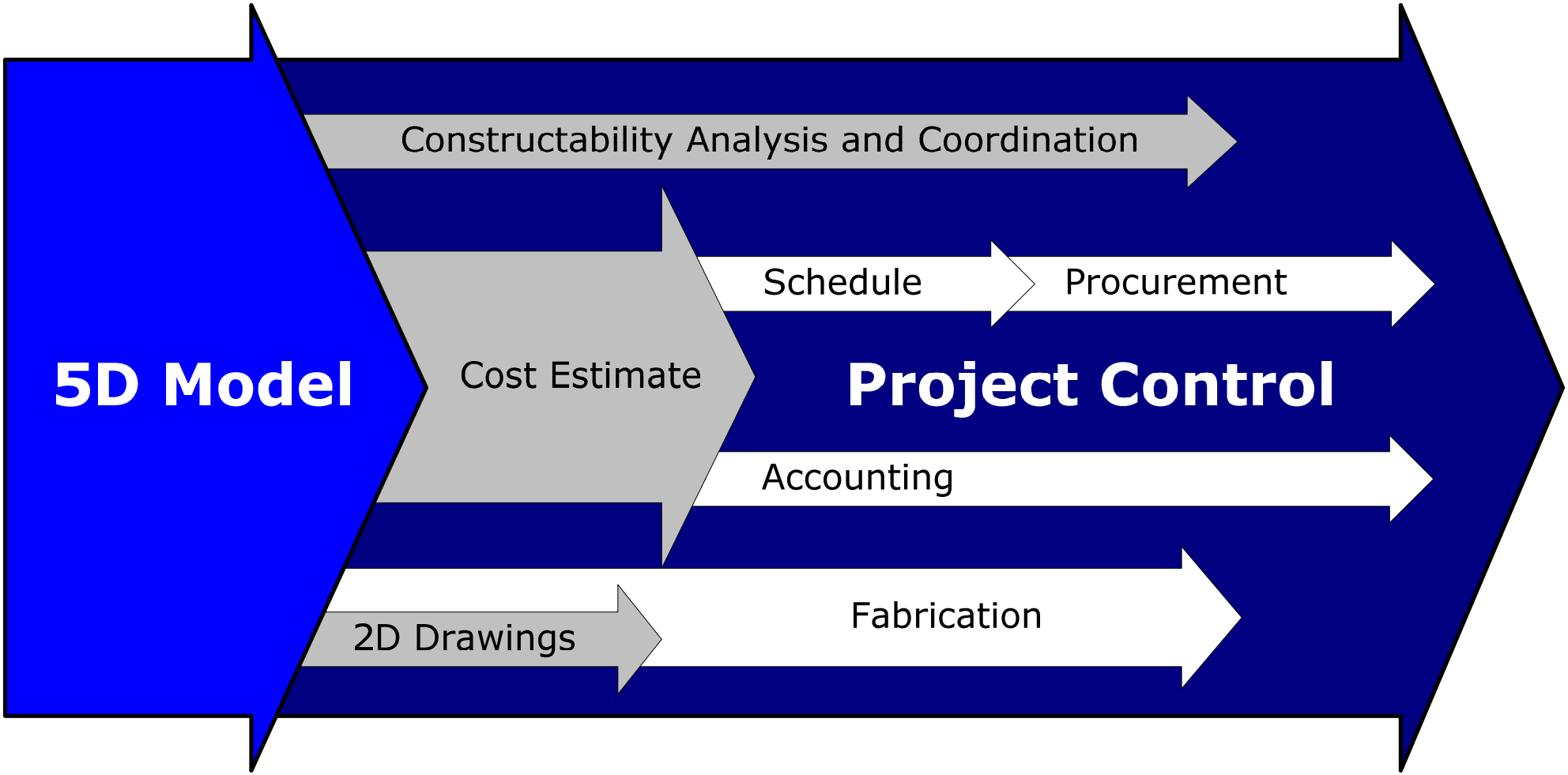
NHS Building, www.paastudio.com

Linked Schedules

Linked Estimating Recipes

(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Work Flow



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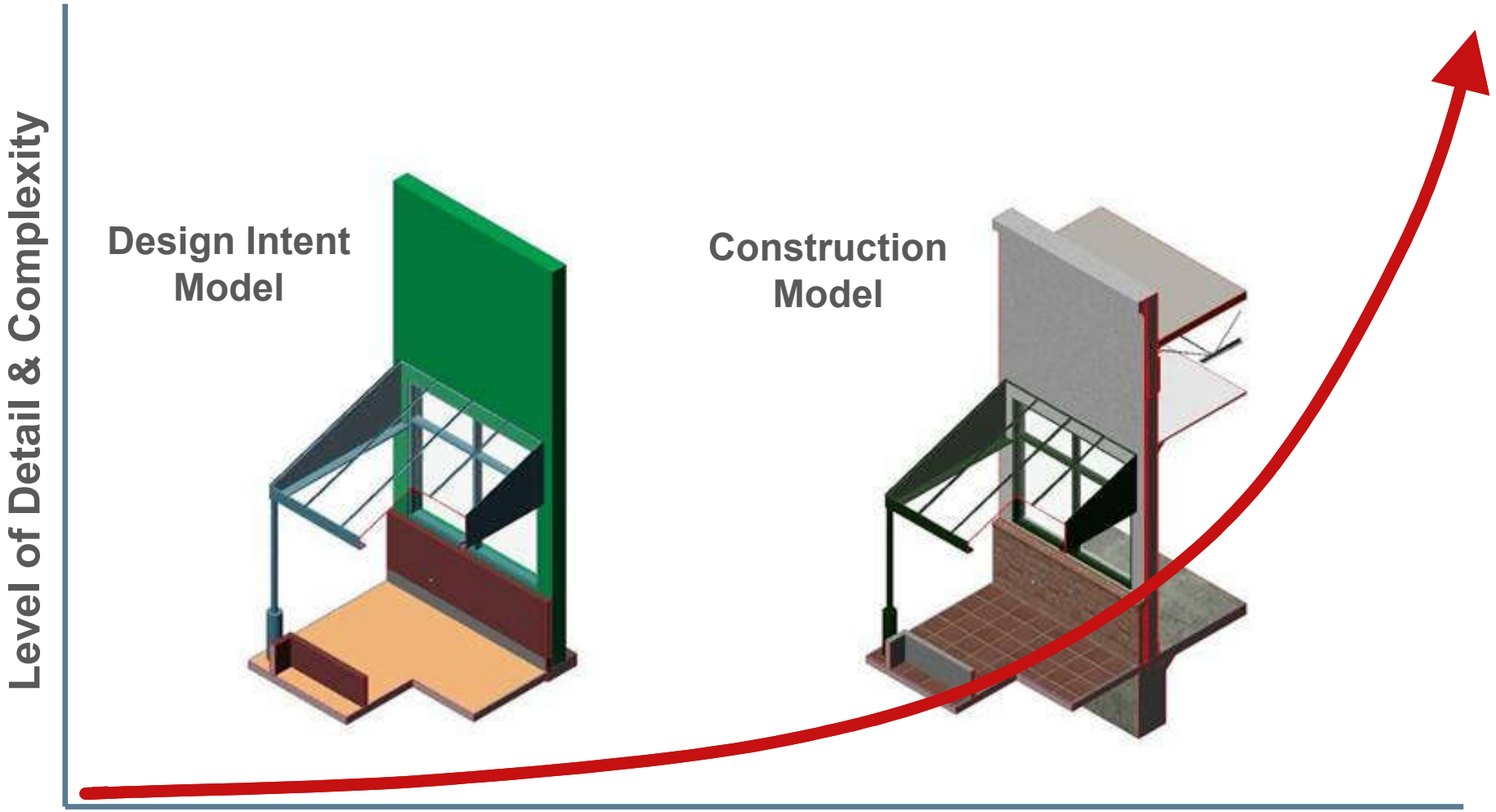
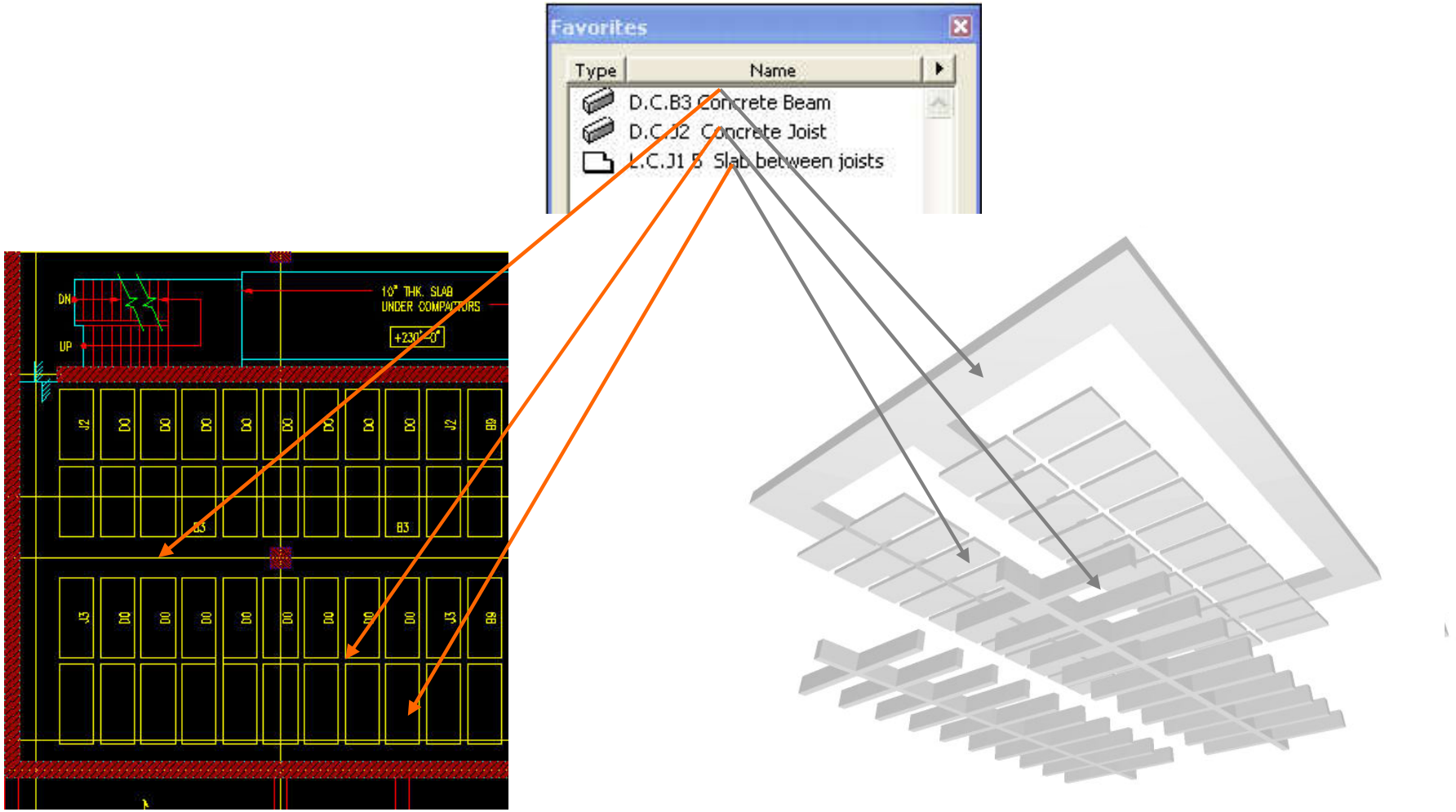
Construction Modelling



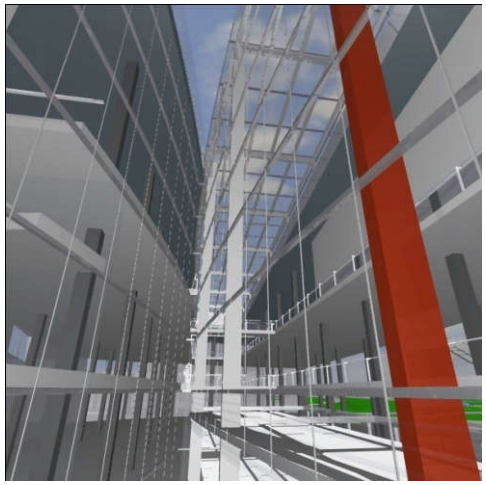
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Construction Modelling



