

MEP Coordination



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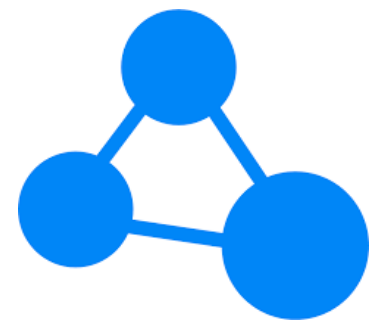
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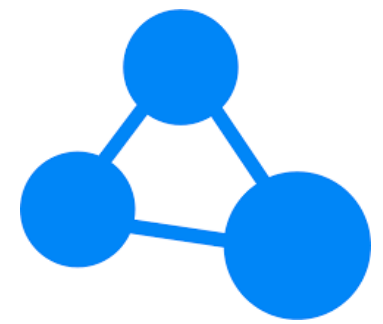
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- Clash detection & avoidance
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Introduction



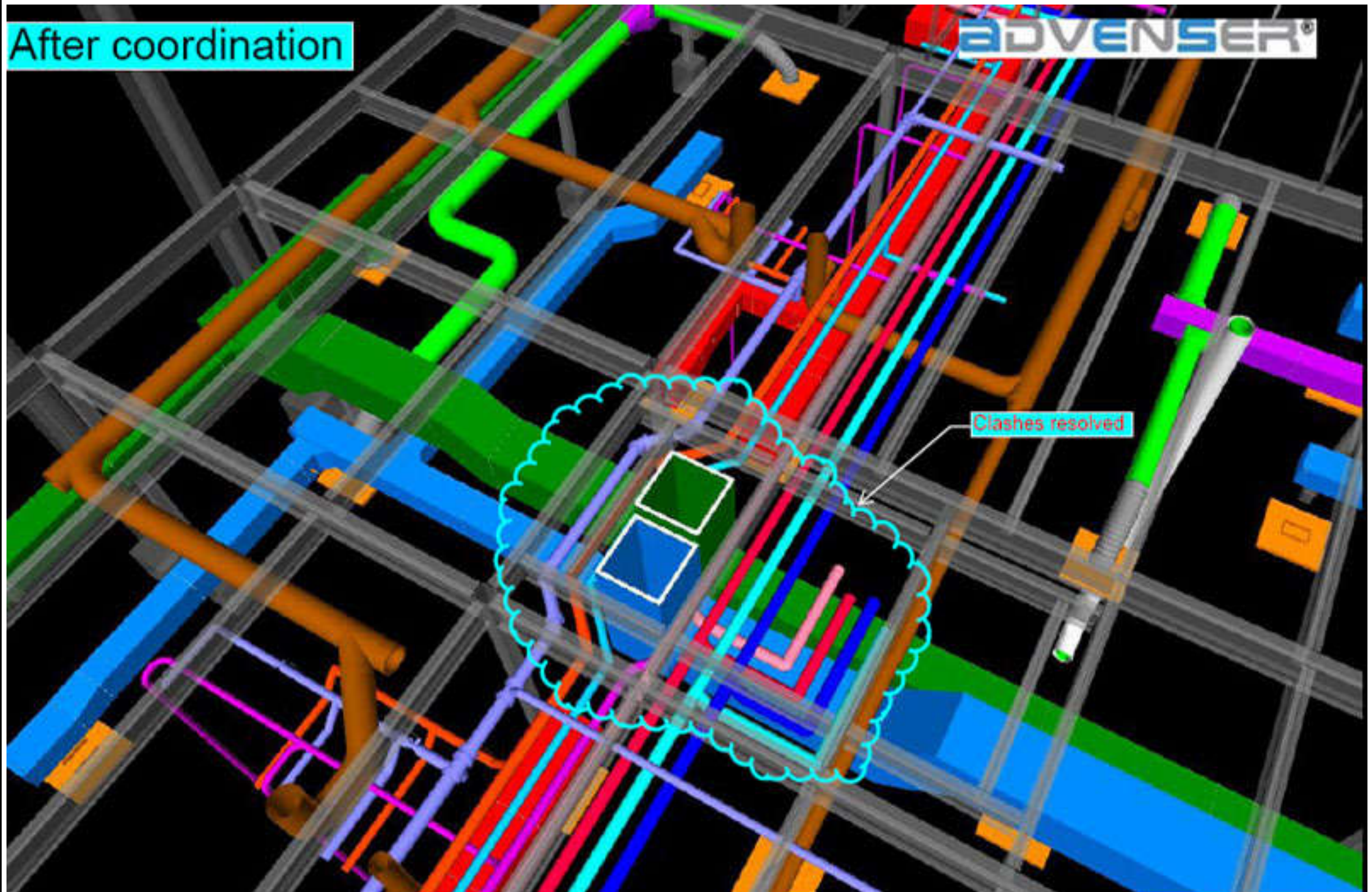
- Design coordination*
 - Integration of designs prepared by different project team members to create a single, unified set of information that can be constructed without clashes between components (“**clash free**”)
 - Effective design coordination can help to reduce costs, delays and disruption that can be caused by problems on site and the need for remedial or abortive works and redesign
 - Such as installing MEP systems in confined spaces

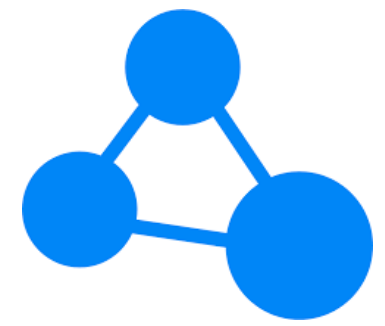


Introduction

- MEP coordination refers to the spatial coordination of all building services (HVAC, pipework, plumbing & electrical systems) with other disciplines making up the building structure, architectural elements, fabric & external envelope (steel, concrete, false ceilings, etc.)
 - Acts as a link between the architectural design, the engineering system & the construction process

An example of MEP coordination

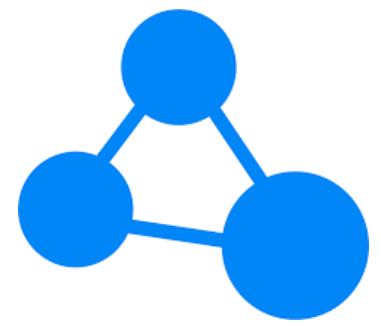




Introduction

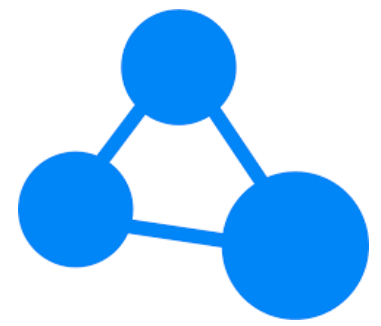
- Typical stages involved in MEP coordination:
 - <http://www.xscad.com/blog/typical-stages-involved-in-mep-coordination/>
 - 1. Review of consultant design drawings & architectural/structural plans
 - 2. 3D model creation
 - 3. Clash detection & resolution
 - 4. Create coordinated drawings & sections
 - 5. Create detailed service drawings
 - 6. Create fabrication drawings, spool and hangar drawings
 - 7. Create as-built drawings which include all site-based changes, modifications & differences

Introduction



- Problems with traditional 2D MEP coordination:
 - Lack of ability to identify conflicts in 2D models
 - Delays in construction process due to conflict being identified on site
 - Rework to fix the conflict issues not identified during design & coordination
 - Increased site supervision required to avoid conflicts between trade contractors
 - More Request for Information (RFIs) and Change Orders due to identification of conflicts on site after budgets are approved

