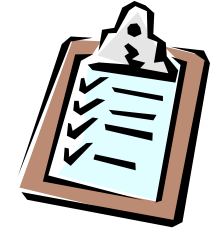# MEP Design Coordination

Thei

Faculty of Science and Technology

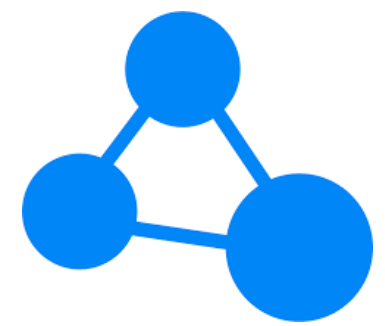Technological and Higher Education Institute of Hong Kong

May 2019

Contents

- Introduction
- Clash detection & avoidance
- Clash analysis & management
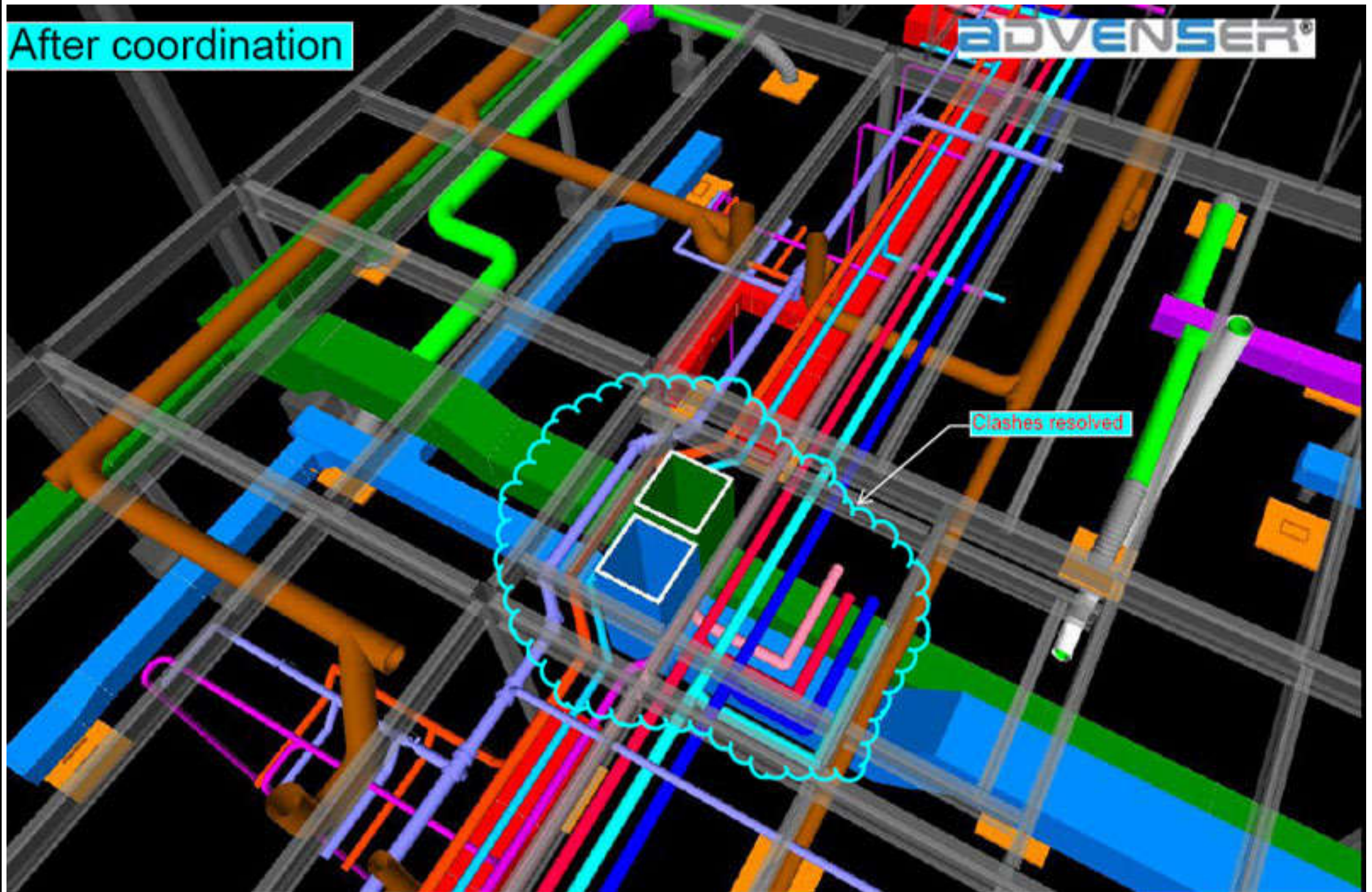- Coordination workflow

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

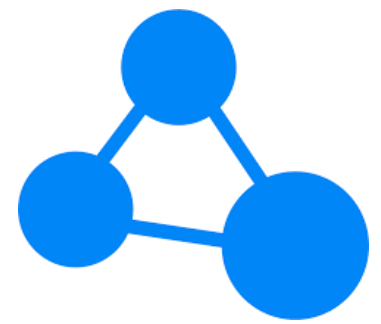   - Such as installing MEP systems in confined spaces

(*See also: Design coordination https://www.designingbuildings.co.uk/wiki/Design_coordination)
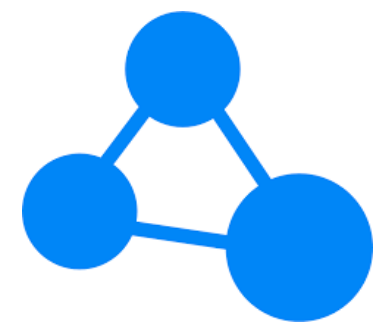
Introduction

- [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
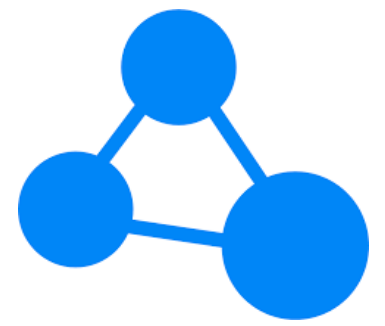
An example of MEP coordination

After coordination

Clashes resolved

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
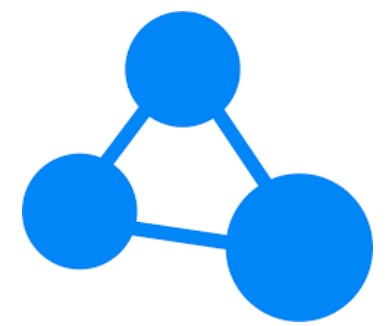
Introduction