(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Recipe

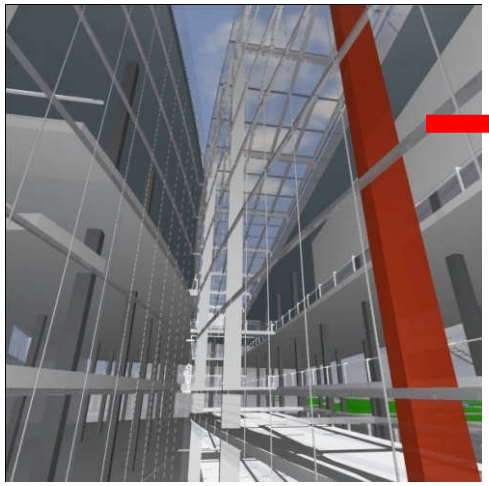


Recipe

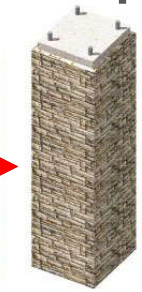
Completed Column

(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Methods



Stages Required
to Finish Column



Reinforcing
Bars

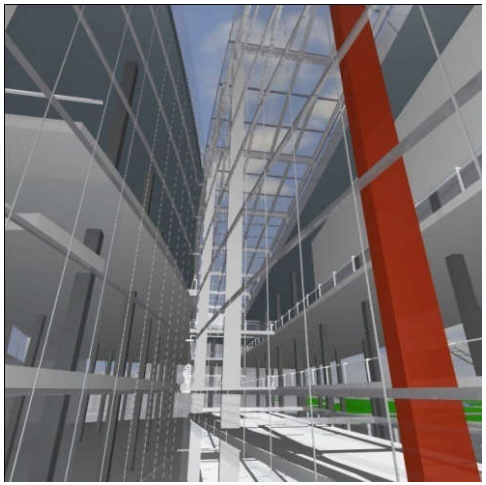
Formwork

Concrete

Cladding /
Surface finish

(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Resources



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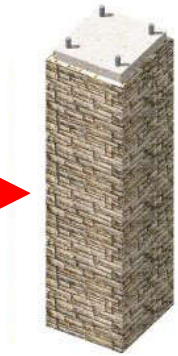
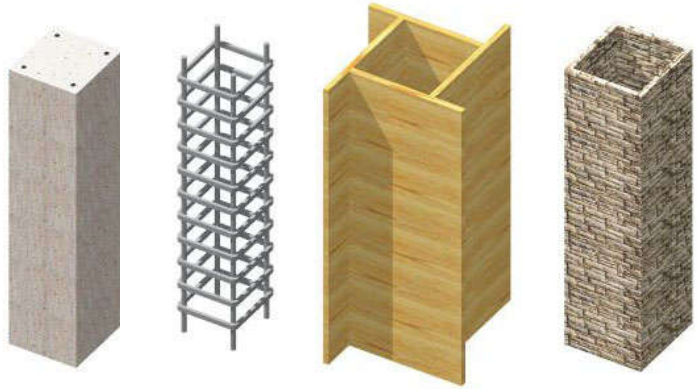


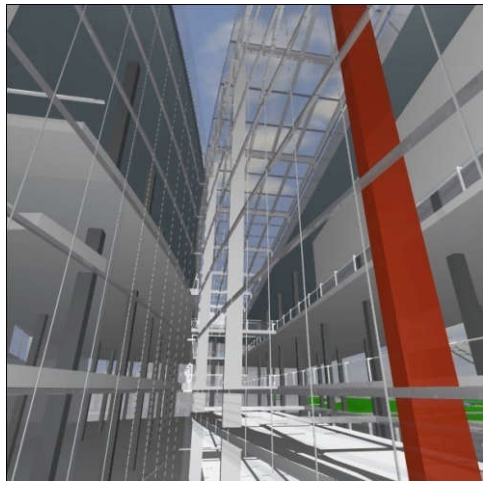
Methods



Resources

(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

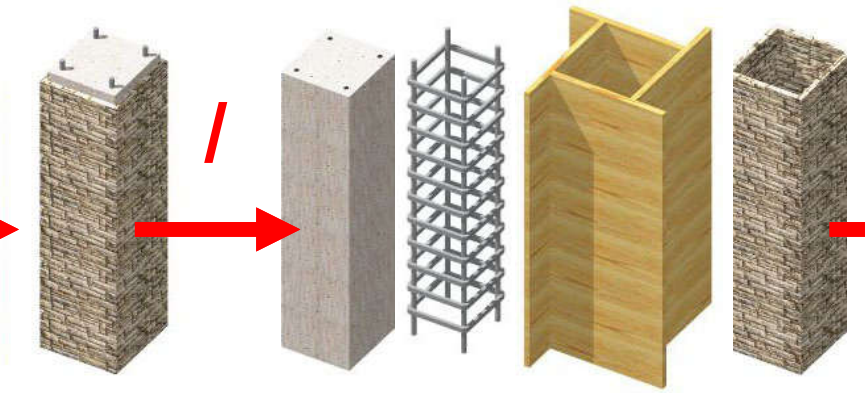
5D



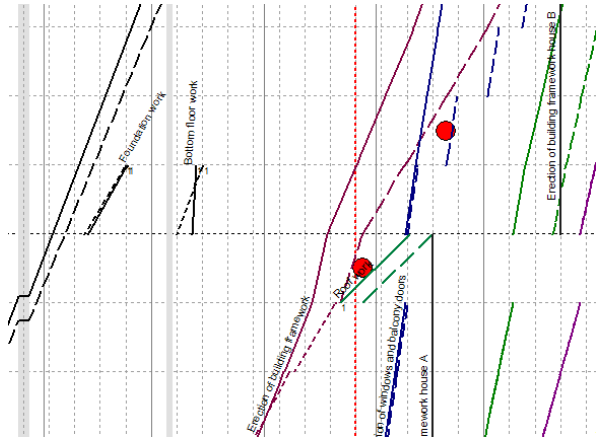
Recipe

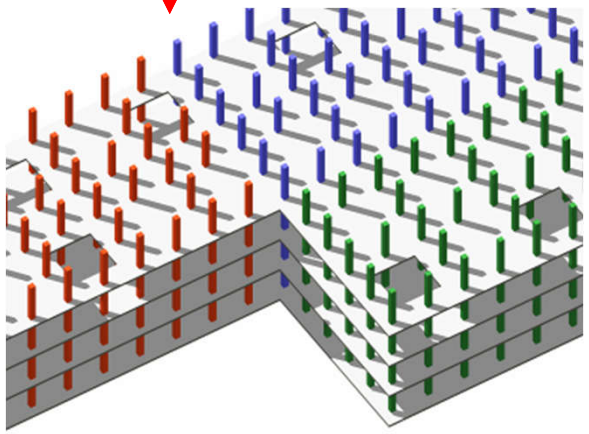
Methods

Resources



Zones/Floors

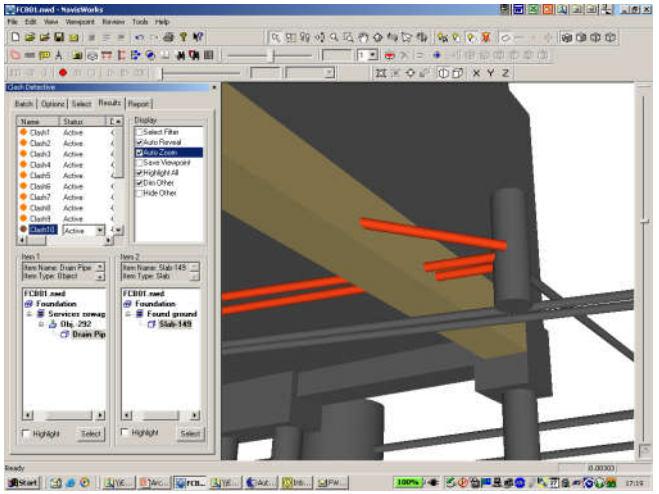


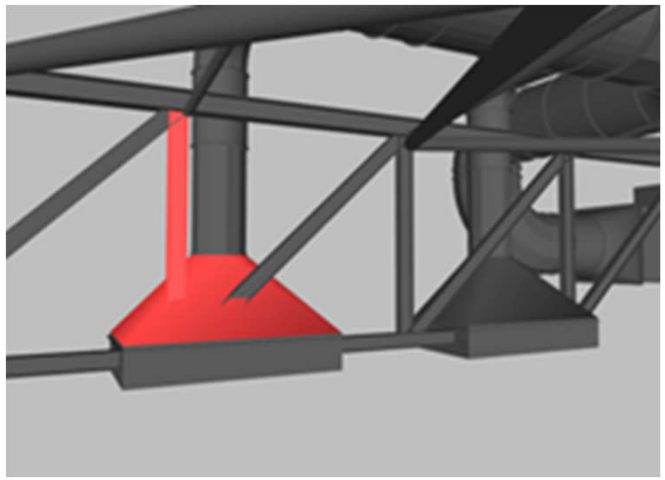


(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Benefits: Clash Detection

- Conventional methods of coordination are extremely time consuming and error-prone.
- Using internal or external clash detection software helps to identify the construction errors in the BIM model
- Construction risks and costs can be reduced significantly





(See also: Coordination and Clash Detection http://www.vicosoftware.com/coordination-and-clash-detection)

(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

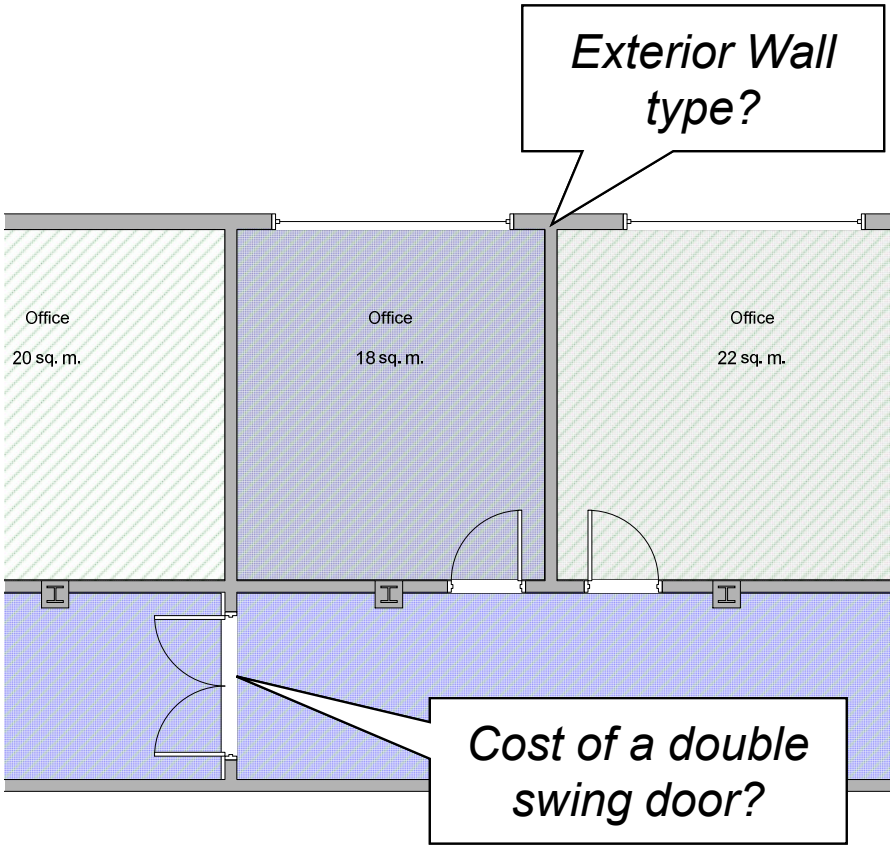
Benefits: Model-based Estimating

Early Design phases:

- Which materials?
- Price of materials?