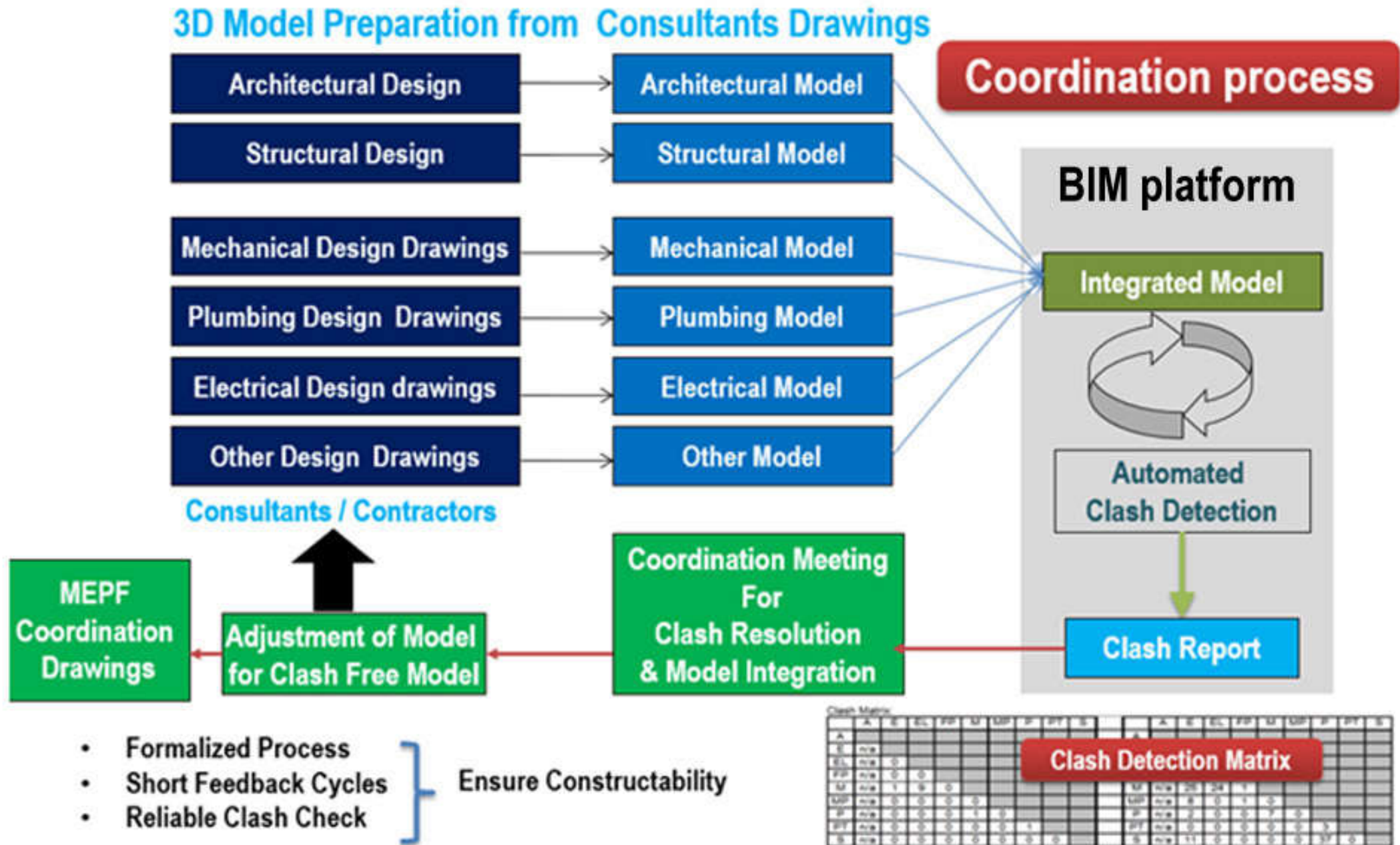
Introduction

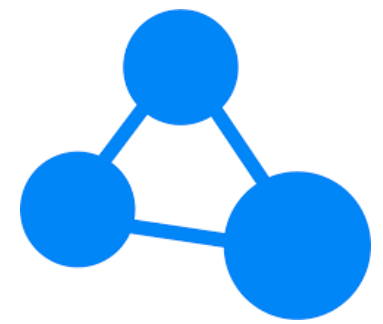


- Benefits of MEP coordination using BIM:
 - Improve the spatial coordination process with a 3D approach
 - Better avoidance of clashes
 - Reduce conflicts & reworks in the field
 - Enhance prefabrication of MEP Systems
 - Promote analytical capabilities using BIM coordination (e.g. knowledge based reasoning)



BIM coordination process

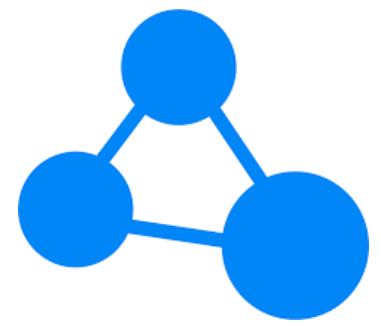




Introduction

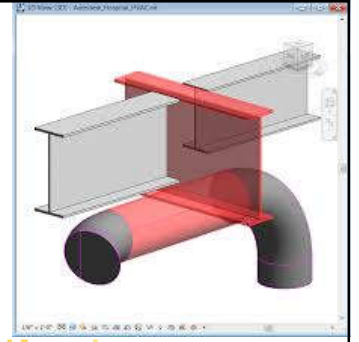
- In a 3D environment, MEP services are coordinated with other disciplines, such as architectural components, fabric, steel and concrete features
- Models are checked for clashes using clash detection software (e.g. Navisworks) and then developed into MEP coordination drawings and single service installation drawings
- In some instances, the MEP element may require redesign, while in some the architectural design may need to be changed

Introduction



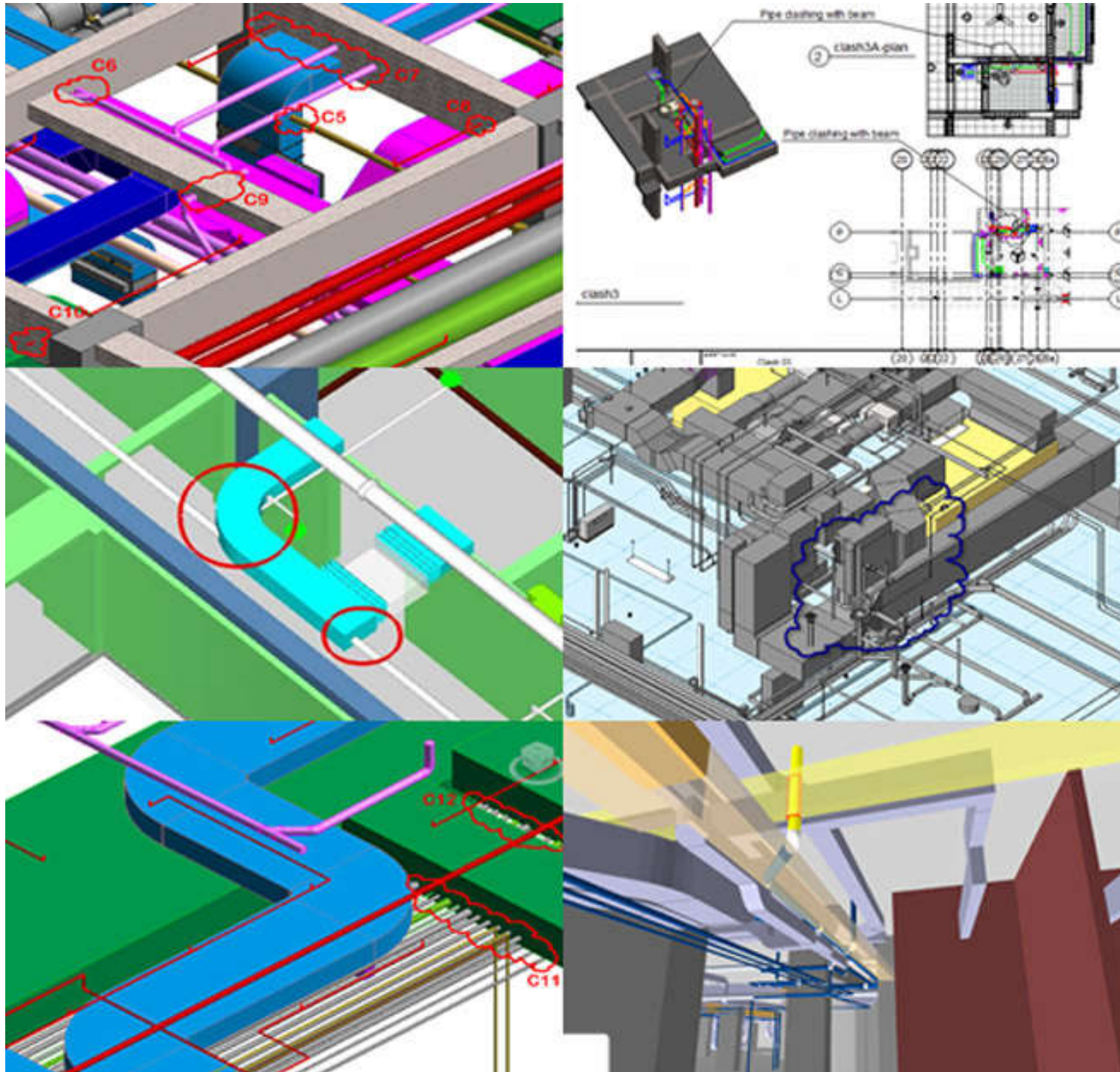
- Desirable outcomes of MEP coordination:
 - 1. Spatially coordinated, installation friendly **3D models** featuring all building services within the context of architectural, structural and process models
 - 2. Spatially **coordinated building services drawings** for MEP consulting engineers and building engineering services contractors, mechanical contractors, electrical contractors and specialist trade contractors
 - 3. MEP coordinated 3D models and drawings for **plant rooms**, building **risers**, prefabricated **corridors** and **ceiling modules**

