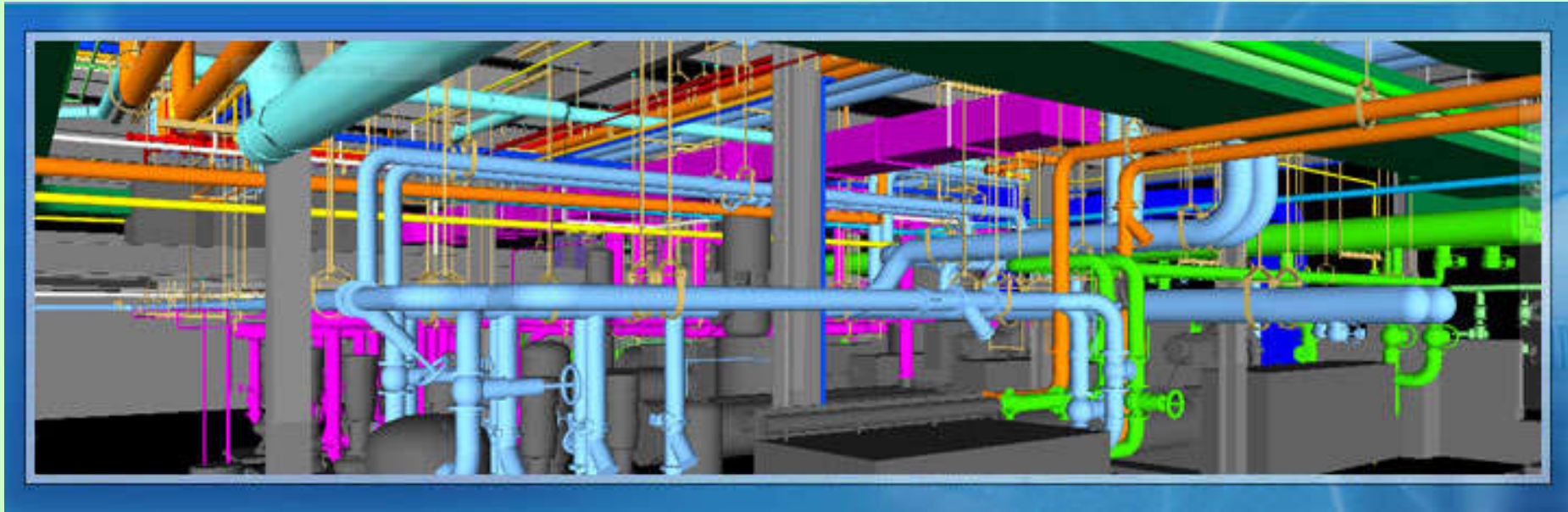


SBS5411 Building Information Modelling for BSE

<http://ibse.hk/SBS5411/>



Introduction



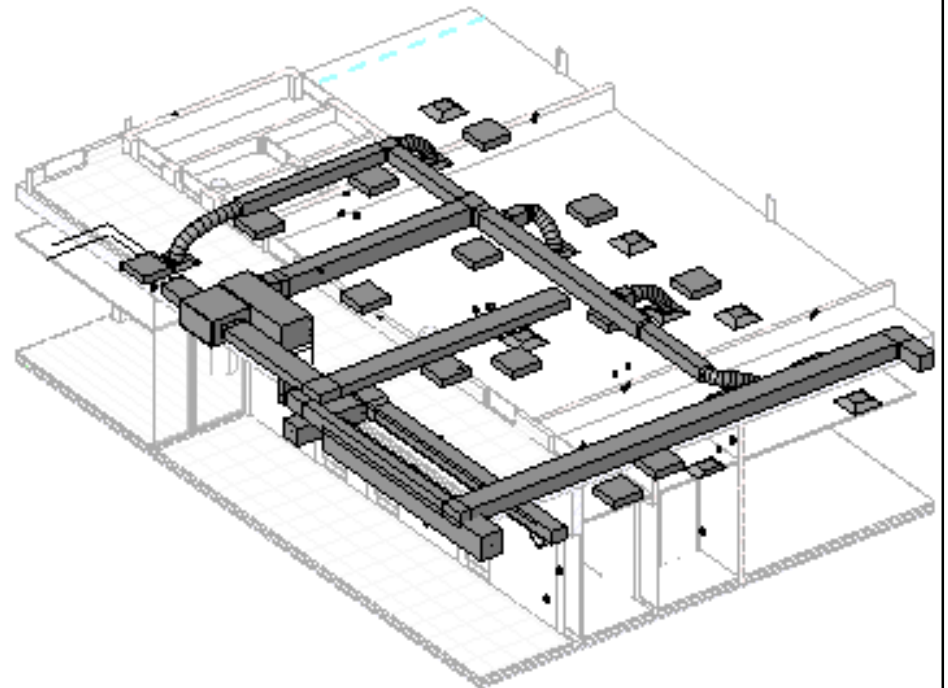
Ir. Dr. Sam C. M. Hui
Faculty of Science and Technology
E-mail: cmhui@vtc.edu.hk