Solution:

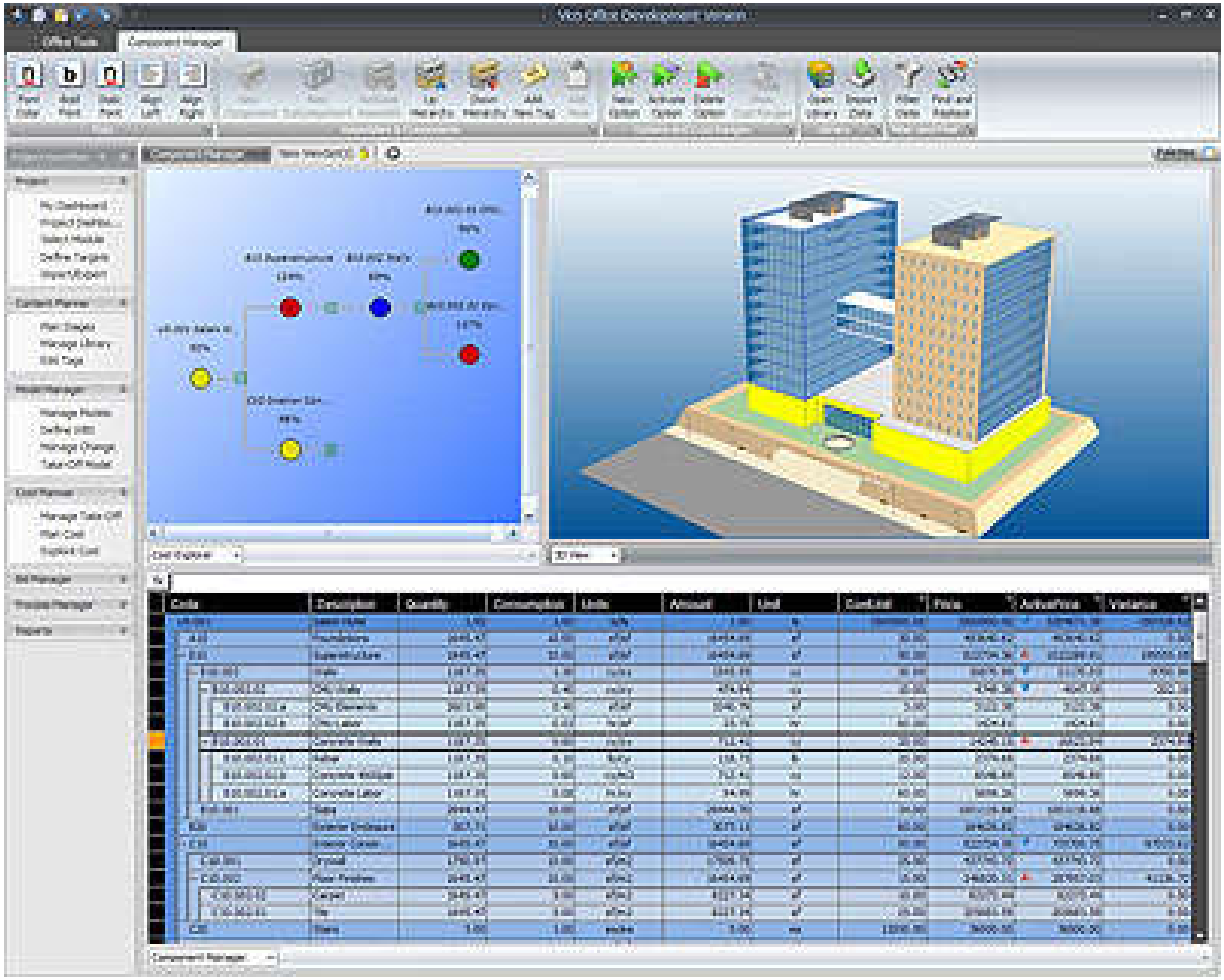
- Calculate cost ranges instead of fixed prices



(See also: Model-Based Estimating http://www.vicosoftware.com/model-based-estimating)

(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Benefits: Vico Cost Planner



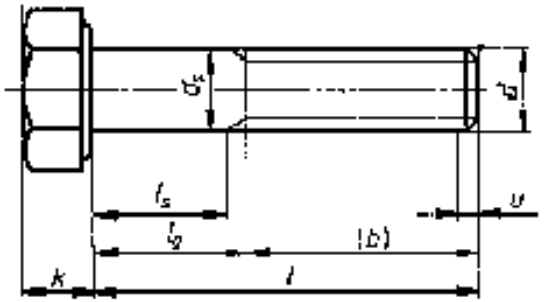
(See also: Cost Planning vs Estimating http://www.vicosoftware.com/cost-planning-versus-estimating)

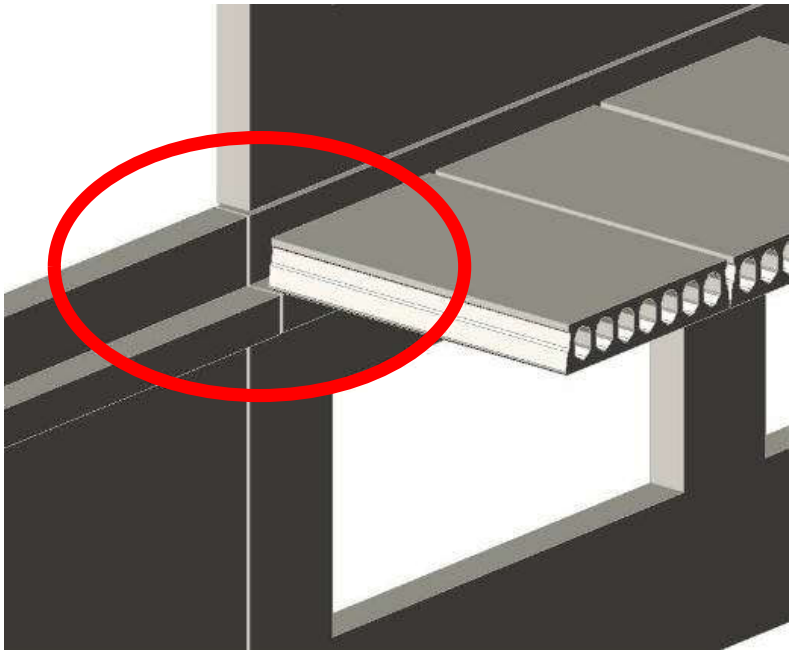
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Benefits: Design to Build

Design follows construction methodology:

- Acceptable Tolerance
- Coordination of Trades
- Quality Check

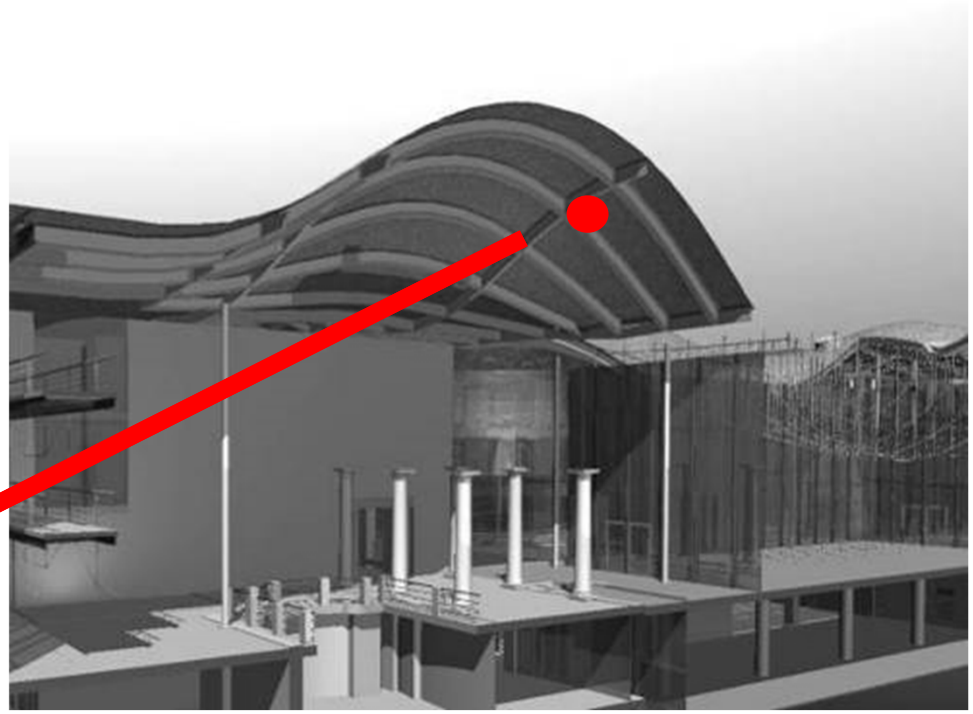


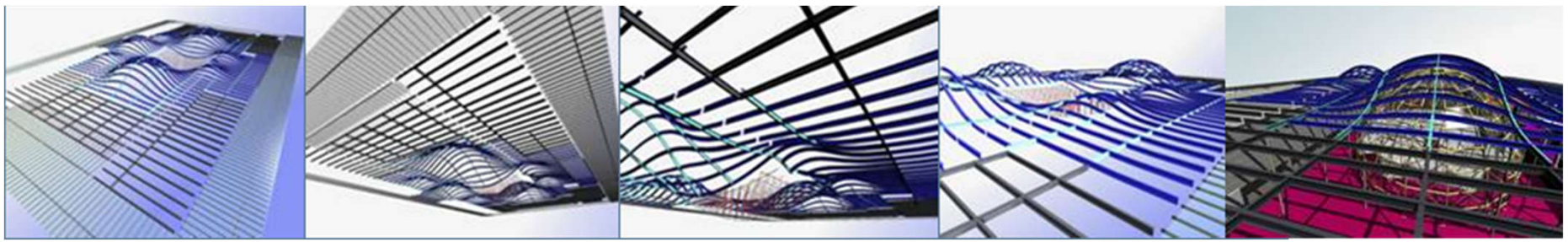


(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Benefits: Build to Design

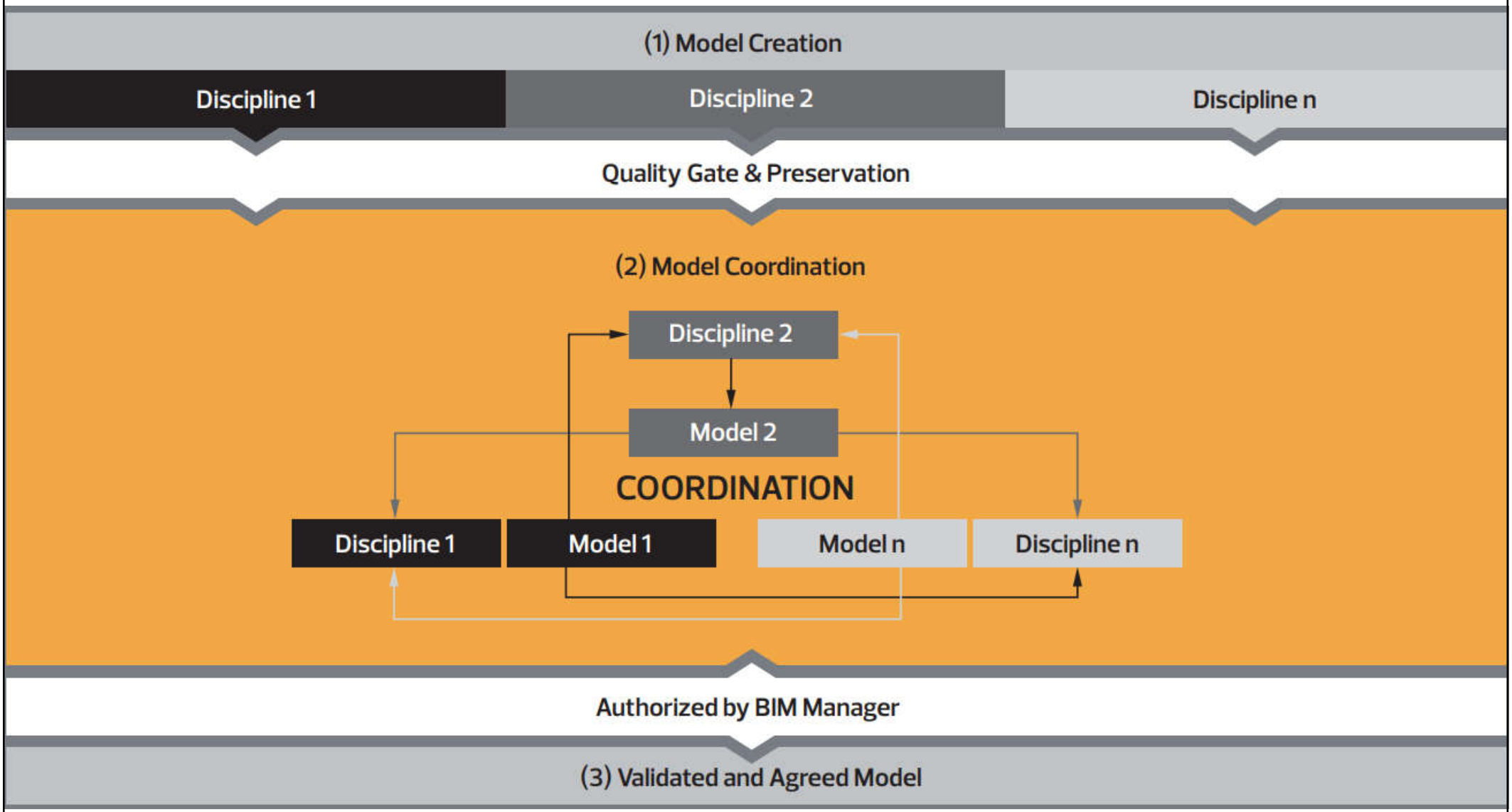
- Measure points
- Check Onsite
- Guarantee Fit