- 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
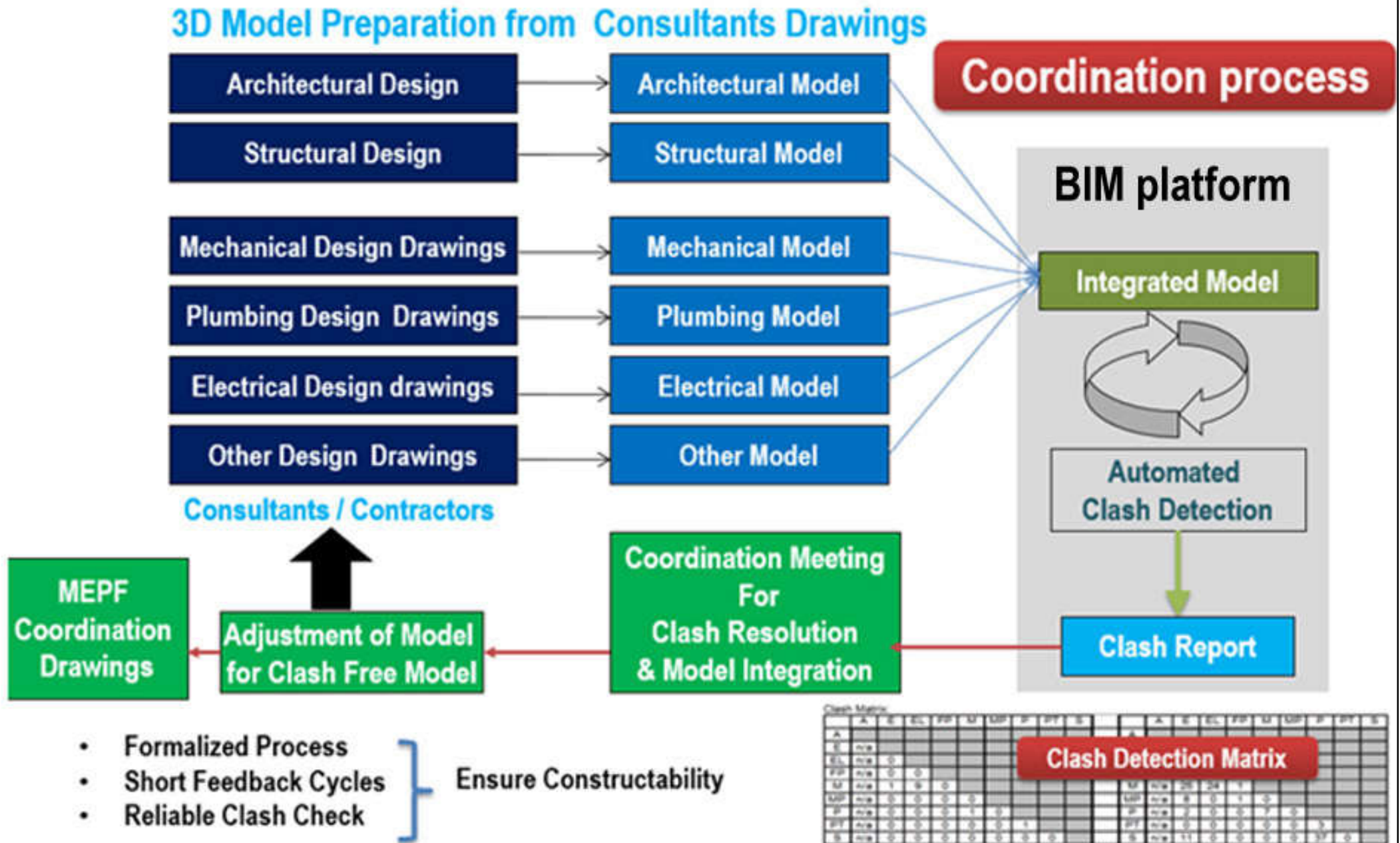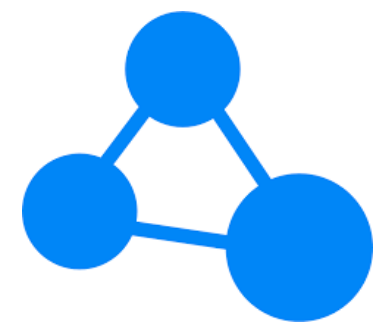
Introduction

- 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

3D Model Preparation from Consultants Drawings

Architectural Design	→ Architectural Model
Structural Design	→ Structural Model
Mechanical Design Drawings	→ Mechanical Model
Plumbing Design Drawings	→ Plumbing Model
Electrical Design drawings	→ Electrical Model
Other Design Drawings	→ Other Model

Consultants / Contractors

Coordination process

BIM platform

Integrated Model

Automated Clash Detection

Clash Report

MEPF Coordination Drawings

Adjustment of Model for Clash Free Model

Coordination Meeting For Clash Resolution & Model Integration

Clash Detection Matrix

- Formalized Process
- Short Feedback Cycles
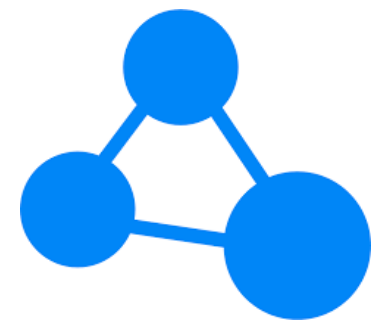- Reliable Clash Check
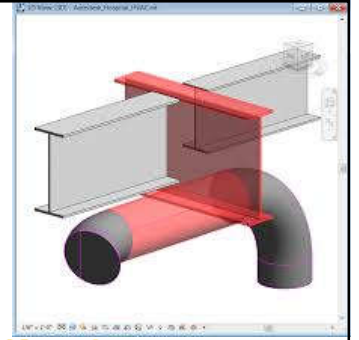
Ensure Constructability