Clash detection & avoidance



- Three types of clashes: (or interferences)
 - 1. Hard clash: when two objects intersect with each other, e.g. the route for pipework runs through a steel beam
 - 2. Soft/Clearance clash: can be the result of construction tolerances, too little space to install or maintain a component of the building, lack of consideration of health and safety requirements
 - 3. 4D/Logistic/Workflow clash: scheduling clashes & deviations as well as delivery clashes, e.g. too many workers being programmed to carry out works in the same space at the same time, or no equipment exists on site

Examples of clash detection



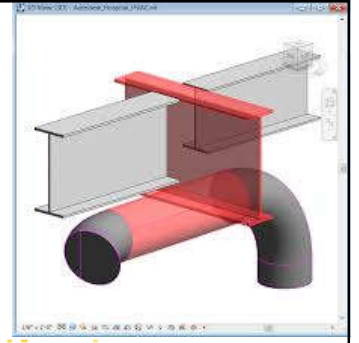
Common causes of clashes in a BIM model

- | | |
|---|--|
| <ul style="list-style-type: none">• Use of wrong or low level of detail• Design uncertainty/use of placeholders• Failing of design rules• Accuracy versus deadline• 3D model objects exceeding allowable clearance• Designers working in isolation from each other | <ul style="list-style-type: none">• Design complexity• Insufficient time• Use of 2D instead of 3D models• Design errors• Use of different file formats• Lack of experts |
|---|--|

Clash avoidance strategies by researchers

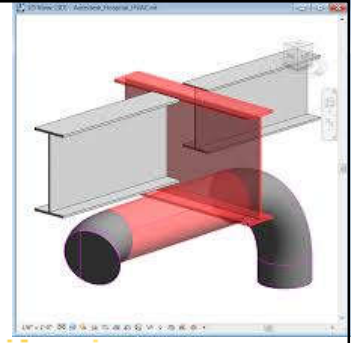
- | | |
|--|---|
| <ul style="list-style-type: none">• Impose BIM in traditional procurement• Integrating engineering, construction and procurement• Improvement in software detection algorithms• Co-creation among designers in a shared workspace | <ul style="list-style-type: none">• Designers working with more information provided by other specialists• Designers being more careful/accurate with their own model output• Design coordination in a common data environment• Shared situational awareness |
|--|---|

Clash detection & avoidance



- Clash avoidance/prevention
 - Ensure all building components & systems will fit in their allocated space and that all items can maintain access & serviceability
 - Can be performed while developing the design, especially for congested or critical areas of the building
- Clash detection
 - A review process to ensure all building components, assemblies, and systems properly fit in their to-be-installed condition without interferences with any other building assemblies

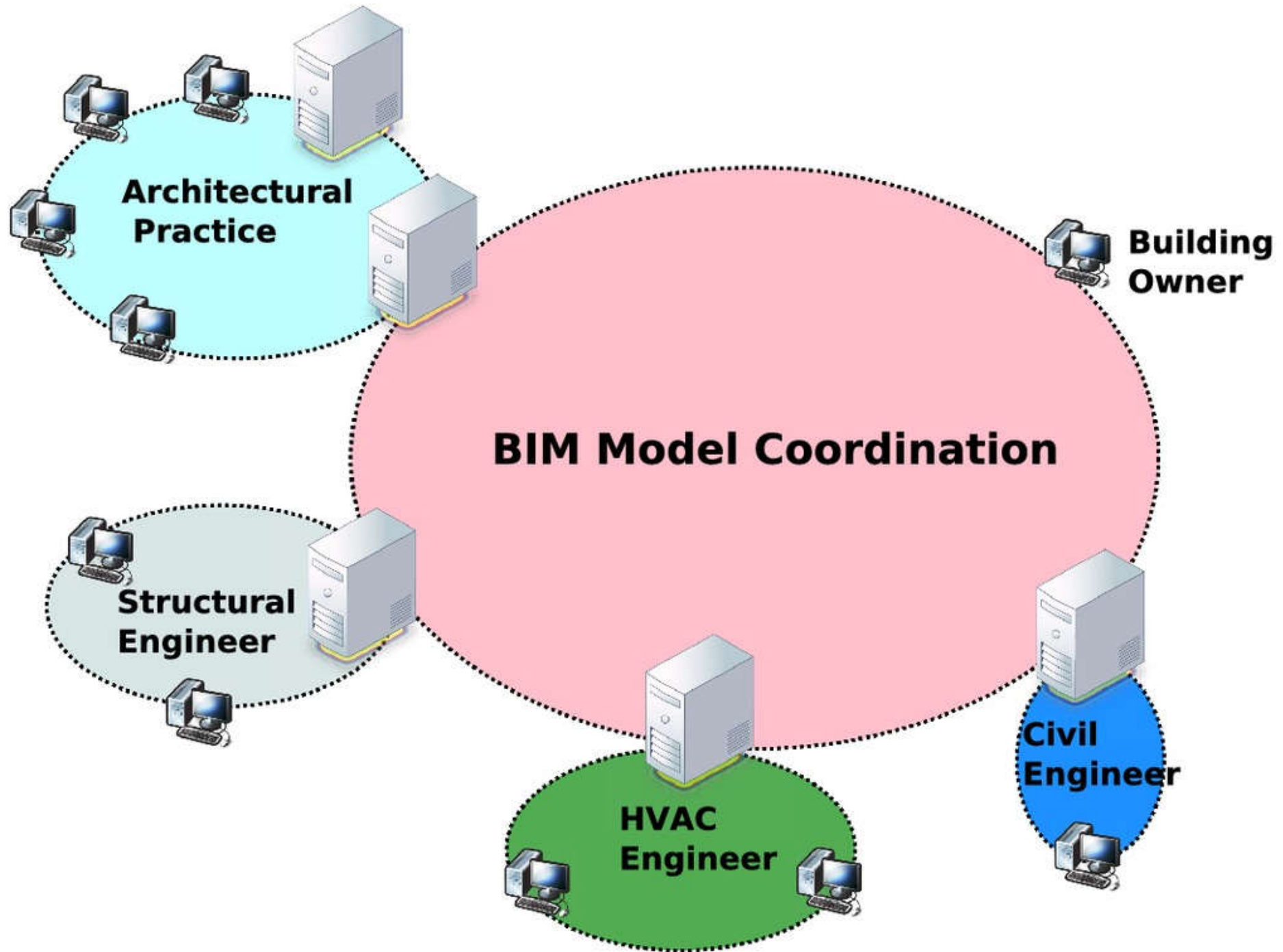
Clash detection & avoidance



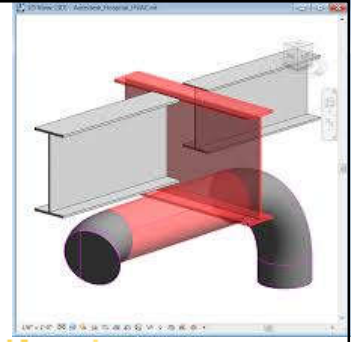
- BIM can reduce clashes by bringing together the entire design team to work on one collaborative, coordinated building model, as an integral part of the entire design & construction process*
- Recommended clash strategy:
 - Define standard methods & procedures
 - Establish a BIM volume strategy (manageable spatial subdivision of a project)
 - Specialist design & creation of a virtual construction model
 - Models are updated with as-constructed information