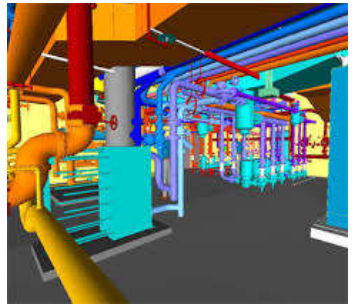
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Schematic BIM-based creation, coordination, and collaboration process



(Source: https://info.allplan.com/hubfs/07_Guides/Whitepaper_BIM_Integration_Framework_EN.pdf)

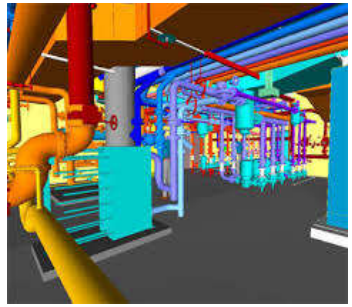
BIM-based coordination



- Model-based collaboration
  - With digital, structured building models
  - Discipline-oriented or Federation model approach
    - Every author, in accordance with their discipline, is responsible for their own digital model and shall have access for this model content only
    - Discipline model, submodel or technical model
  - With clear allocation of authors to individual discipline models, the components and changes can be organized clearly

(Source: https://info.allplan.com/hubfs/07_Guides/Whitepaper_BIM_Integration_Framework_EN.pdf)

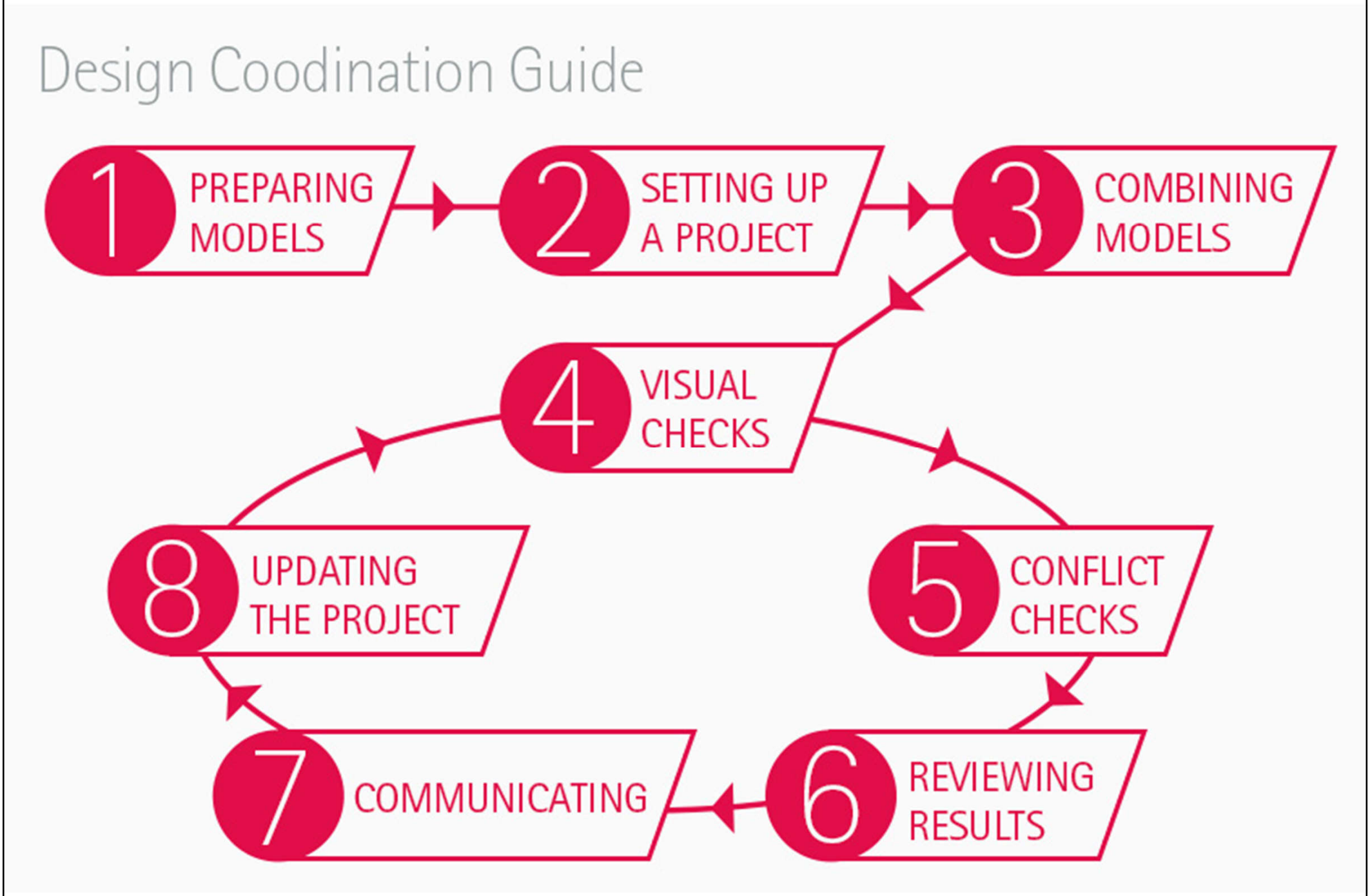
BIM-based coordination



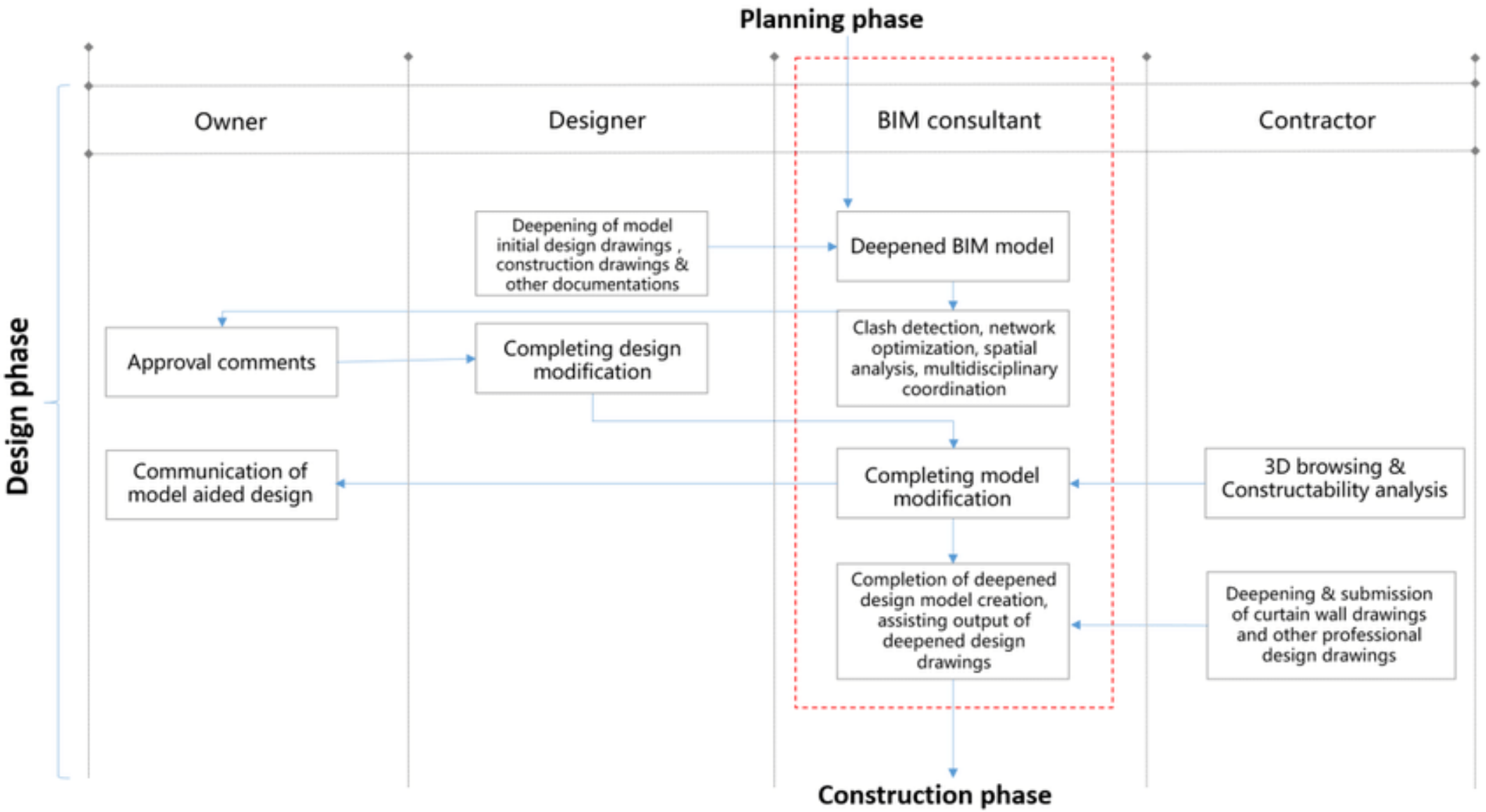
- Model-based collaboration (cont'd)
  - To safeguard the integrity and consistency of the entire model, the technical models must be checked at regular intervals by the BIM manager in a coordination environment
  - The organization and management of digital information and associated processes is the principle task during the entire BIM-based construction project, under a Common Data Environment (CDE)

(Source: https://info.allplan.com/hubfs/07_Guides/Whitepaper_BIM_Integration_Framework_EN.pdf)