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
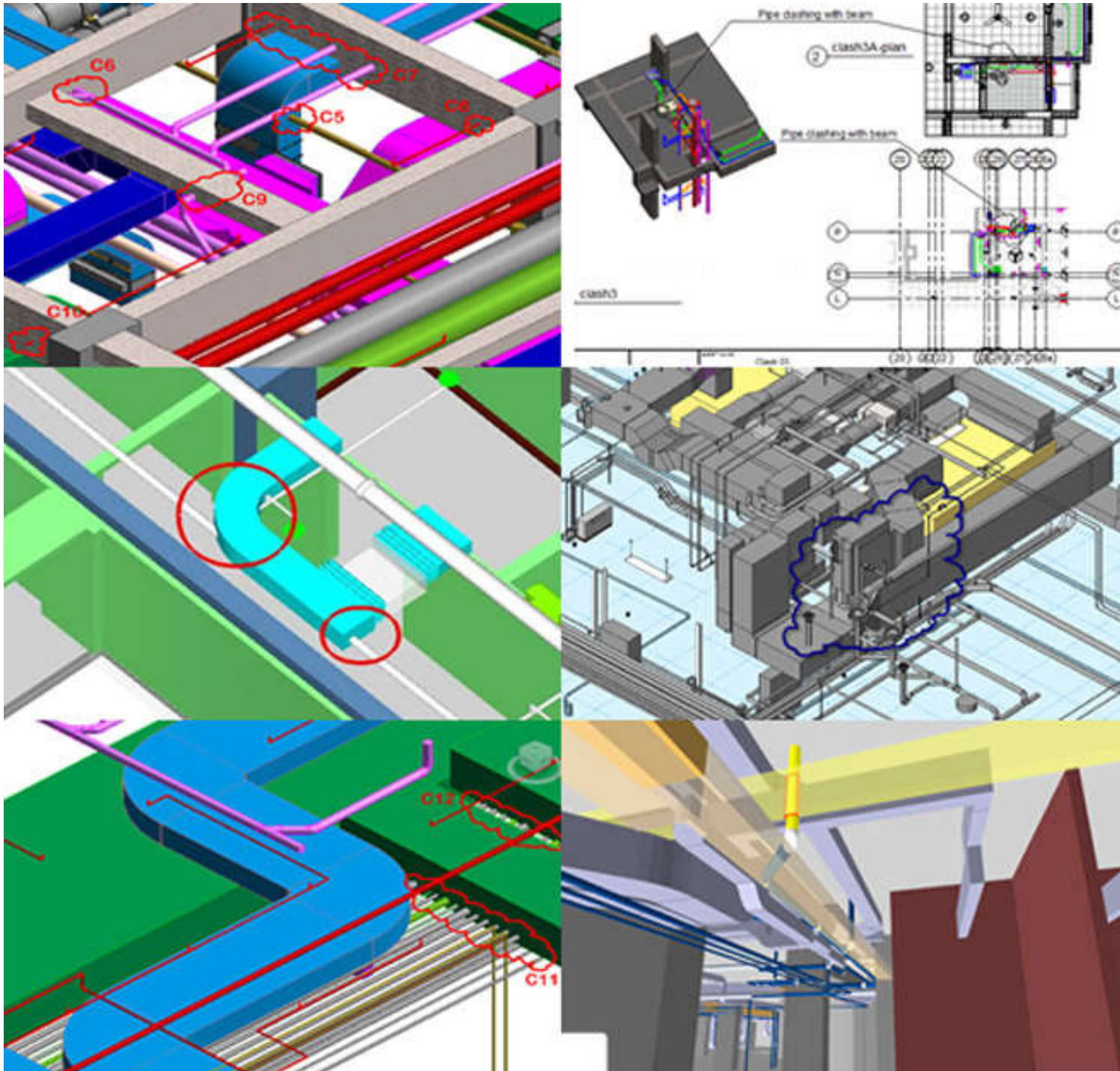
(*See also: Video: Building Services Coordination - Hospital Boiler Room Case Study (6:10) https://youtu.be/YjK7wa9YqDo)

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

- 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

- 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

- Impose BIM in traditional procurement
- Integrating engineering, construction and procurement
- Improvement in software detection algorithms
- Co-creation among designers in a shared workspace

- 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
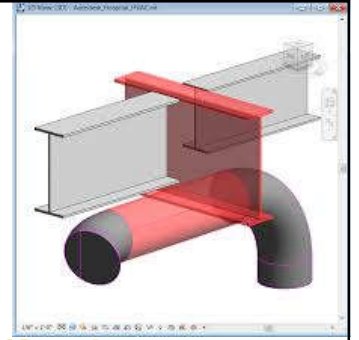
- Clash avoidance/prevention
  - Ensure all building components & systems will fit in their allocated space and that all items can maintain access & serviceability
  - Can be performed while developing the design, especially for congested or critical areas of the building
- Clash detection
  - A review 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
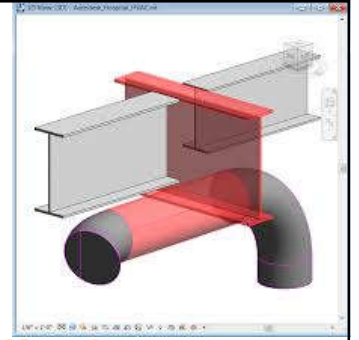
- BIM can reduce clashes by bringing together the entire design team to work on one collaborative, co-ordinated building model, as an integral part of the entire design & construction process*