(*See also: Clash avoidance https://www.designingbuildings.co.uk/wiki/Clash_avoidance)

BIM model coordination

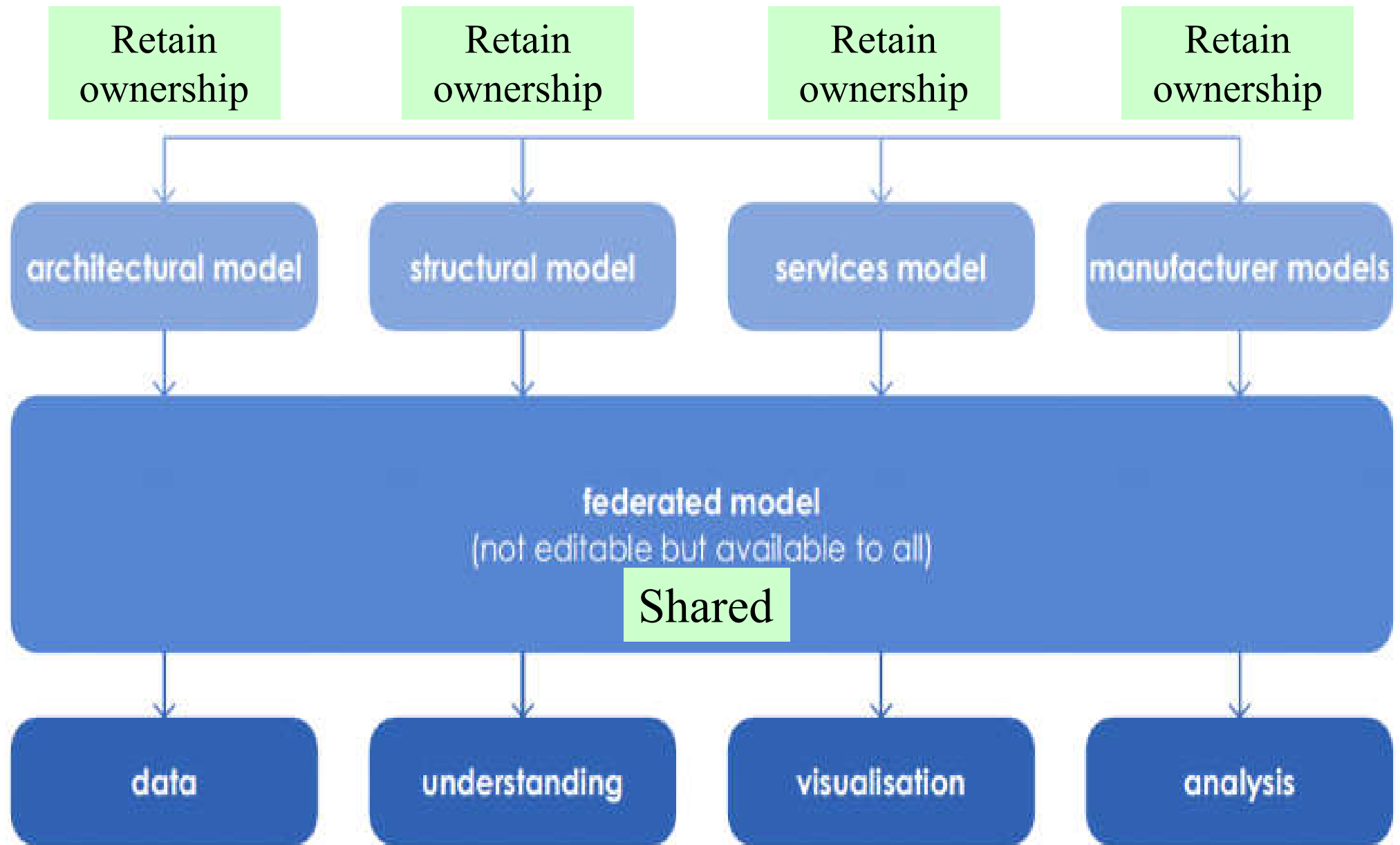


Clash detection & avoidance

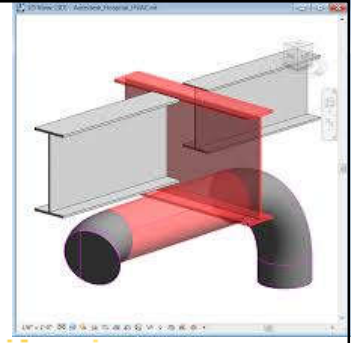


- **Federated model** in BIM
 - It is an assembly of distinct discipline models to create a single, complete model of the building
 - It consists of linked but distinct component models, drawings derived from the models, texts, and other data sources that do not lose their identity or integrity by being so linked, so that a change to one component model in a federated model does not create a change in another component model in that federated model

Federated model

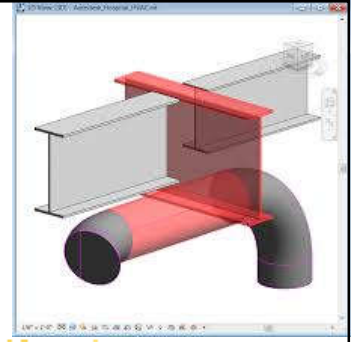


Clash detection & avoidance



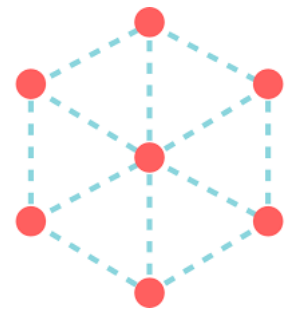
- A single federated model is useful for design co-ordination, clash avoidance & clash detection, approvals processes, design development, estimating and so on, but the individual models do not interact, they have clear authorship and remain separate
 - This means that the liabilities of the originators of the separate models are not changed by their incorporation into the federated model

Clash detection & avoidance



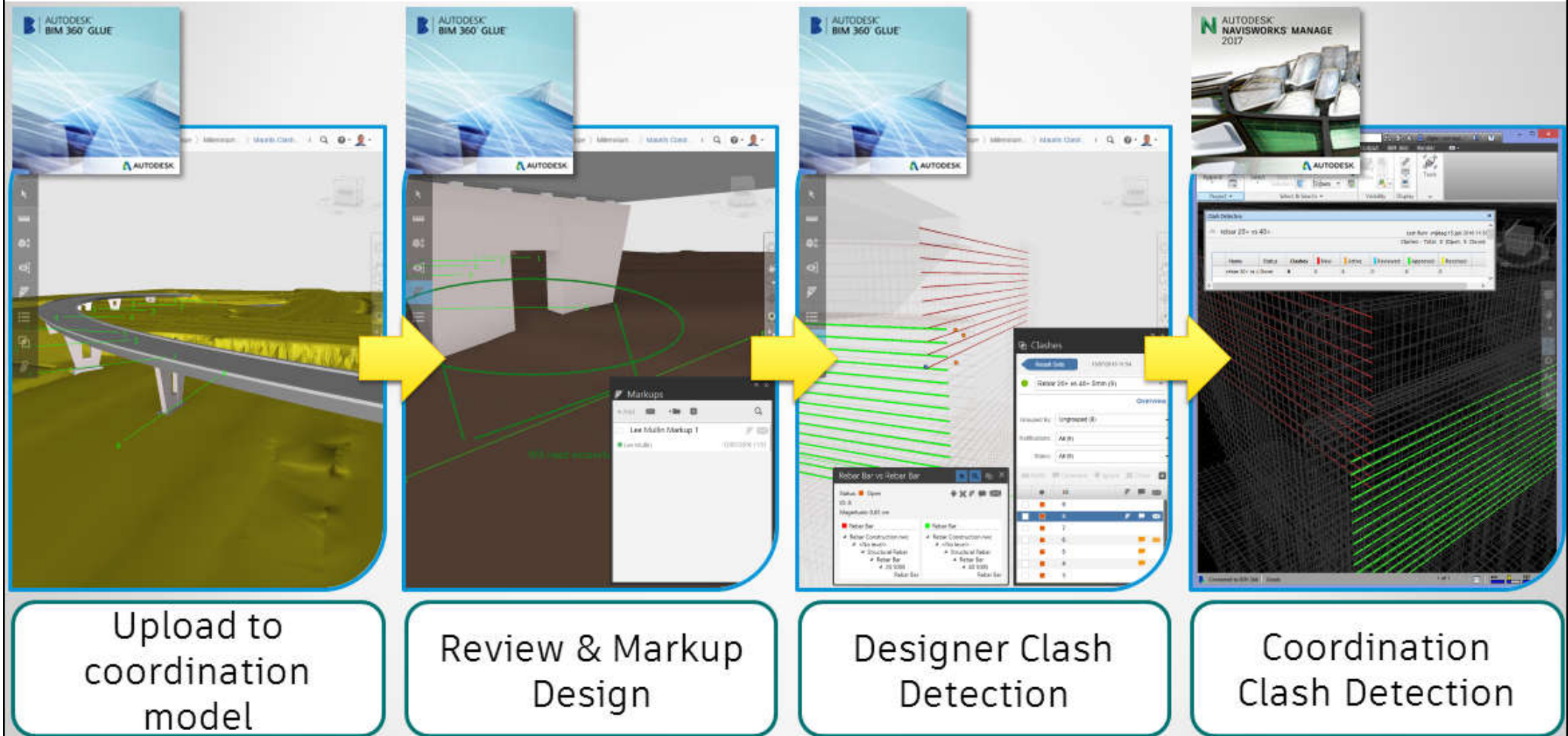
- Clash detection is usually done by the design team or on the contractor side
- Typical clash detection tasks:
 - Interference check reports in Revit
 - Clash detective in Navisworks Manage
 - Model checks by visual inspection in 3-D coordination views (e.g. colour-coded with filters) & structural plan view