Design coordination in BIM

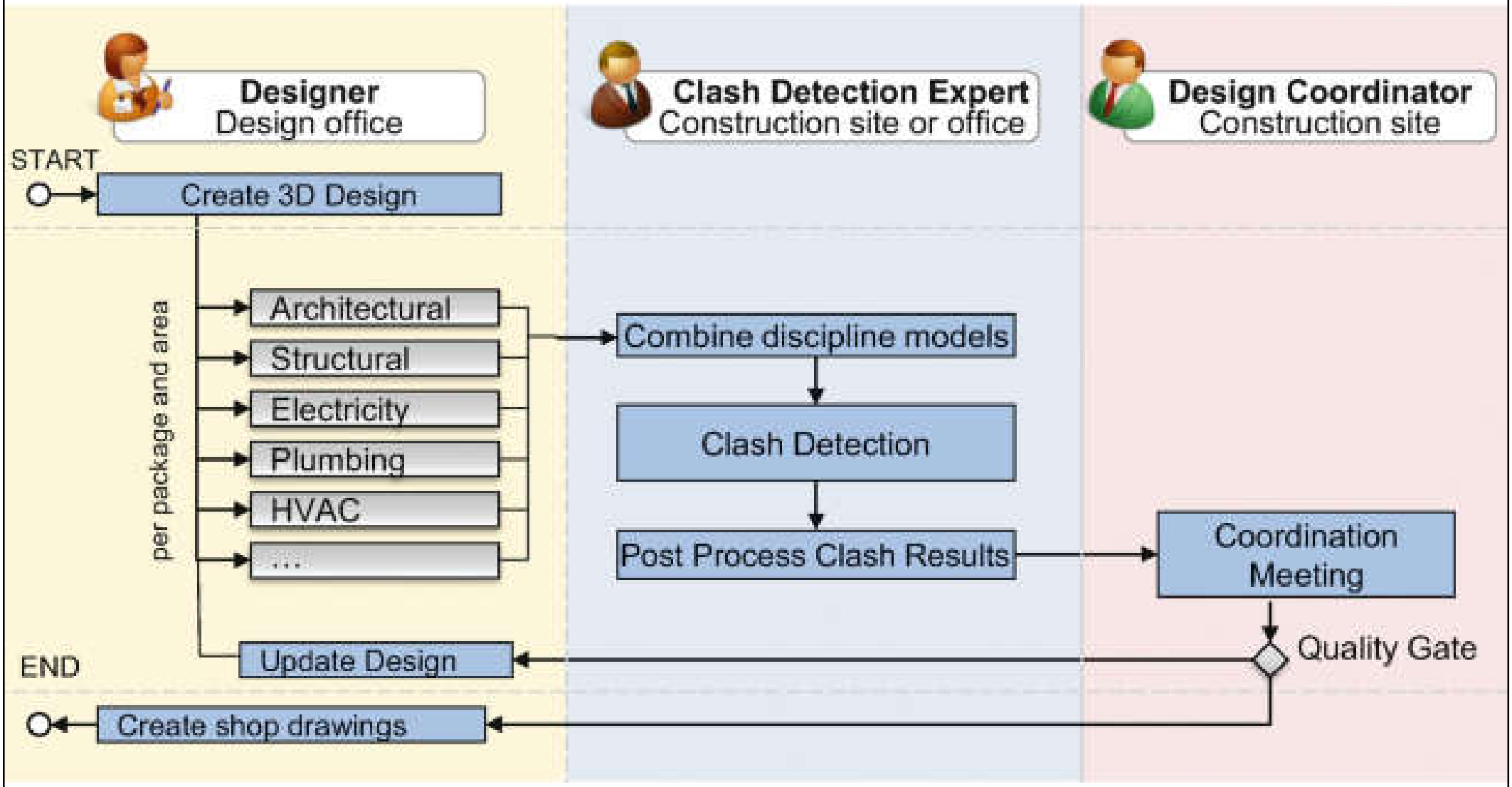


BIM-based design coordination system



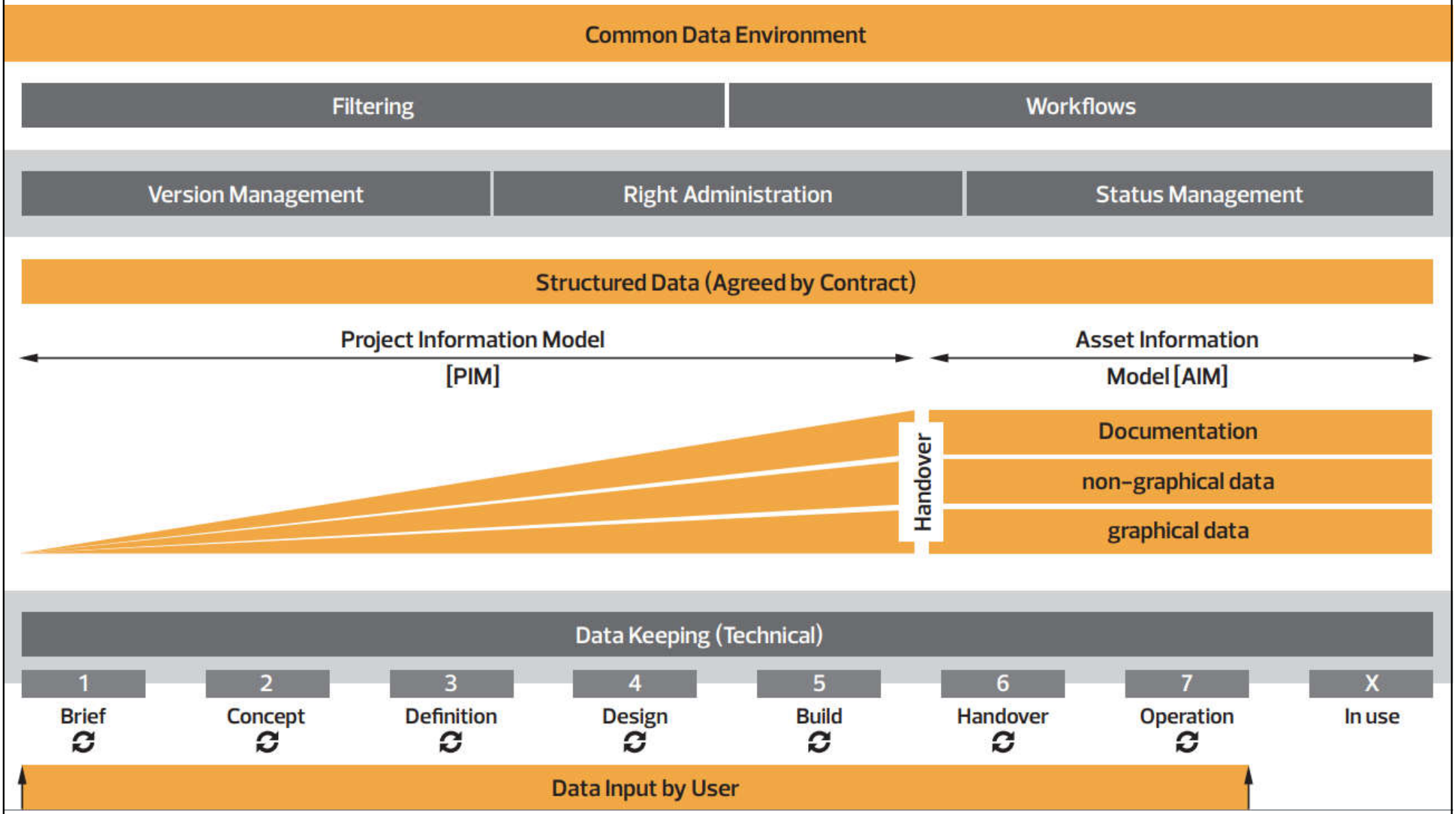
(Source: https://www.researchgate.net/publication/319131971_BIM-Based_design_coordination_for_china's_architecture_engineering_and_construction_industry)

BIM-based design coordination process



(Source: https://link.springer.com/chapter/10.1007/978-3-319-92862-3_18)

Example of Common Data Environment (CDE)



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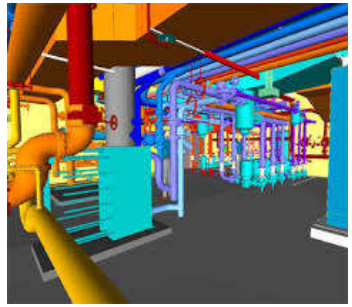
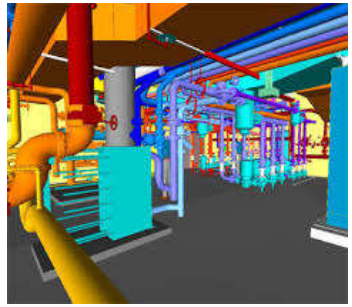
BIM-based coordination



- Common Data Environment (CDE)
  - An information management strategy generally using a piece of software or a paper process
  - Create a single source of truth (SSOT) for any given project (or asset)
  - To collect manage and disseminate all relevant approved project documents for multi-disciplinary design teams members (architects, engineers, MEP) in a managed process

(Source: http://www.cadnet.ltd.uk/services/bim-data-management/common-data-environment/)

BIM-based coordination

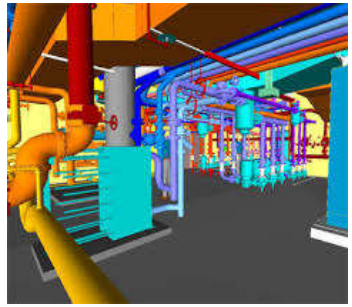


- Common Data Environment (CDE) (cont'd)
  - The centralization of the stored data within the CDE reduces the risk of redundancies and simultaneously ensure that all data is up-to-date
  - The CDE results in a higher reuse rate, simplifies the aggregation of model information and at the same time serves as the central platform for archiving and documentation

(See also: Common data environment CDE https://www.designingbuildings.co.uk/wiki/Common_data_environment_CDE)

(Source: https://info.allplan.com/hubfs/07_Guides/Whitepaper_BIM_Integration_Framework_EN.pdf)

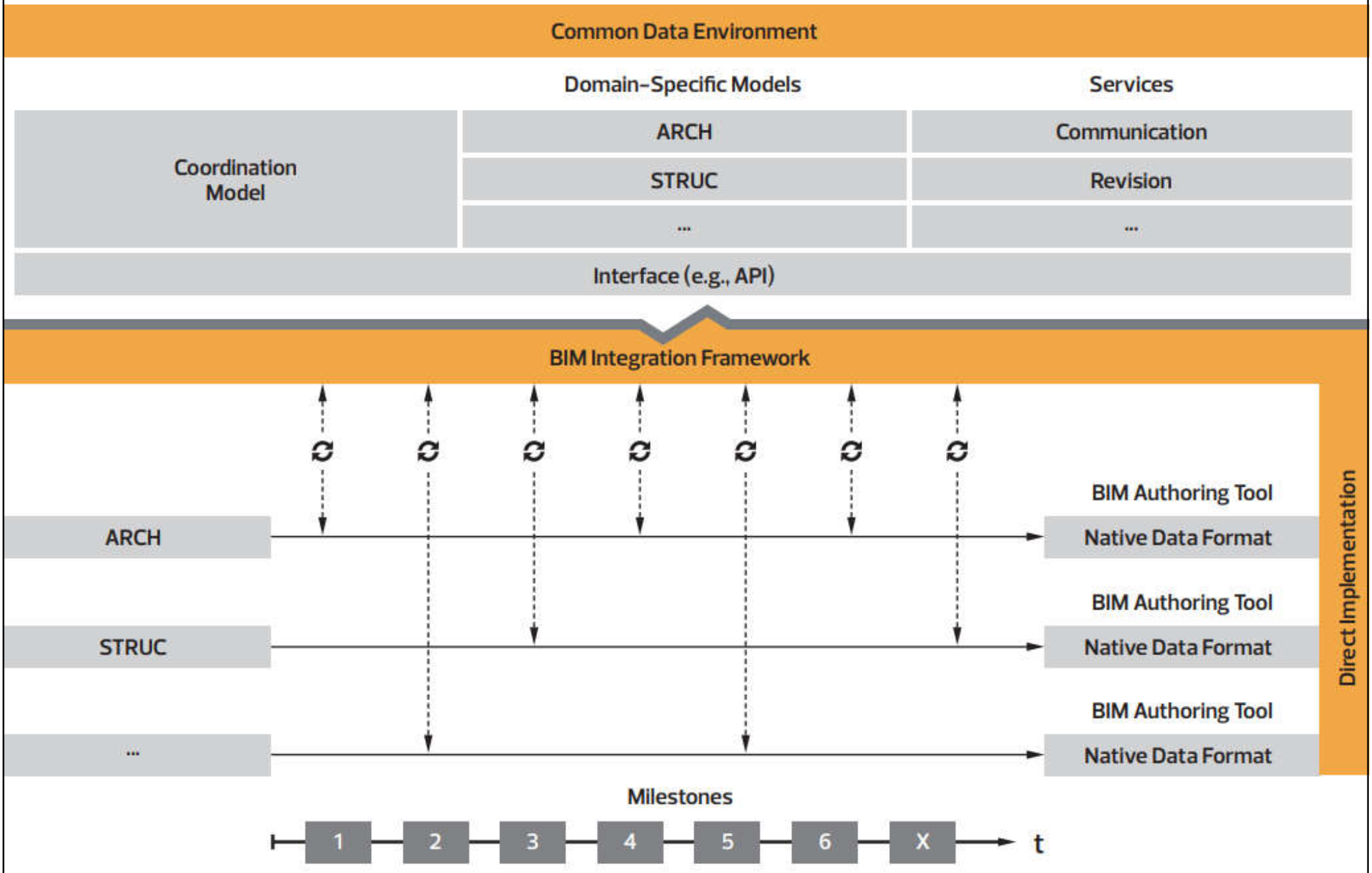
BIM-based coordination



- BIM Integration Framework (BIF)
  - It represents a software concept which can establish the link from any BIM tool to a CDE
  - Provide seamless integration of access
  - BIF assembles all functions of the interface
  - Functions are simultaneously standardized regardless of the BIM tool used, in order to enable smooth collaboration (e.g. information exchange, process management or communication)