- 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
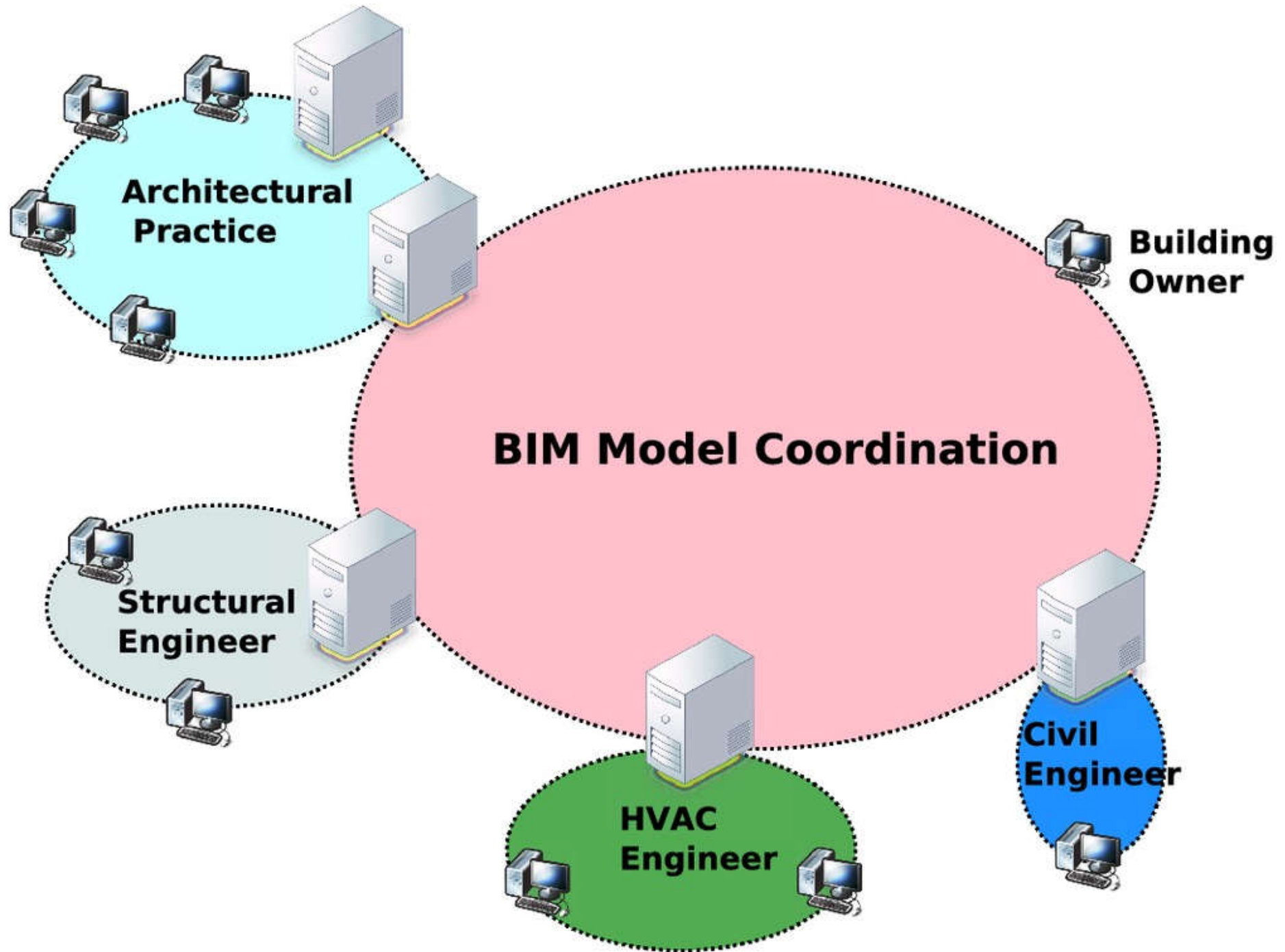
Clash detection & avoidance
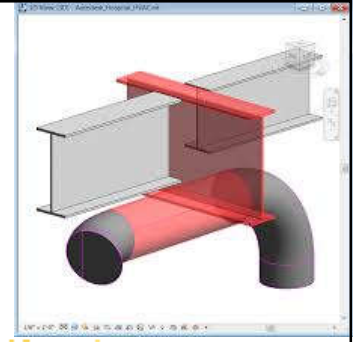
- Federated model in BIM
    - It is an assembly of distinct discipline models to create a single, complete model of the building
    - It consists of linked but distinct component models, drawings derived from the models, texts, and other data sources that do not lose their identity or integrity by 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

| Retain ownership | Retain ownership | Retain ownership | Retain ownership |

| architectural model | structural model | services model | manufacturer models |

federated model
(not editable but available to all)

Shared

| data | understanding | visualisation | analysis |
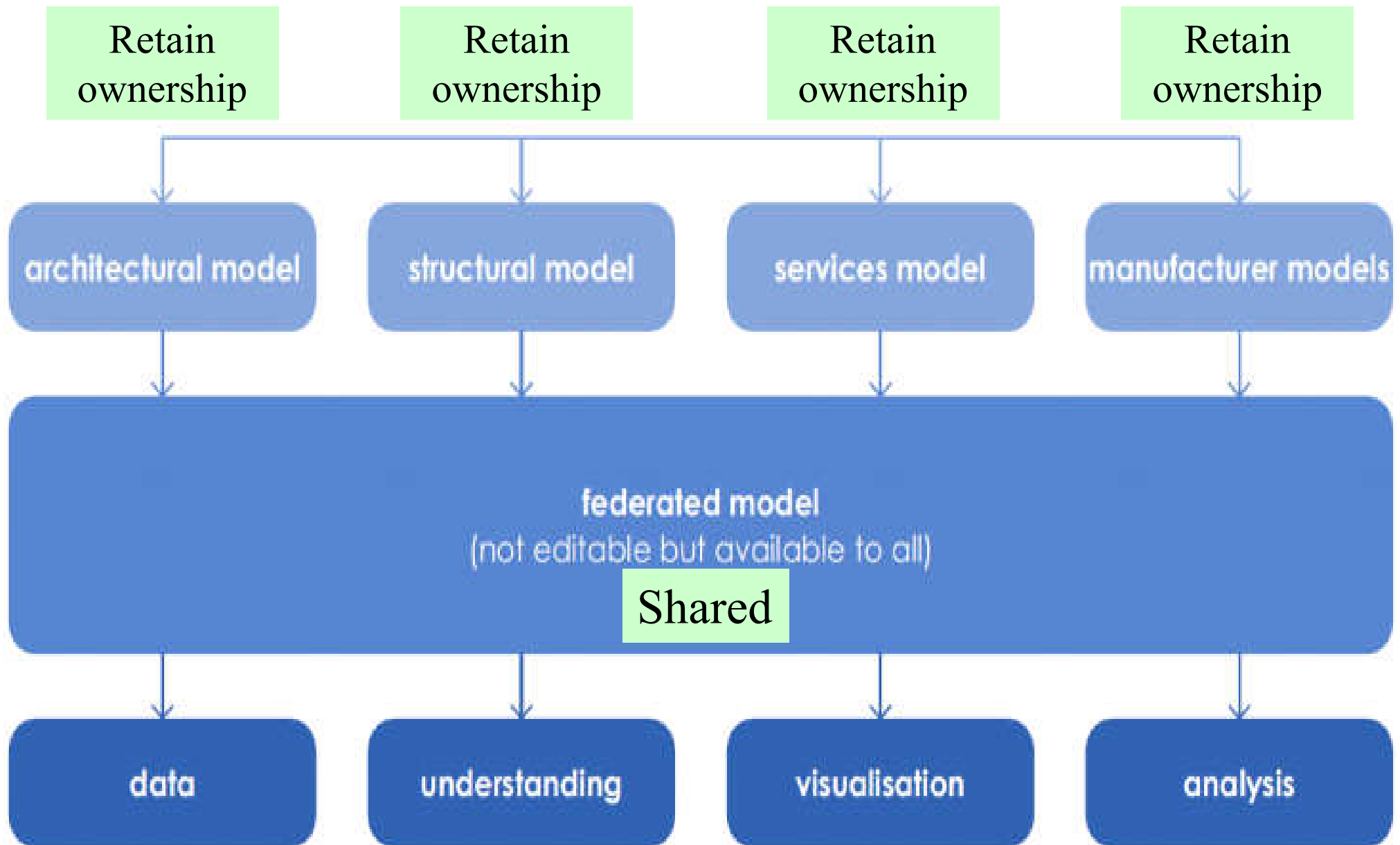
Clash detection & avoidance

- 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

(See also: Video: The Federated BIM Model (5:39) https://youtu.be/uUo6Lek-ykc)