Clash analysis & management

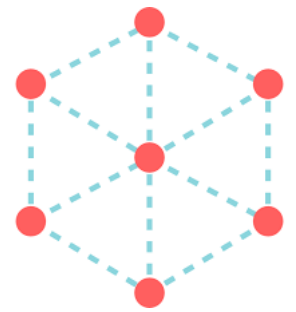


- BIM clash detection software, such as:
 - BIM 360 Glue <https://info.bim360.autodesk.com/bim-360-glue>
 - Navisworks <http://www.autodesk.com/products/navisworks/>
 - Solibri Model Checker <http://www.solibri.com/>
 - Synchro Pro <http://synchro ltd.com/>
 - Tekla BIMSight <http://www.teklabimsight.com/>
- Also, real-time clash detection & automation
 - ClashMEP - Real-time Clash Detection for Revit
 - <http://buildingsp.com/index.php/products/clashmep>

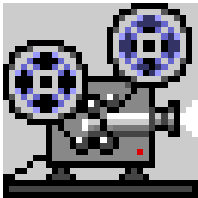
Multidiscipline coordination (using BIM 360 & Navisworks Manage)



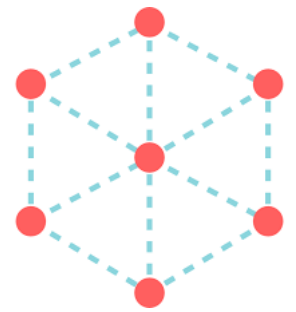
Clash analysis & management



- Video demon: clash detection & BIM model coordination
 - BIM 360 Glue Workflow Introduction (4:01)
<https://youtu.be/Vc6ehBJNtQQ>
 - Autodesk BIM 360 Glue and Navisworks Manage 2016 (3:39) <https://youtu.be/AZUqci3jPfU>
 - BIM 360 Glue vs. Navisworks Manage (13:22)
<https://youtu.be/0doN9JDpvsI>

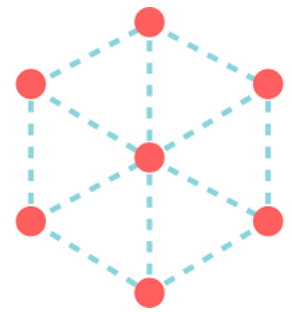


Clash analysis & management



- Clash test: a predefined set of elements which have to be checked for collisions
- Clash rule: Formula used to select specific objects that need to be included in a clash test
- Clash report: a document shared with stakeholders on a given project using PDF, XML, HTML or another type of format

Clash analysis & management



- Clash matrix

- To define combinations of disciplines & priority based on the construction schedule & deliverable
- Set clash tests from clash rules

Clash Matrix:

	A	E	EL	FP	M	MP	P	S
A								
E	n/a							
EL	n/a				4			
FP	n/a					2		
M	n/a							3
P	n/a							
S	n/a							1

Basement & ground- Clashes between

A – Architectural

E – Electrical

EL – Electrical Lighting

F – Fire Protection

M – Mechanical (HVAC)

P – Plumbing

S – Structural (Foundations, Columns, Beams & Walls, No Slabs)

Examples of clash report (from Navisworks)



AR vs MEP	Tolerance	Clashes	New	Active	Reviewed	Approved	Resolved	Type	Status
	0.000m	301	2	296	1	1	1	Hard	OK

										Item 1				Item 2			
Image	Clash Name	Status	Distance	Grid Location	Description	Date Found	Date Approved	Approved By	Clash Point	Item ID	Layer	Item Name	Item Type	Item ID	Layer	Item Name	Item Type
	Clash1	New	-0.128	C-2 : 01- First Floor	Hard	2017/1/19 09:14:07			x:7.857, y:6.112, z:5.950	Element ID: 271189	01- First Floor	Default Wall	Solid	Element ID: 790871	02- Second Floor	PVC-C	Line
	Clash2	Reviewed	-0.125	C-2 : 02- Second Floor	Hard	2017/1/19 09:14:07			x:6.913, y:6.112, z:6.245	Element ID: 306133	02- Second Floor	Default Wall	Solid	Element ID: 790633	02- Second Floor	PVC-C	Line
	Clash3	Active	-0.125	H-2 : 01- First Floor	Hard	2017/1/19 09:14:07			x:27.809, y:6.112, z:3.197	Element ID: 300480	01- First Floor	Default Wall	Solid	Element ID: 797230	Level 1	PVC-C	Line
	Clash4	Active	-0.125	C-2 : 01- First Floor	Hard	2017/1/19 09:14:07			x:6.913, y:6.112, z:3.197	Element ID: 271189	01- First Floor	Default Wall	Solid	Element ID: 791663	Level 1	PVC-C	Line



Name
Distance*
Status*
Clash Point*

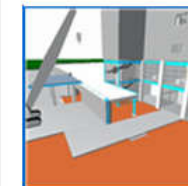
Basement Clashes
-0.10m
Active
-52.83m, 4.11m, 7.72m

Item 1*

Element ID 292404
Layer 2ND FLOOR
Item Name* W14X159
Item Type* Solid

Item 2*

Element ID 870736
Layer <No level>
Item Name* Galvanized
Item Type* Solid



Name
Distance
Clash Group
Description
Status
Clash Point
Date Created

Clash1
-0.10m
Basement Clashes
Hard
Active
-52.83m, 4.11m, 7.72m
2011/12/12 10:30:42