(Source: https://info.allplan.com/hubfs/07_Guides/Whitepaper_BIM_Integration_Framework_EN.pdf)

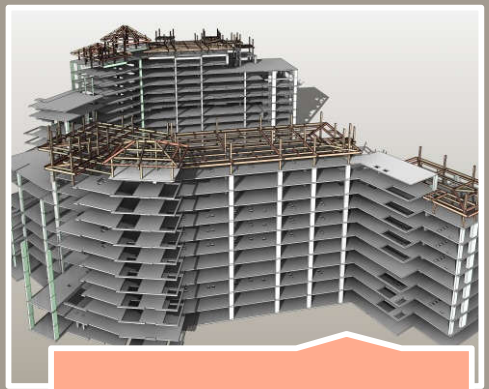
Collaboration processes based on the BIM Integration Framework



(Source: https://info.allplan.com/hubfs/07_Guides/Whitepaper_BIM_Integration_Framework_EN.pdf)

Examples of BIM use in building, construction and infrastructure

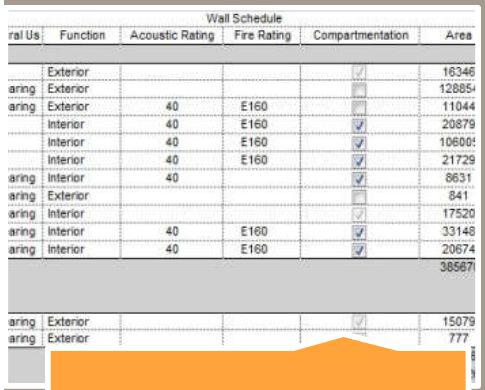
Architectural



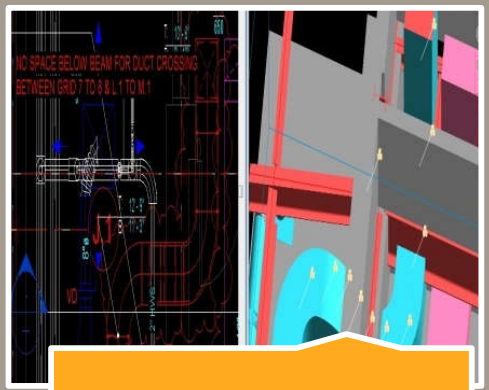
Structural

MEP

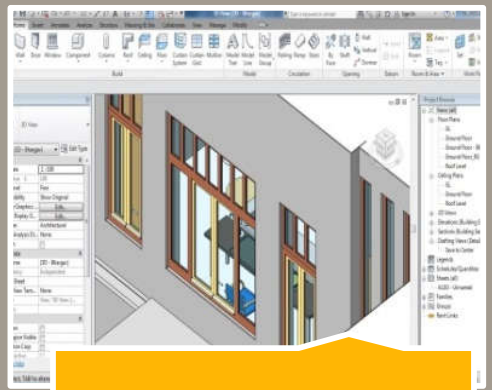
Co-ordination



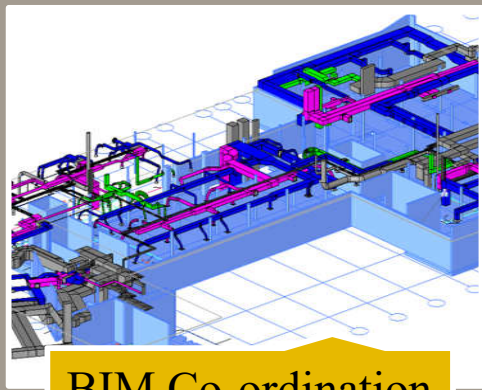
Scheduling



Clash Detection

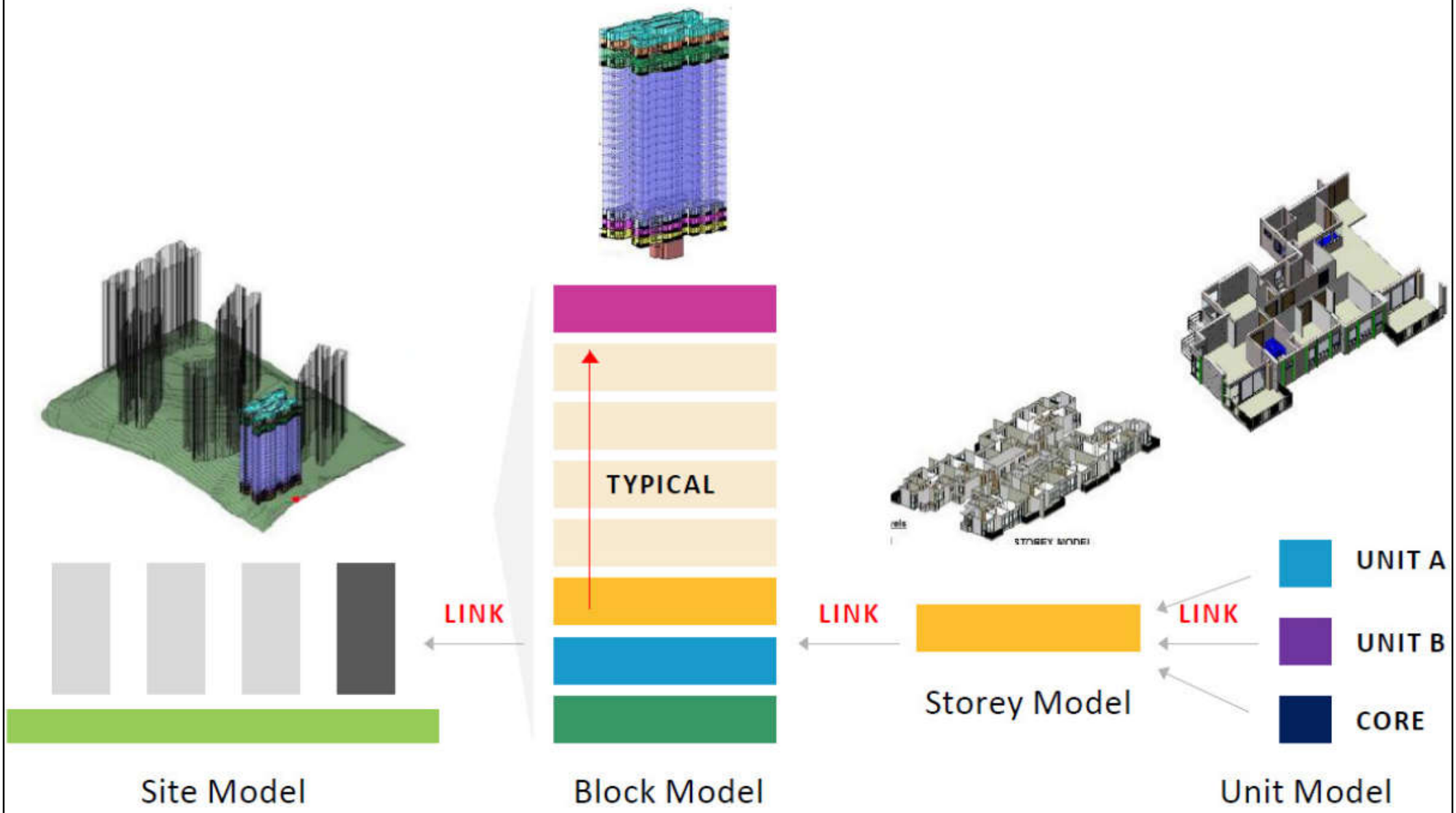


Family Creation



BIM Co-ordination Model

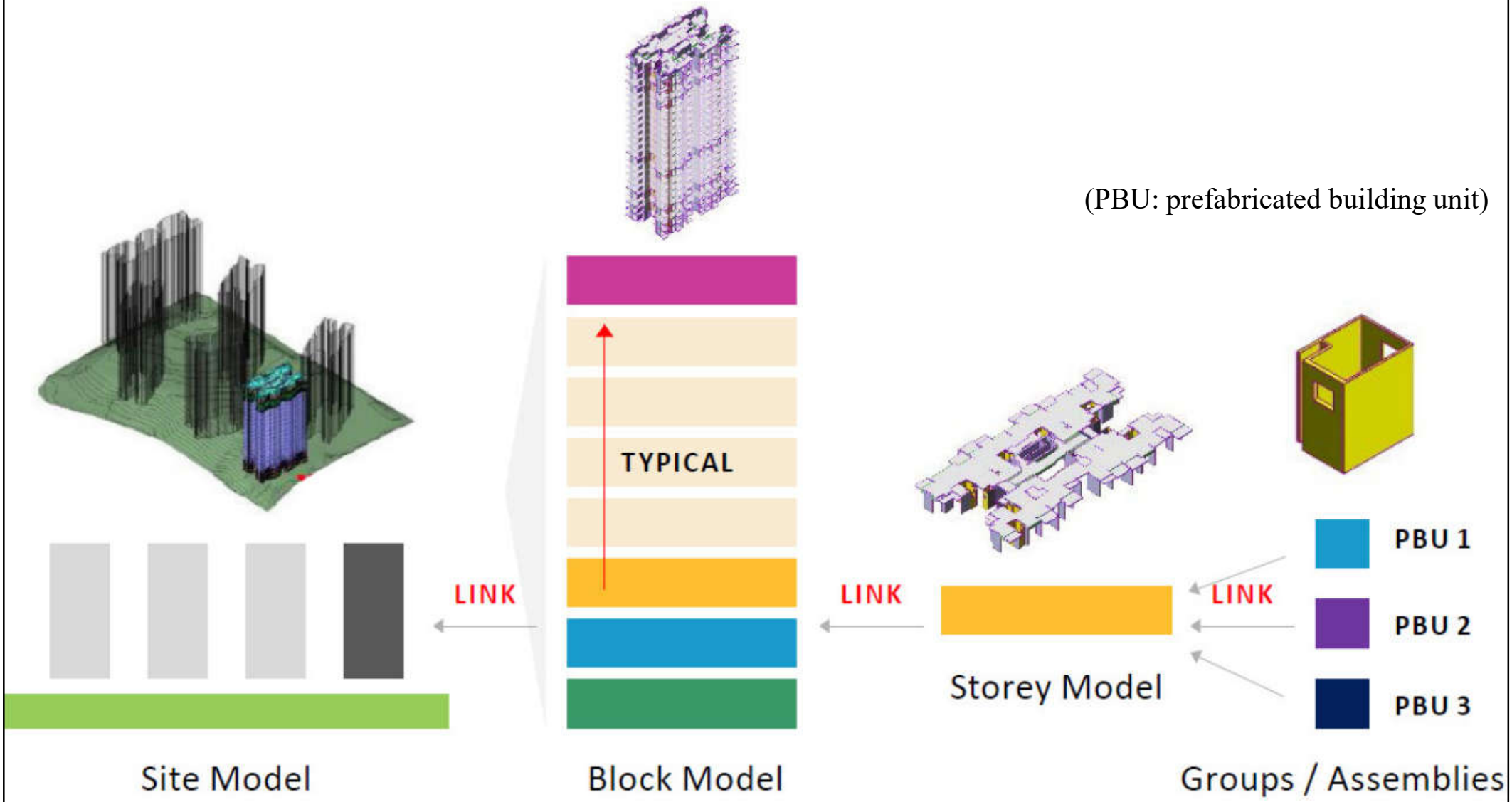
A sample model and linking structure for the Architectural discipline



(Source: Singapore VDC Guide https://www.corenet.gov.sg/media/2094675/singapore-vdc-guide_version1_oct2017.pdf)