Clash detection & avoidance
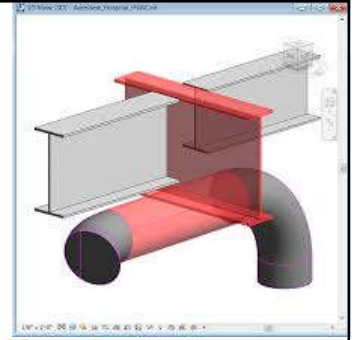
- Clash detection is usually done by the design team or on the contractor side

- 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
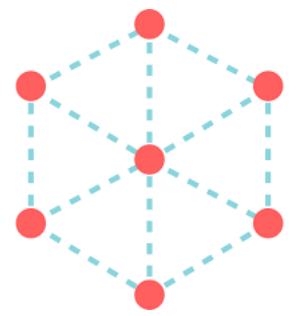
- BIM clash detection software, such as:

  - 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://synchroltd.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)

Upload to coordination model → Review & Markup Design → Designer Clash Detection → Coordination Clash Detection
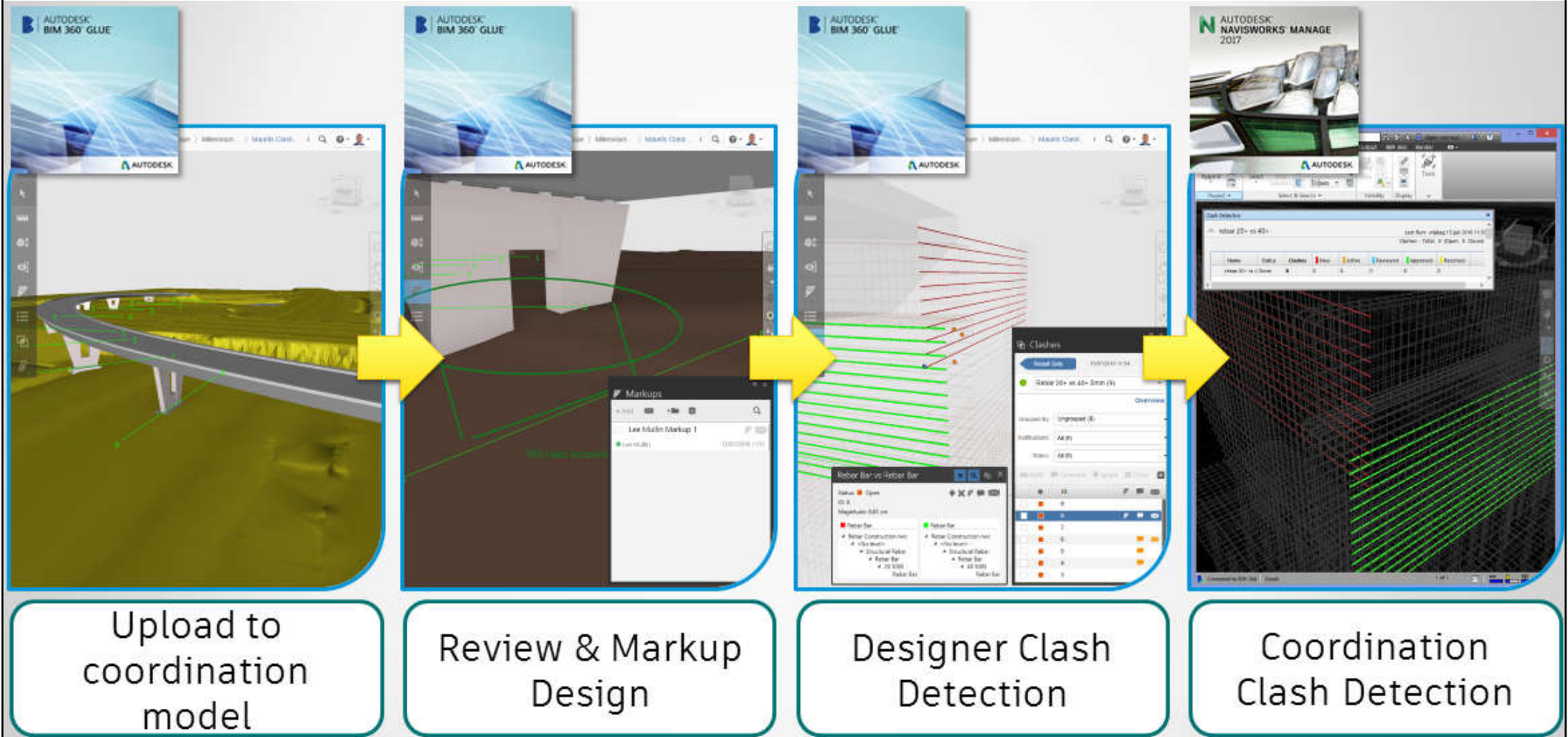
Clash analysis & management
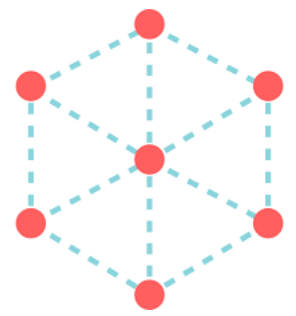
- Video demon: clash detection & BIM model coordination
  - BIM 360 Glue Workflow Introduction (4:01) https://youtu.be/Vc6ehBJNtQQ
  - Autodesk BIM 360 Glue and Navisworks Manage 2016 (3:39) https://youtu.be/AZUqci3jPfU
  - BIM 360 Glue vs. Navisworks Manage (13:22) https://youtu.be/0doN9JDpvsI
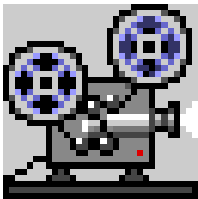
Clash analysis & management
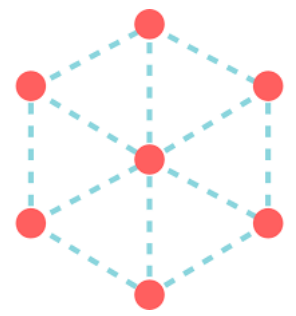
- [Clash test](): a predefined set of elements which have to be checked for collisions

- [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
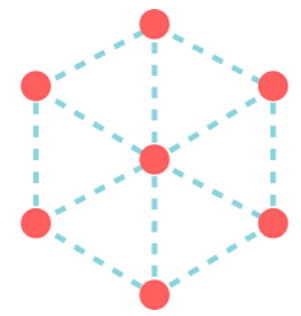
- ## Clash matrix

  - 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)