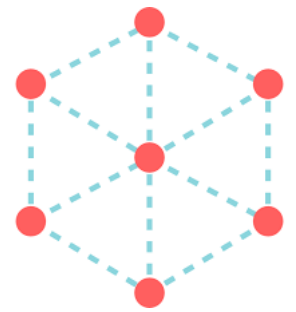
Item 1

Element ID 292404
Layer 2ND FLOOR
Item Name W14X159
Item Type Solid

Item 2

Element ID 870736
Layer <No level>
Item Name Galvanized
Item Type Solid

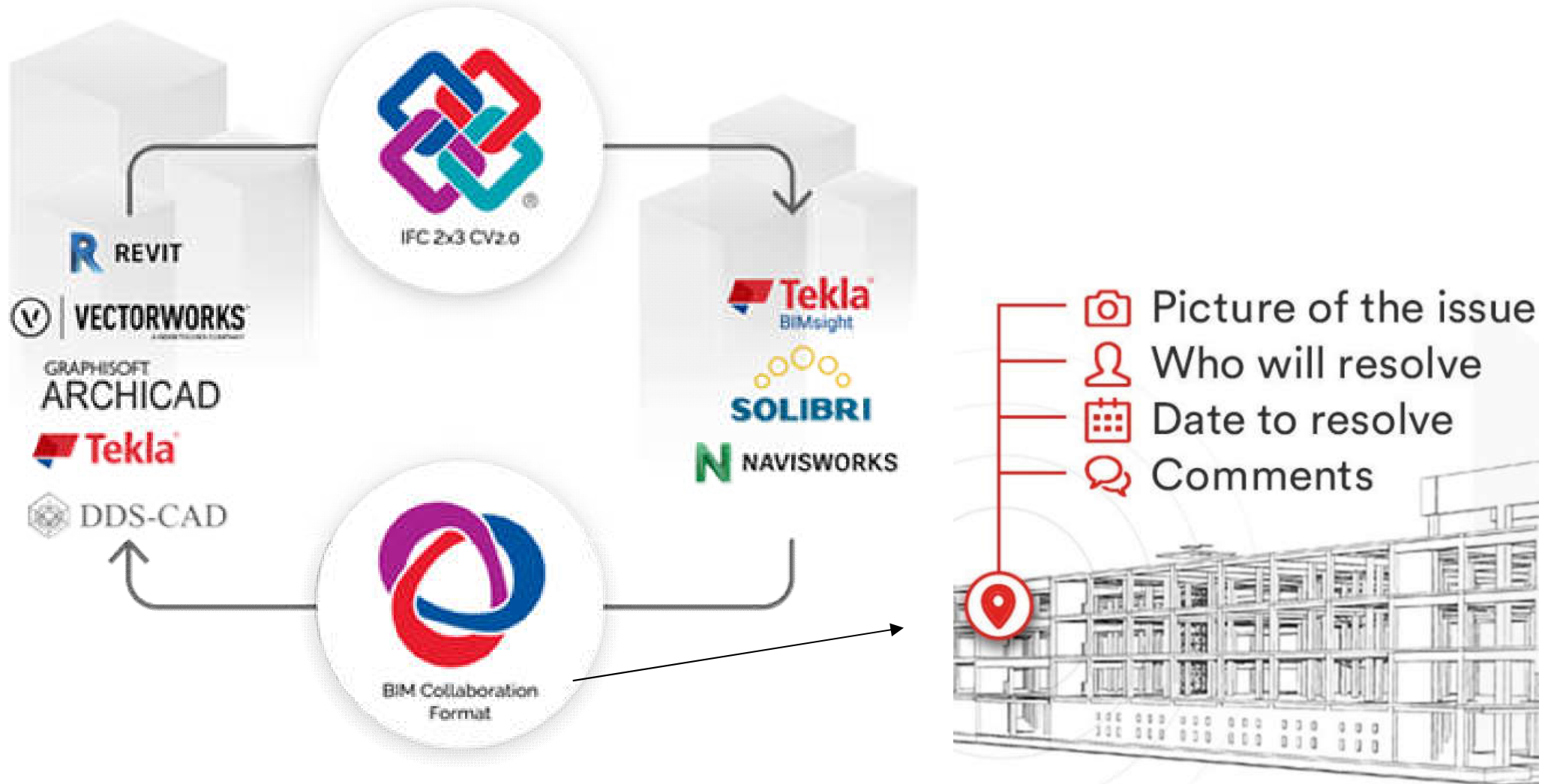
Clash analysis & management



- Traditional clash report is not efficient
 - Take screen shoots of the clash or model issue and create a PDF report to send to everyone
- Using **BIM Collaboration Format (BCF)**
 - It is like “Whatsapp” of BIM; allows you to send model mark-ups, clash reports, and general comments between all project members
 - Each BCF issue is registered with a unique ID, making it easier to track how many issues are open, who is responsible for what issues, and to see when the issues are resolved

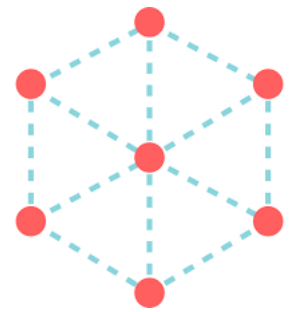


Using BIM Collaboration Format (BCF) to manage issues efficiently

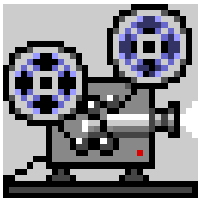


BCF is the **communication** between IFC tools and native modelling software. The BCF will identify exactly which objects are involved in an issue and will even record the screen view. So, when someone opens up a BCF issue in their modelling software they are directed to the exact same view in their model.

Clash analysis & management



- Examples of clash/issue management process
 - Video: BIM Track - Help Center - Clashes to Issues (3:56) <https://youtu.be/iU3k13-os9c>
 - How to publish Navisworks clashes using BIM Track addin & then do issues management
 - Video: BIM Track - Help Center - Revit - Create Issue From 2D Views (1:28) https://youtu.be/_RgyiK17KrQ
 - How to create an issue from a 2D view or sheet in Revit with BIM Track.



Collaboration & communication process for clash management

The screenshot illustrates the BIMTrack interface within Autodesk Revit 2018.3, showing a 3D model of a building structure. The BIMTrack panel on the right displays a list of issues found on 104, with details for issues 852, 848, 847, 820, 819, 818, and 817. The 'Edit Issue #847' dialog is open, showing details for 'Duct and beam' issue, including a thumbnail, description, assigned to, priority, status, zone, phase, group, due date, and comments.

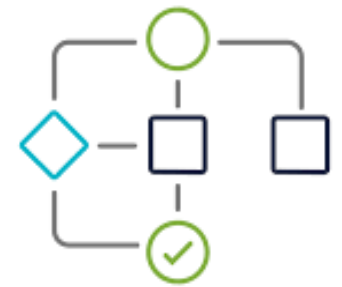
BIMTrack Panel:

- 70 Issues found on 104
- Issues listed: 852. Column spacing, 848. ramp issue, 847. Duct and beam, 820. Beam.1.42 (W14X43), 819. Beam.2.27 (W14X43), 818. Beam.2.33 (W16X67), 817. Beam.2.34 (W16X67)

Edit Issue #847 Dialog:

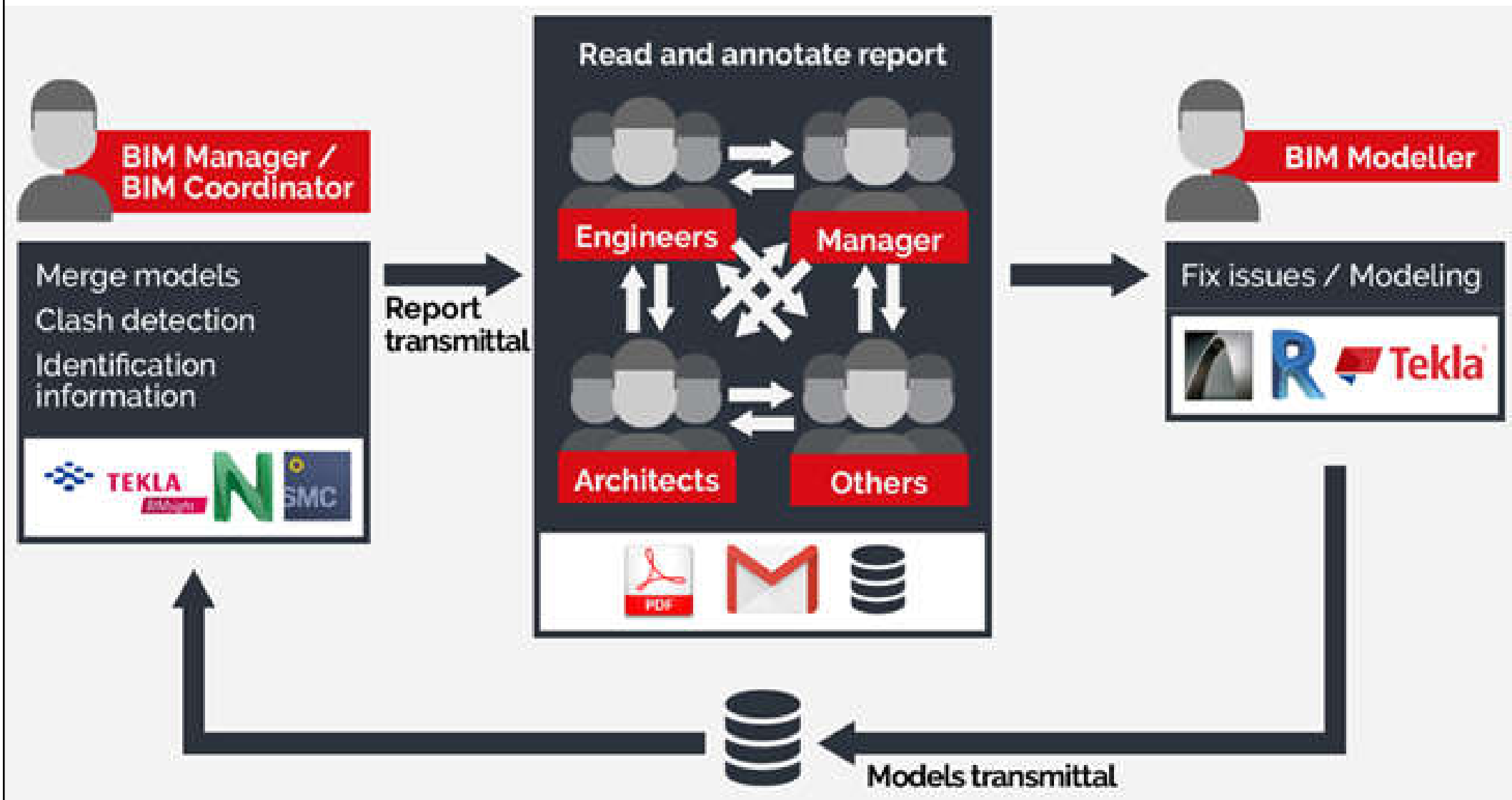
- Title:** Duct and beam
- Description:** lower duct.
- Assigned To:** [Not set]
- Type:** Issue
- Priority:** Low
- Status:** Open
- Zone:** [Not set]
- Phase:** SD
- Group:** [Not set]
- Due Date:** 4/24/2018
- Comments:** Type your comment here...
- Attachments:** [Image of duct and beam]
- History:** Carl Veillette 4/17/2018 14:32 Check connection as well

Coordination workflow



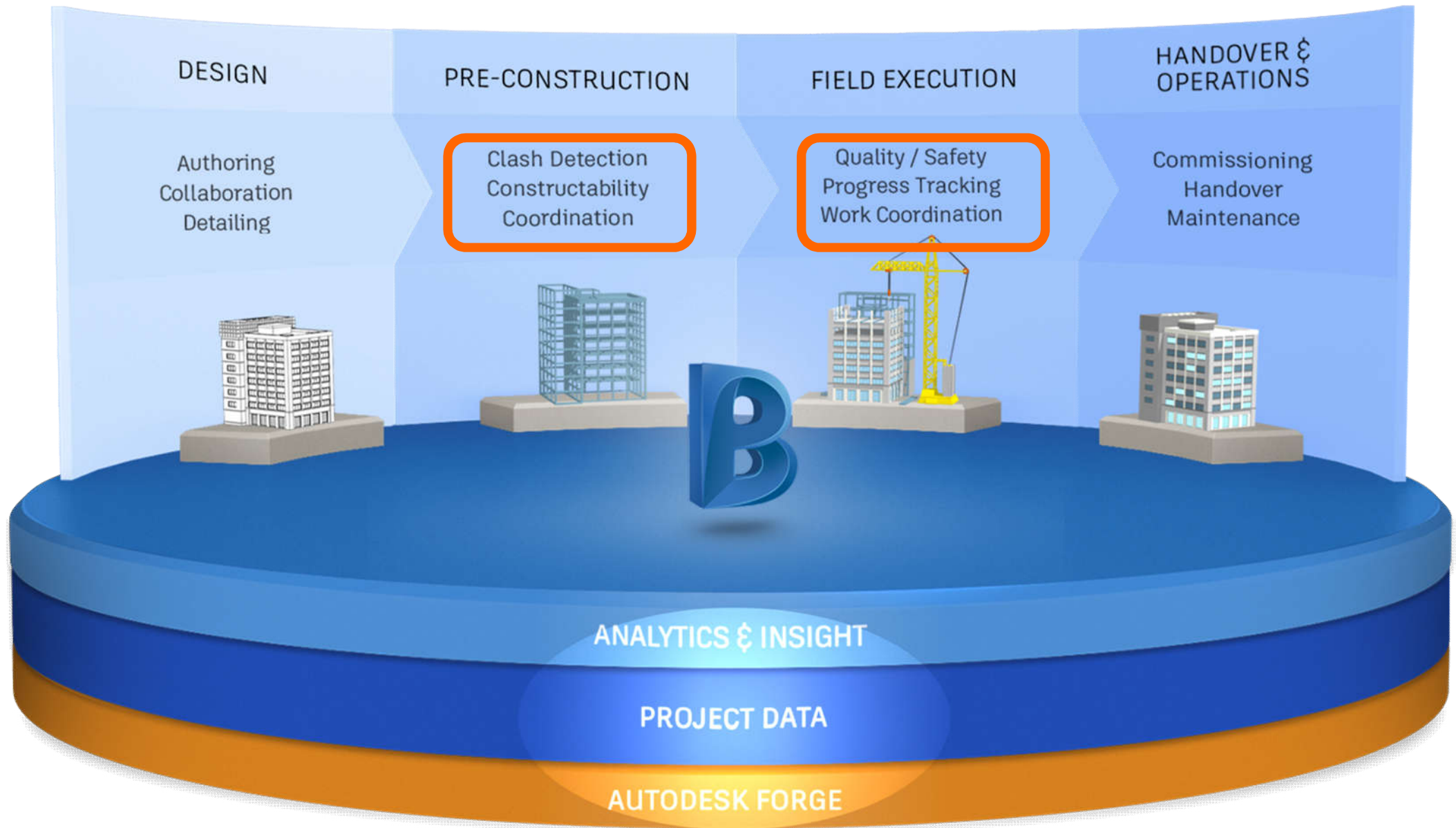
- Common duties of a BIM Coordinator:
 - Export Revit model to Navisworks format
 - Perform clash detection/model coordination
 - Export data from Revit models or to DWG format for use as CAD backgrounds
 - Lead project coordination meetings to review identified issues
 - Publish and/or post the clash report for review by project team

Typical BIM model coordination workflow



(Source: Are you really in control of communications around your 3D models? <https://bimtrack.co/blog/blog-posts/are-you-really-in-control-of-communications-around-your-3d-models>)