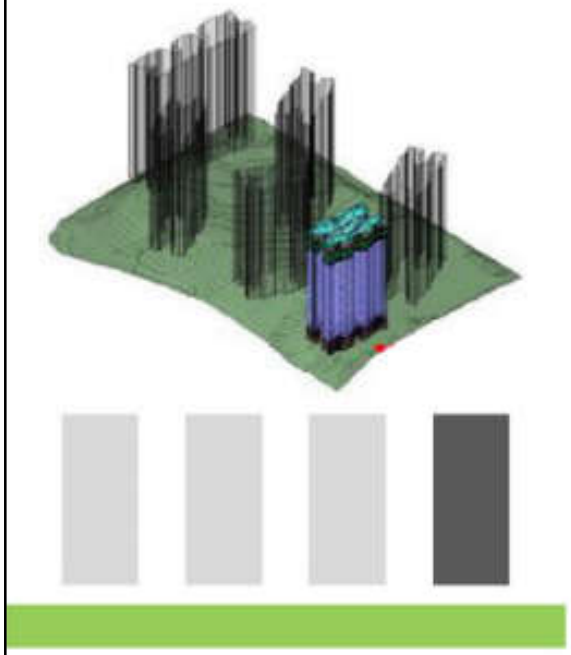
A sample model and linking structure for the Structural discipline

(PBU: prefabricated building unit)



(Source: Singapore VDC Guide https://www.corenet.gov.sg/media/2094675/singapore-vdc-guide_version1_oct2017.pdf)

A sample model for the MEP (Building Services) discipline

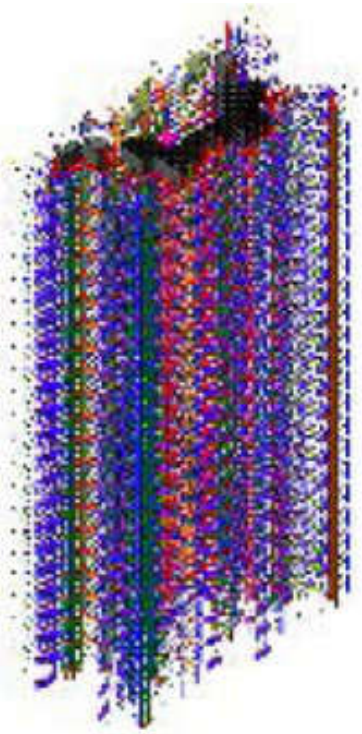


Site Model

ACMV
+
PL/SAN
+
ELECTRICAL
ETC.

Block Model

Block model containing all systems

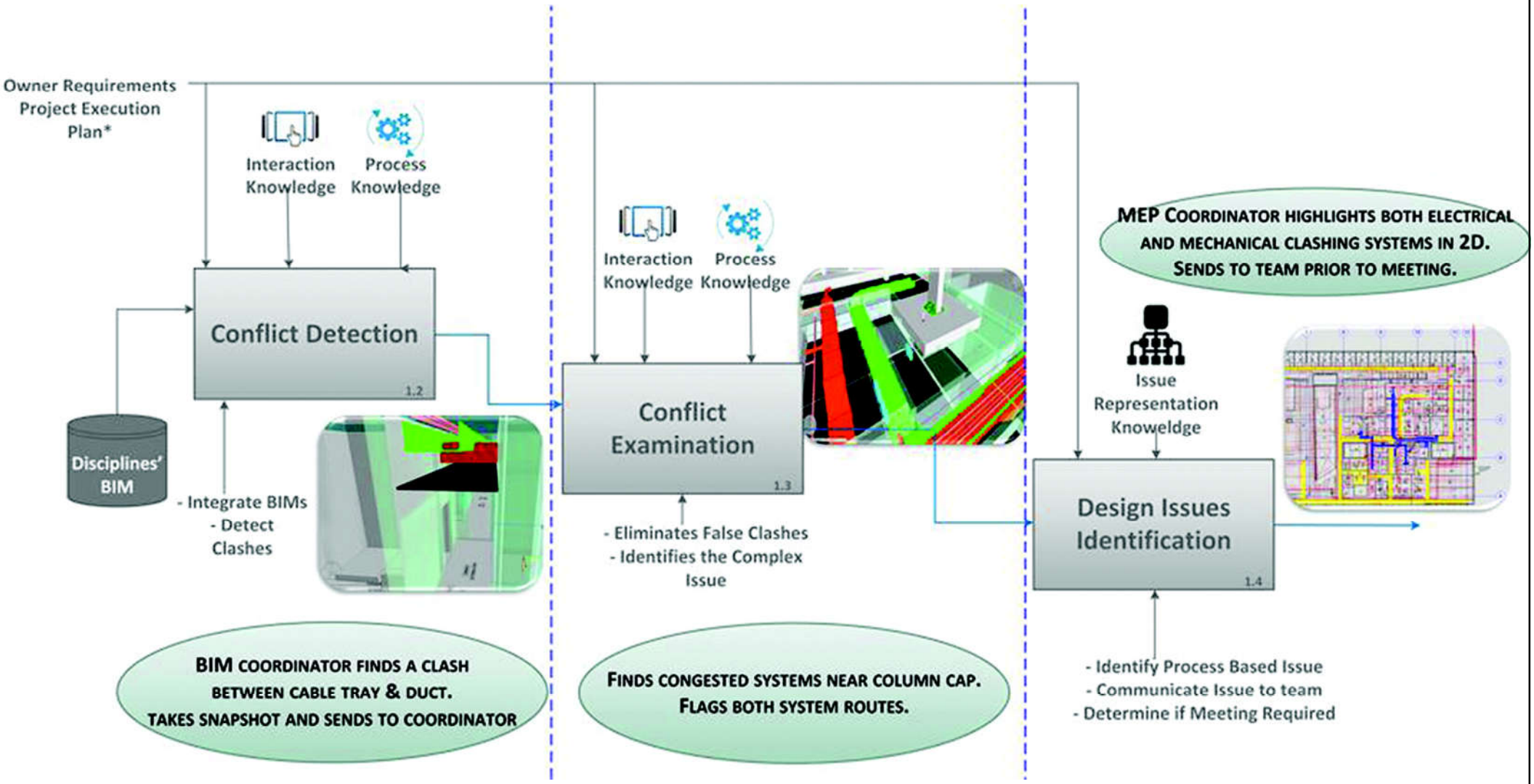


All systems within one zone/block as one file.
Depending on model size, one system of one zone/block in one file (This makes it easier to handover files to different MEP subcontractors for their further development and use), where each system may be further split up into floors if needed.

(ACMV: air-conditioning & mechanical ventilation; PL/SAN: plumbing/sanitation)

(Source: Singapore VDC Guide https://www.corenet.gov.sg/media/2094675/singapore-vdc-guide_version1_oct2017.pdf)

Example of BIM-based building MEP design coordination



(Source: https://cdnsciencepub.com/doi/10.1139/cjce-2018-0287)

Typical coordination issues that are critical to construction

Architectural – Structural Coordination • Column setting out and alignment between Architectural and Structural models • Ceiling to structural framing coordination • Staircase and ramp 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
Architectural – MEP Coordination • Service shaft coordination • Ceiling to concealed MEP services coordination	**Arch-Structure-MEP** • Toilet setting out, including coordination of tile layout, floor drains, and fixtures • Façade coordination

(Source: Singapore VDC Guide https://www.corenet.gov.sg/media/2094675/singapore-vdc-guide_version1_oct2017.pdf)

Main responsibilities of the **BIM co-ordinator**

- Developing and maintaining the project's BIM Protocol
- Following the mandated BIM collaboration format (BCF)
- Co-ordinating stakeholders in terms of their role within the BIM process
- Ensuring the accuracy of models and datasets by establishing quality control procedures
- Using clash detection software to identify clashes
- Where there are shared data and inter-model relationships, e.g. shared project coordinates, floor levels, etc., making sure these are recorded and monitored
- Co-ordinating data modelling and management
- Liaising with the design team and client

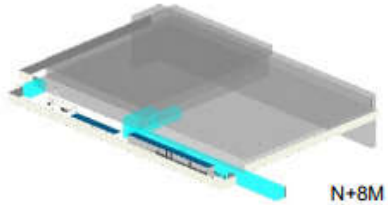
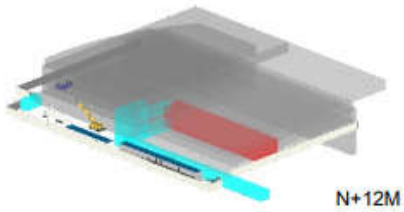
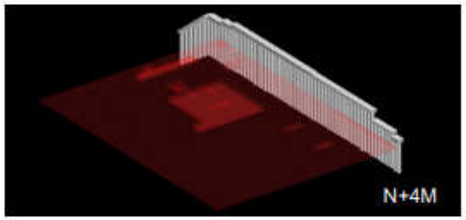
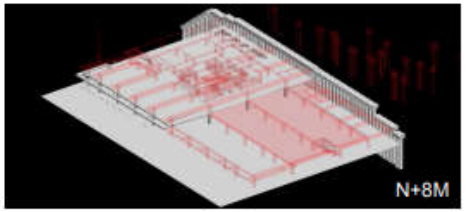
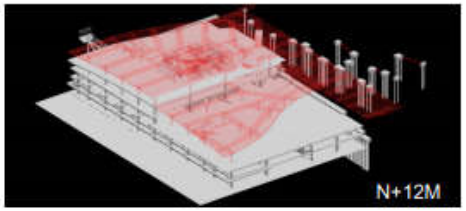
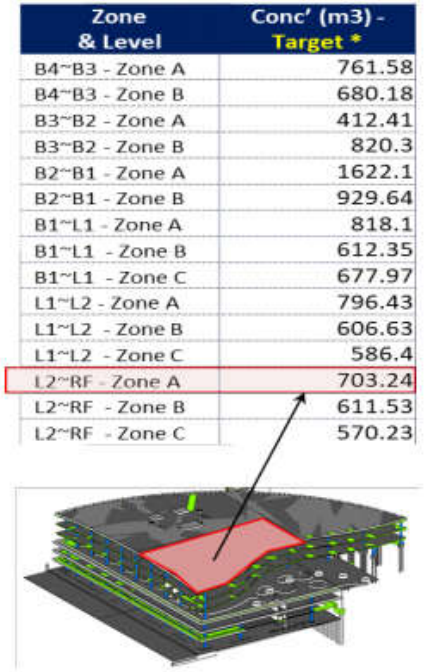
BIM coordination tasks:
- Clash detection & resolution
- Interactive walk-through & fly-by animations
- Virtual mock-up & review

(Source: BIM co-ordinator https://www.designingbuildings.co.uk/wiki/BIM_co-ordinator)