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

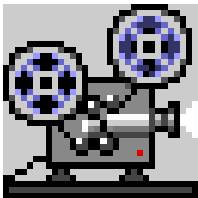# Using BIM Collaboration Format (BCF) to manage issues efficiently
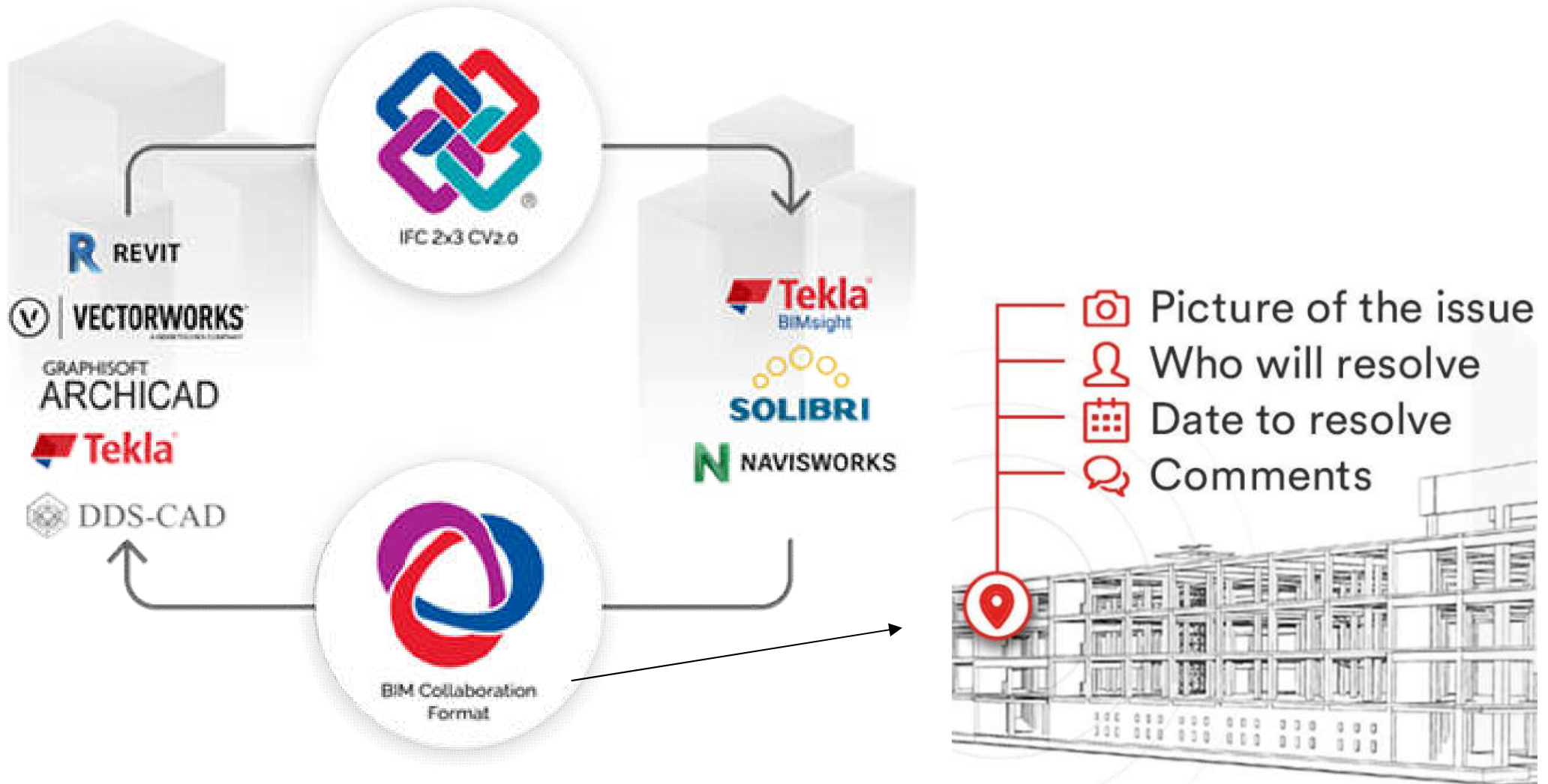
BCF is the communication between IFC tools and native modelling software. The BCF will identify exactly which objects are involved in an issue and will even record the screen view. So, when someone opens up a BCF issue in their modelling software they are directed to the exact same view in their model.

(Source: https://bimtrack.co/blog/blog-posts/understanding-clash-detection-and-making-it-more-efficient)

Clash analysis & management
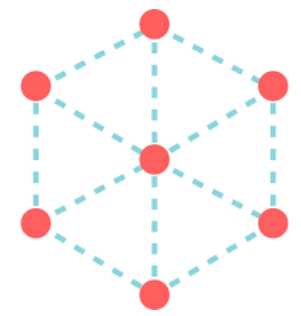
- Examples of clash/issue management process
  - Video: BIM Track - Help Center - Clashes to Issues (3:56) https://youtu.be/iU3k13-os9c
    - How to publish Navisworks clashes using BIM Track addin & then do issues management
  - Video: BIM Track - Help Center - Revit - Create Issue From 2D Views (1:28) https://youtu.be/_RgyiKl7KrQ
    - How to create an issue from a 2D view or sheet in Revit with BIM Track.

Collaboration & communication process for clash management

(Source: BIM Track https://bimtrack.co/)