Cloud-based worksharing to support clash detection & coordination

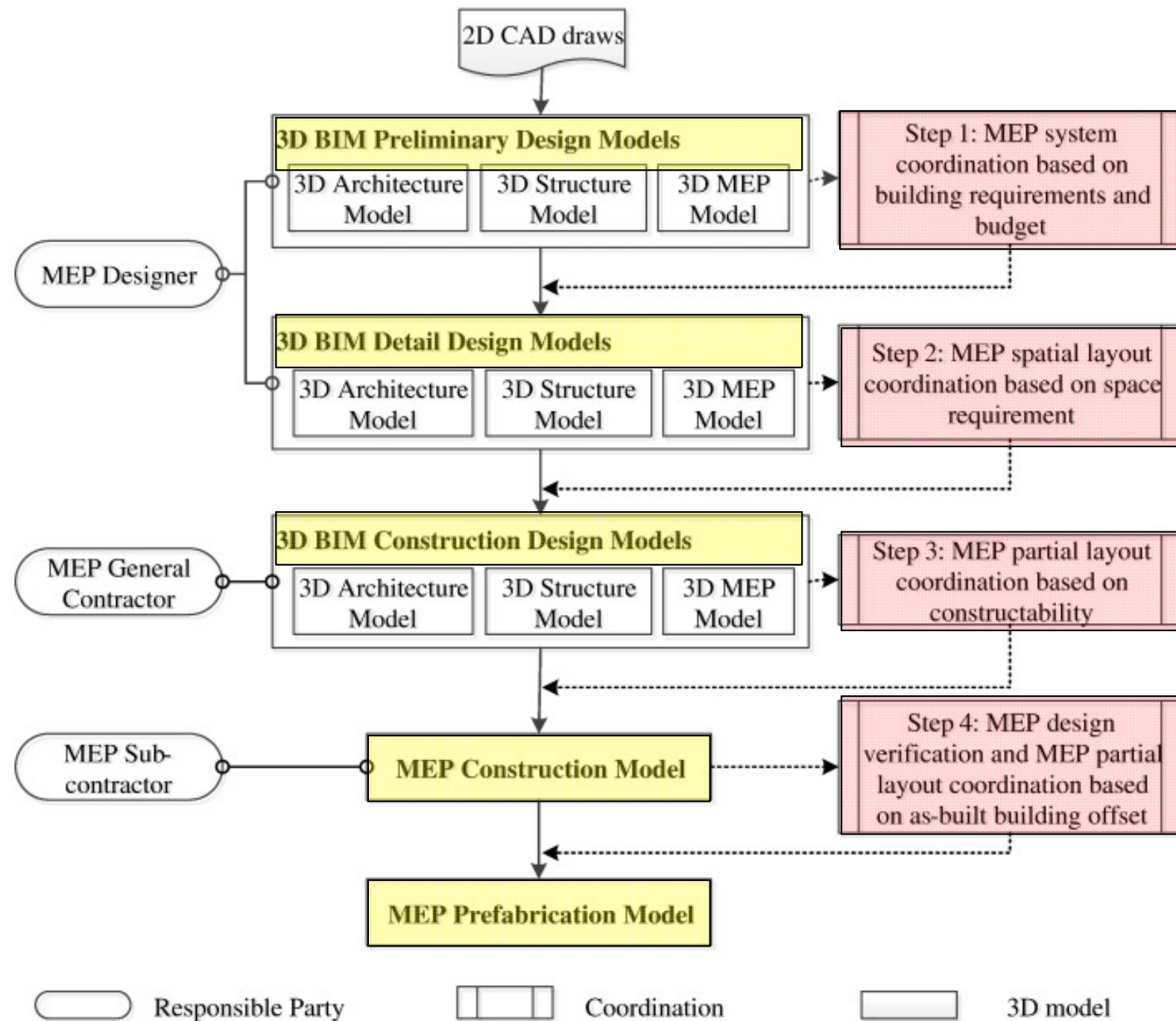


(See also: BIM 360 Glue <https://info.bim360.autodesk.com/bim-360-glue>)

Comparison of typical & cloud-based coordination workflows

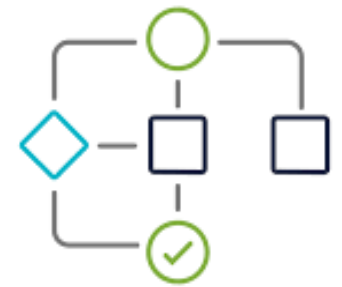
Typical model coordination workflow	Cloud-based collaborative workflow
<ul style="list-style-type: none">• The BIM modelers create the models in their favorite authoring software• The models are shared with BIM managers and coordinators• The BIM managers or coordinators merge the models, inspect them for quality insurance, run a clash analysis, and inspect clashes• The issues and comments are compiled in a report and share the report with other stakeholders• The stakeholders read, annotate, and share the reports back to the BIM modelers to correct the models• The modelers return the revised models to the data sharing environment with resolved and unresolved issues	<ul style="list-style-type: none">• BIM modelers create the models and share them with the BIM managers and coordinators on the cloud platform• The BIM managers and coordinators merge the models, inspect them for quality assurance, run clash analyses, verify information, and so on• They both post issues directly in the cloud platform and have access to all the latest information• The issues are centralized and the rest of the project team can view the issues through web browsers using mobile devices or computers without the need to install any third-party software• Different platforms are connected through the cloud using BIM Collaboration Format (BCF), with issue tracking & analytics

Framework for BIM-based MEP layout design and constructability



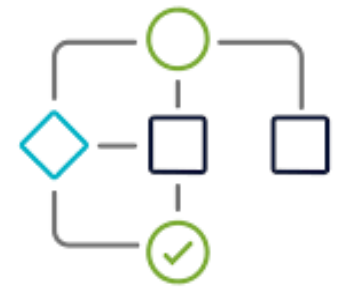
(Source: Wang J, Wang X, Shou W, Chong H.-Y. and Guo J., 2016. Building information modeling-based integration of MEP layout designs and constructability, *Automation in Construction*, 61 (2016): 134-146.)

Coordination workflow



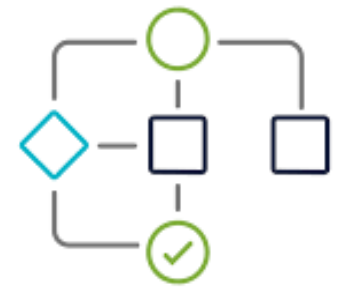
- Four steps of MEP coordination:
 - 1. MEP system coordination based on building requirements and budget
 - 2. MEP spatial layout coordination based on space requirements
 - 3. MEP partial layout coordination based on constructability
 - 4. MEP design verification and MEP partial layout coordination based on as-built building offset

Coordination workflow



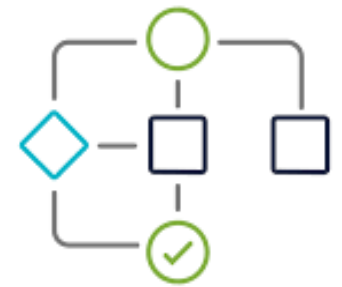
- 1. MEP system coordination based on building requirements and budget
 - In the preliminary design stage, more than one alternative of MEP schemes might be provided
 - Designers can conduct sunlight analysis, indoor air quality simulation, energy analysis, ventilation simulation, etc.
 - The best MEP scheme will be selected to satisfy cost budget and green building certification standards
 - The coordination of this stage focuses on the comparison between alternative MEP systems

Coordination workflow



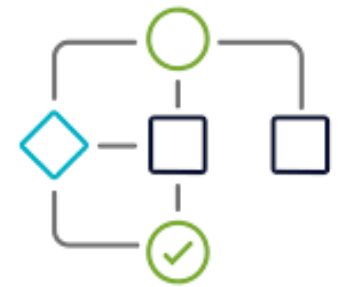
- 2. MEP spatial layout coordination based on space requirements
 - In the detailed design stage, many collisions occur when integrating MEP with architecture & structure model
 - Currently, BIM tools can identify the clashes or conflicts (hard, clearance, duplicity, positioning & routing)
 - In addition, the visualization capabilities enable the specialty trades, designers & coordinators to review & detect these conflicts faster, better and more accurately
 - One can instantly make the necessary changes into the BIM model, and also trace the effect of the suggested solutions on other components and systems

Coordination workflow



- 3. MEP partial layout coordination based on constructability
 - Prior to installation, MEP contractors need to assess the constructability of the existing MEP design schemes based on their construction expertise
 - The MEP layout optimization in this phase may consider:
 - Access requirement (e.g. free space around system component)
 - Configuration (e.g. to use standard materials & configurations, allow prefabrication offsite, allow desired installation sequence)
 - Construction method (e.g. to maximize prefabrication, allow efficient material handling)
 - Safety (e.g., to minimize exposure time and provide permanent scaffolding)

Coordination workflow



- 4. MEP design verification and MEP partial layout coordination based on as-built building offset
 - This step is the most important works in the whole MEP design process
 - The critical works of this stage are measuring construction deviations especially in tight space area, updating existing BIM models in line with as-built building, analyzing deviations, and adjusting original design to satisfy construction requirement



Further reading

- Design coordination
 - https://www.designingbuildings.co.uk/wiki/Design_coordination
- Clash avoidance
 - https://www.designingbuildings.co.uk/wiki/Clash_avoidance
- Federated building information model
 - https://www.designingbuildings.co.uk/wiki/Federated_building_information_model
- Understanding clash detection and making it more efficient
 - <https://bimtrack.co/blog/blog-posts/understanding-clash-detection-and-making-it-more-efficient>