BIM software list for BIM Coordinators

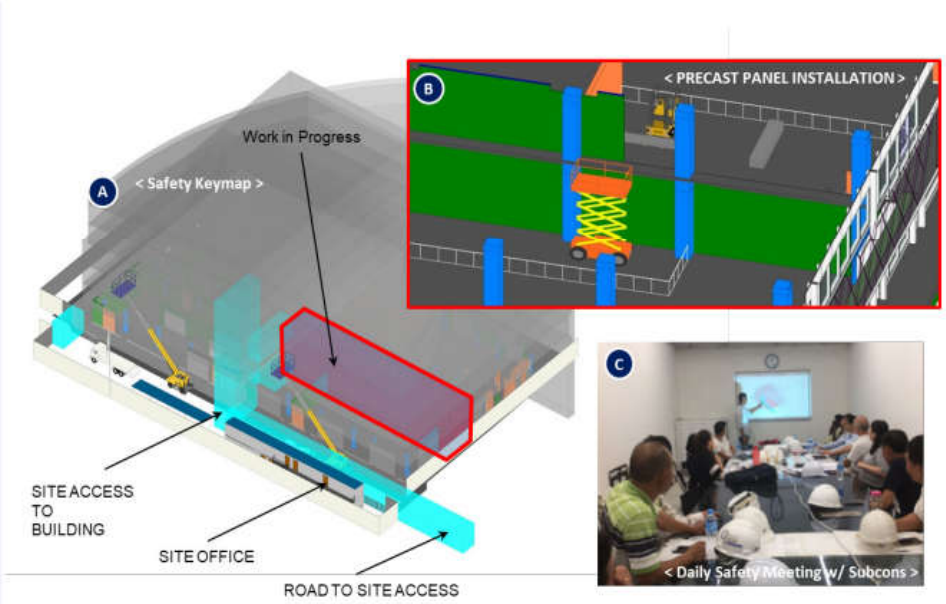
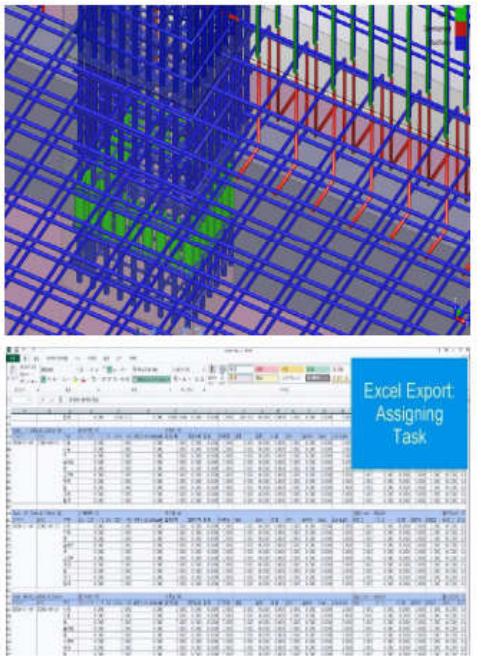
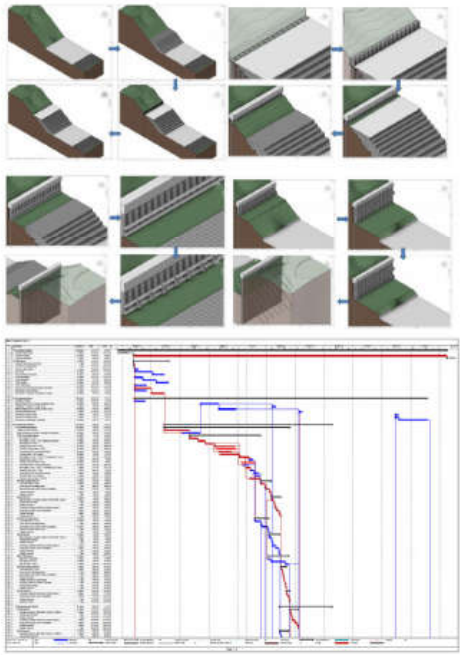
(Source: https://bimcorner.com/ultimate-bim-software-list-for-bim-coordinators/)

Integration of BIM & production planning / scheduling: From master planning to weekly work planning

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.
Sample Images	  	  		 
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

(Source: Singapore VDC Guide https://www.corenet.gov.sg/media/2094675/singapore-vdc-guide_version1_oct2017.pdf)

Integration of BIM & production planning / scheduling: Weekly and daily coordination, review and tracking

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				
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)

(Source: Singapore VDC Guide https://www.corenet.gov.sg/media/2094675/singapore-vdc-guide_version1_oct2017.pdf)

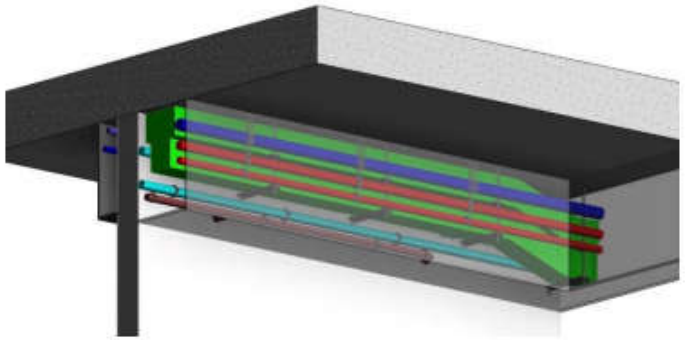
An example of coordination matrix

	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									

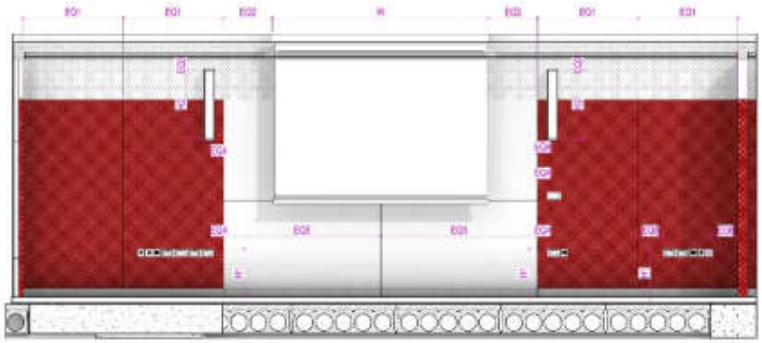
(Source: Singapore VDC Guide https://www.corenet.gov.sg/media/2094675/singapore-vdc-guide_version1_oct2017.pdf)

Sample virtual review coordination

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.

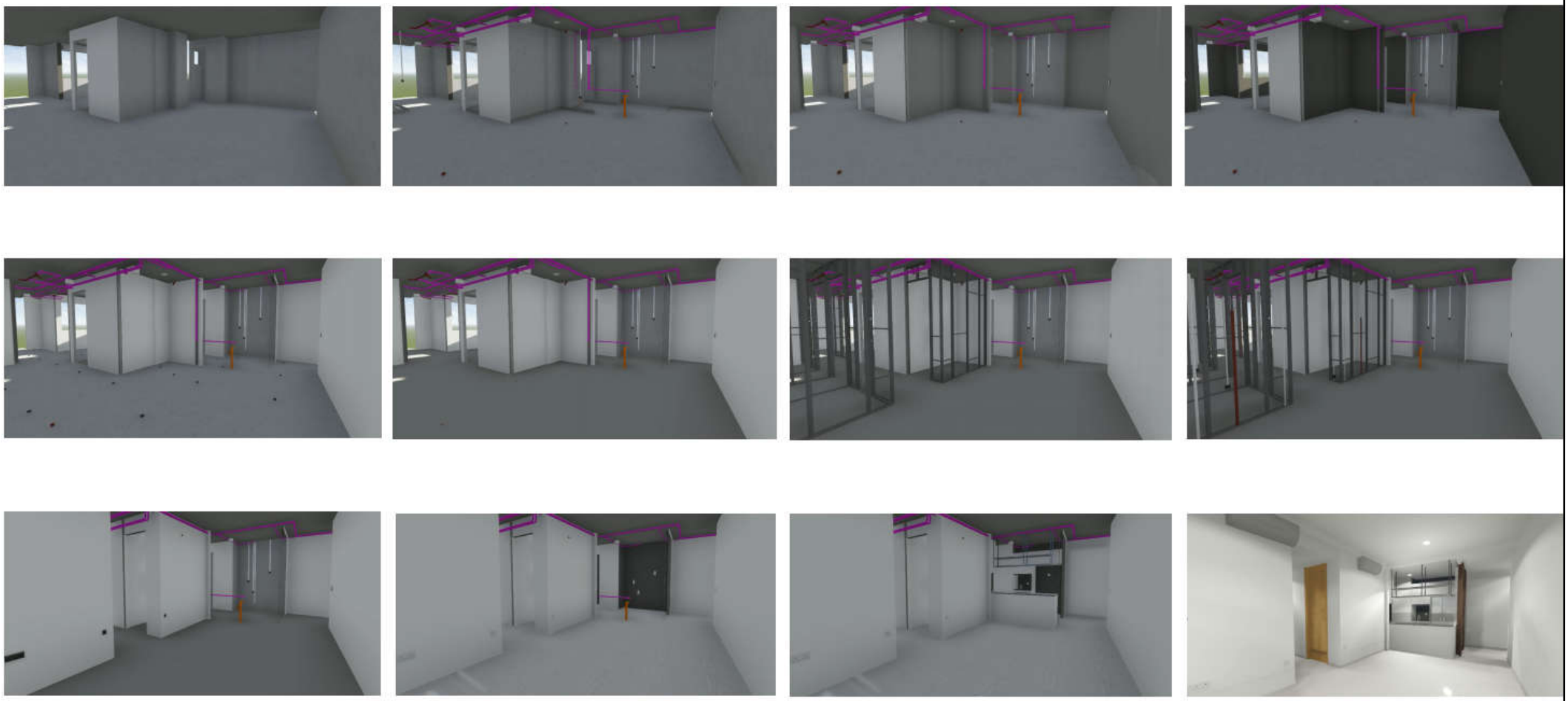
- On 14 Nov 2016, PTA commented, Ceiling at master bedroom as per HPK-Archi-RFI-151, to be added.

- 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 skirting 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

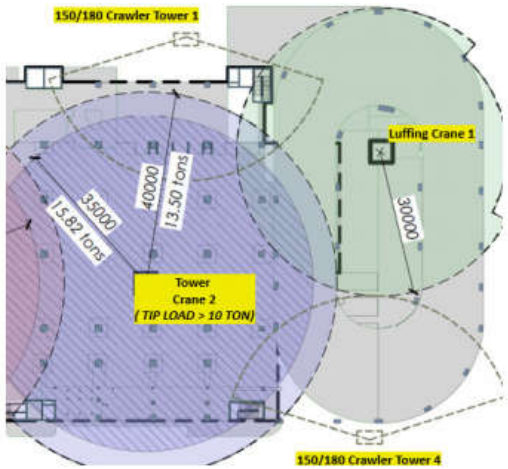
(Source: Singapore VDC Guide https://www.corenet.gov.sg/media/2094675/singapore-vdc-guide_version1_oct2017.pdf)

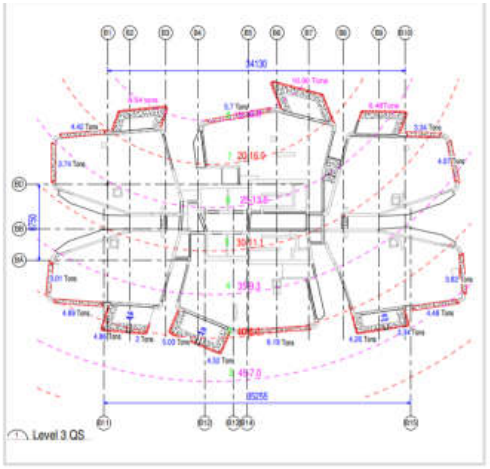
Sample virtual sequencing for residential unit mock-up

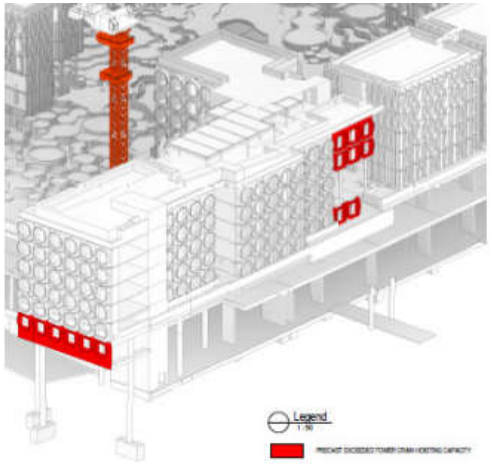


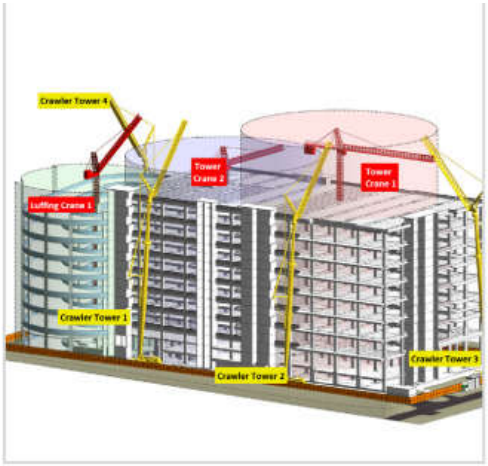
(Source: Singapore VDC Guide https://www.corenet.gov.sg/media/2094675/singapore-vdc-guide_version1_oct2017.pdf)

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

(Source: Singapore VDC Guide https://www.corenet.gov.sg/media/2094675/singapore-vdc-guide_version1_oct2017.pdf)