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

BIM Manager / BIM Coordinator

Merge models
Clash detection
Identification information

TEKLA BIMsight   N   SMC

Report transmittal

Read and annotate report

Engineers   Manager

Architects   Others

PDF   M

BIM Modeller

Fix issues / Modeling

R   Tekla

Models transmittal
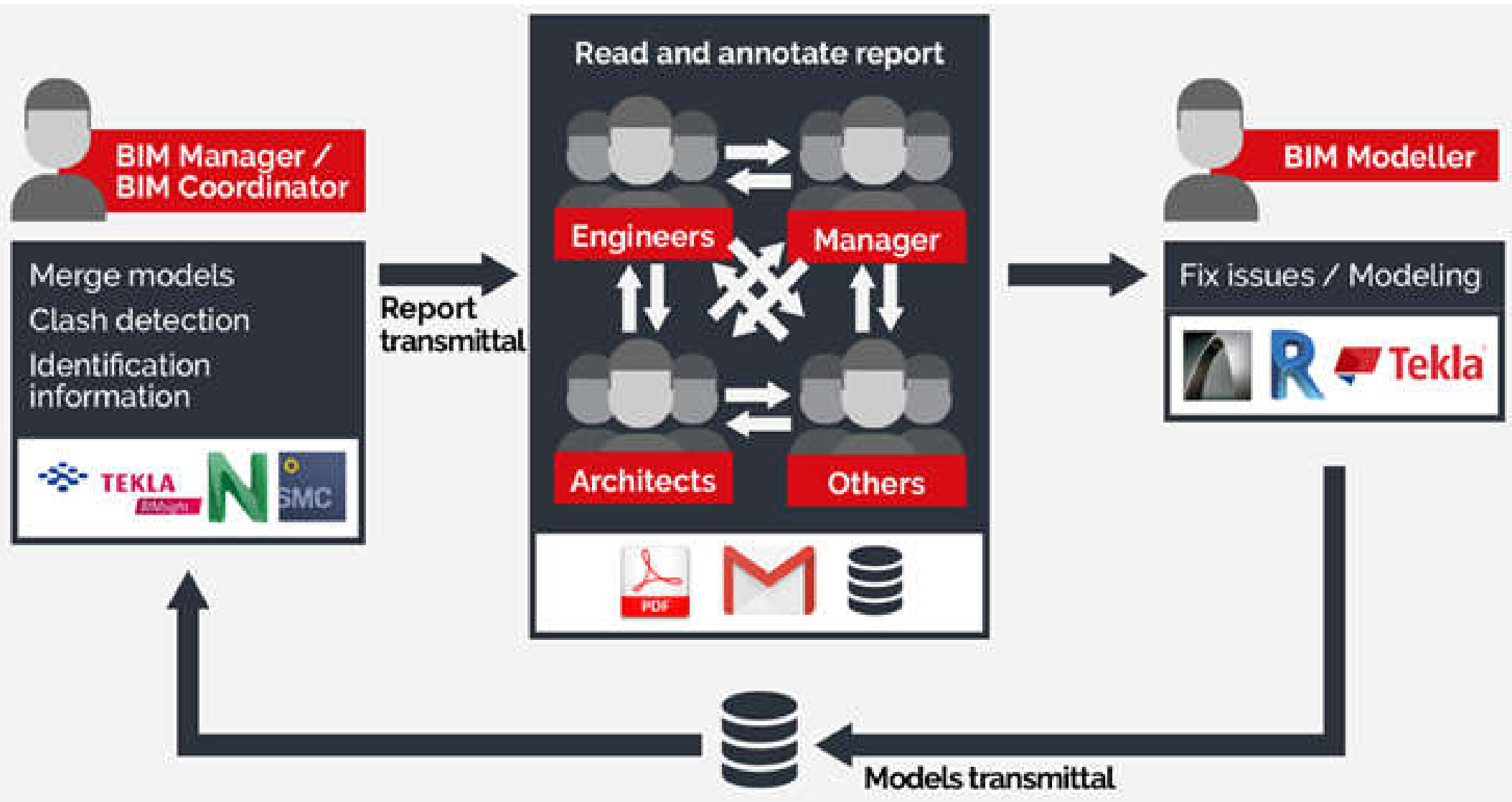
Cloud-based worksharing to support clash detection & coordination
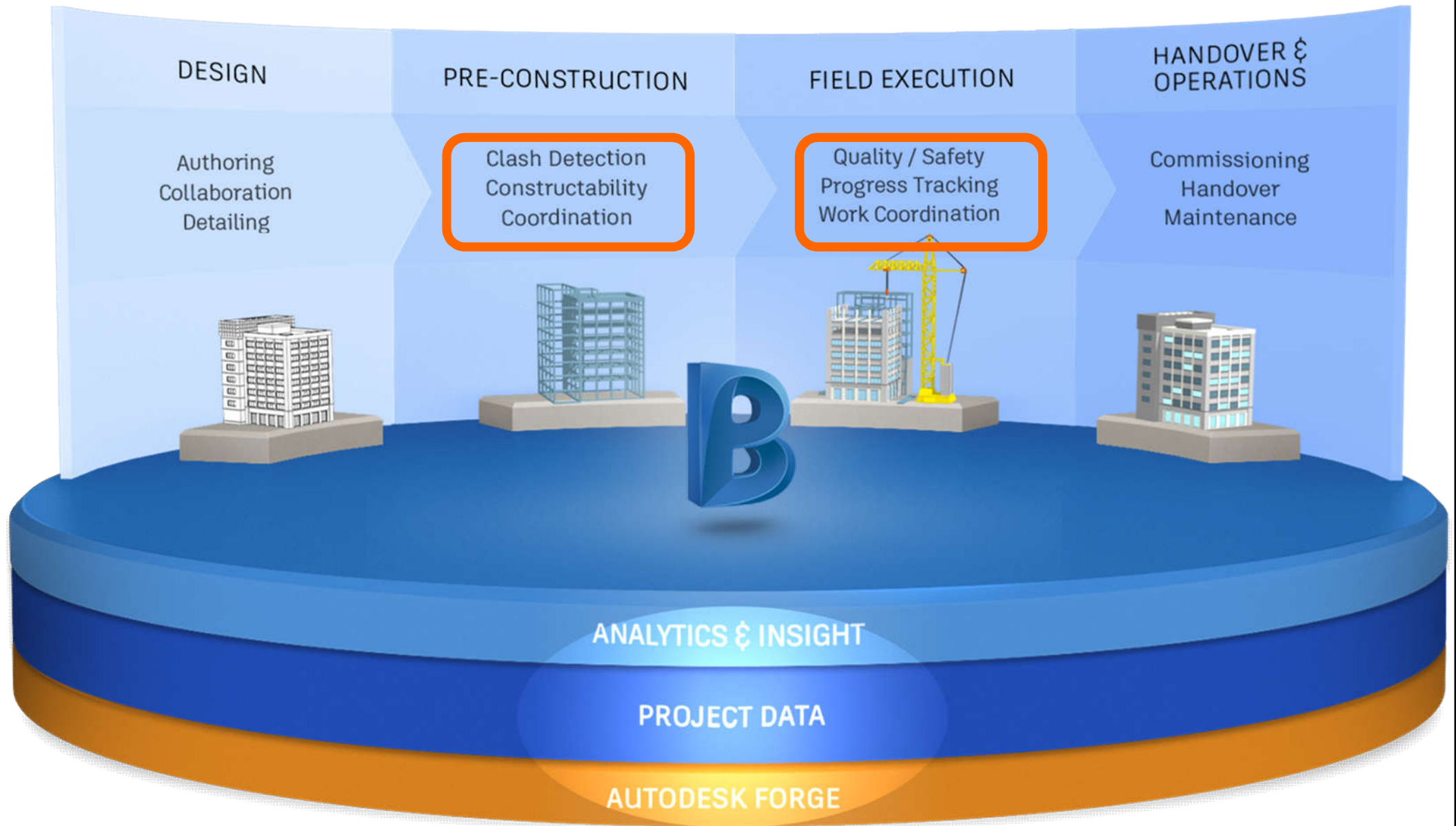
(See also: BIM 360 Glue https://info.bim360.autodesk.com/bim-360-glue)

Comparison of typical & cloud-based coordination workflows

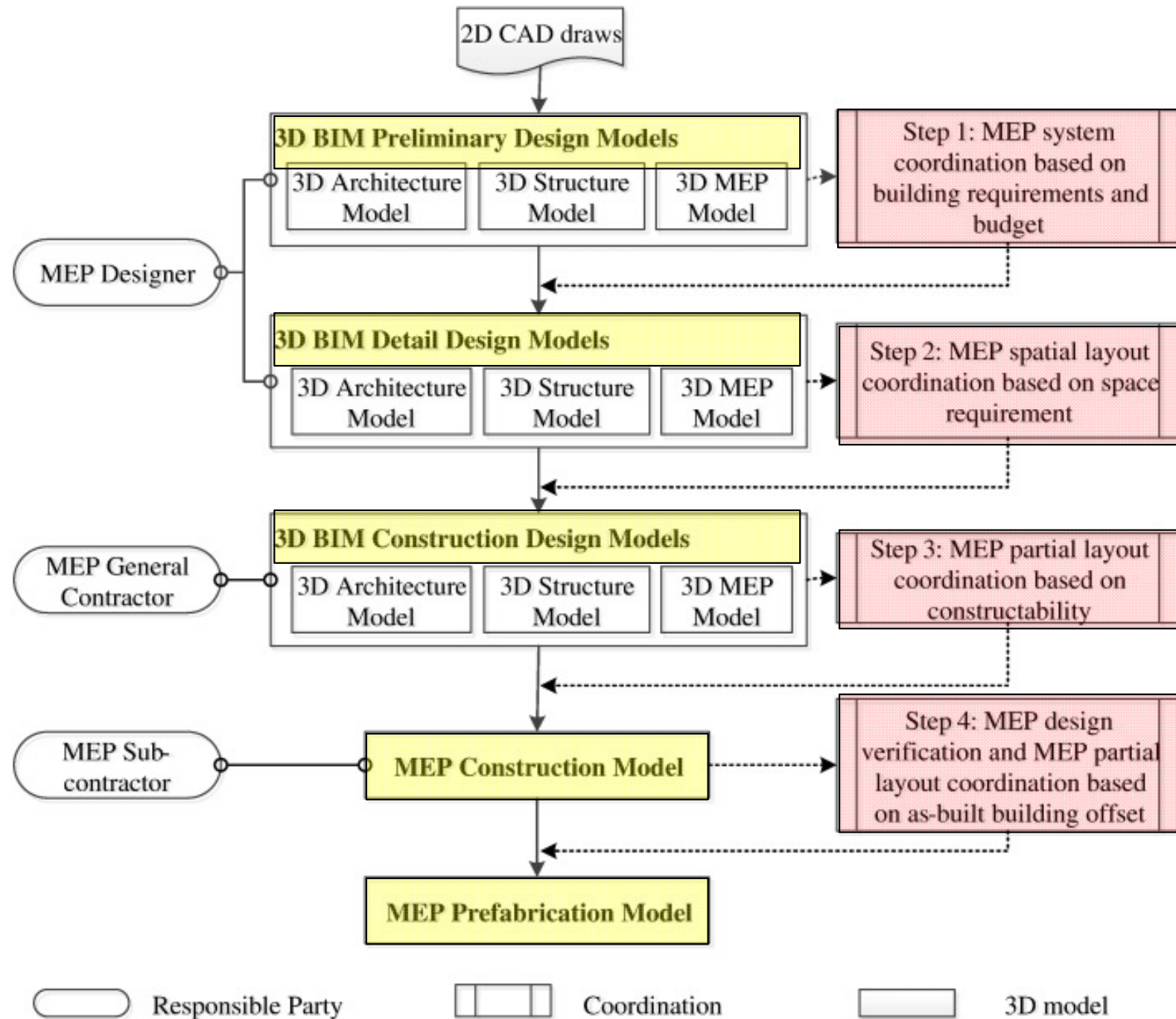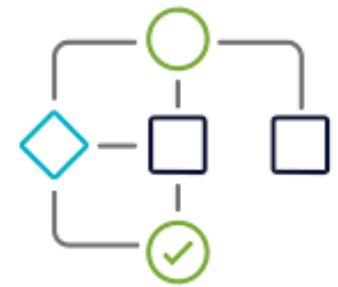| Typical model coordination workflow	Cloud-based collaborative workflow
• The BIM modelers create the models in their favorite authoring software • The models are shared with BIM managers and coordinators • The BIM managers or coordinators merge the models, inspect them for quality insurance, run a 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	• 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

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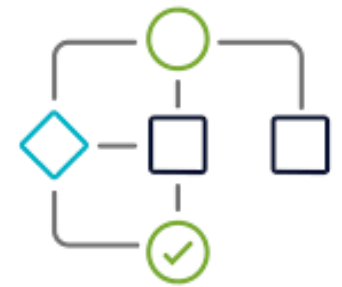
(Source: Wang J, Wang X, Shou W, Chong H.-Y. and Guo J., 2016. Building information modeling-based integration of MEP layout designs and constructability, *Automation in Construction*, 61 (2016): 134-146.)

Coordination workflow

- 1. <u>MEP system coordination based on building requirements and budget</u>
  - 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
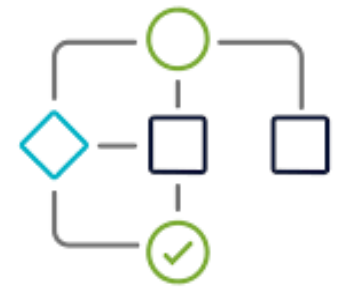
- 2. <u>MEP spatial layout coordination based on space requirements</u>

  - 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
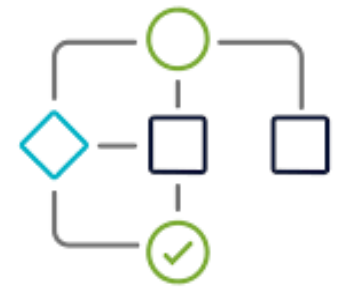
- 3. <u>MEP partial layout coordination based on constructability</u>

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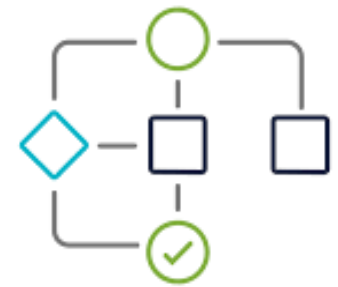
- 4. <u>MEP design verification and MEP partial layout coordination based on as-built building offset</u>
    - This step is the most important works in the whole MEP design process
    - The critical works of this stage are measuring construction deviations especially in tight space area, updating existing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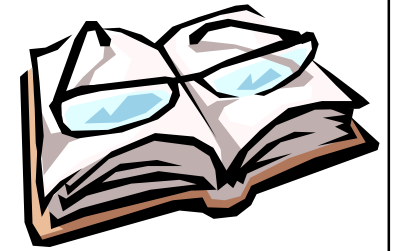
Further reading

- 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