Aug 2018

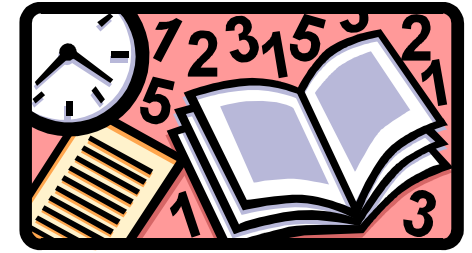
Contents



- Background
- BIM for MEP
- Potential benefits
- MEP model coordination
- Revit learning

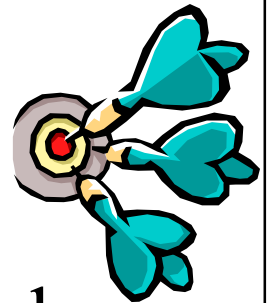


Background

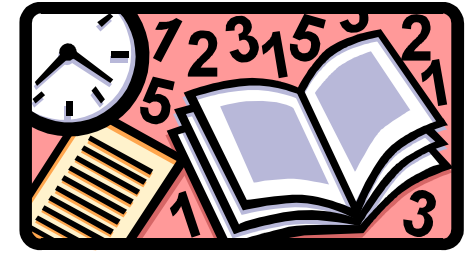


- Module Aim(s):

- This module aims at providing students with a scope of the most popular IT and building information modelling (**BIM**) technologies for **building services engineering**. The module enables students to integrate those technological tools into building services design and building physics analysis. It will enhance students' understanding of the applications of BIM to building services engineering and develop their skills in using BIM software for **MEP** (mechanical, electrical and plumbing) design.



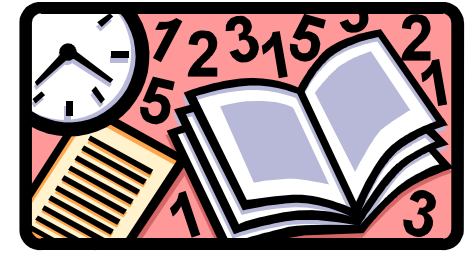
Background



- Learning Outcomes:

- 1. apply IT available technology in BSE design and building physics analysis;
- 2. apply integrating software design into the BSE system design and interpret the input and output for the software analysis; and
- 3. set up a validation of the system and perform building physics analysis and construction BIM coordination.





Background

- Lecturers:

- Ir Dr. Sam C. M. Hui (cmhui@vtc.edu.hk)
- Dr. PAN Yan, Penny (pennypan@vtc.edu.hk)

- Course Website: (with links and resources)

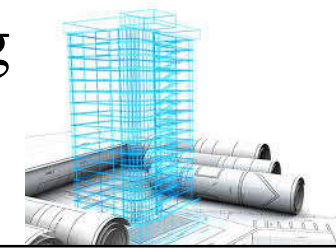
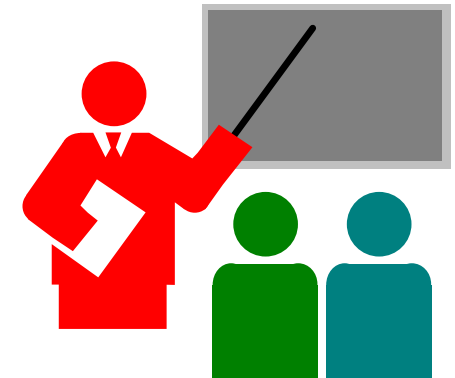
- <http://ibse.hk/SBS5411/>

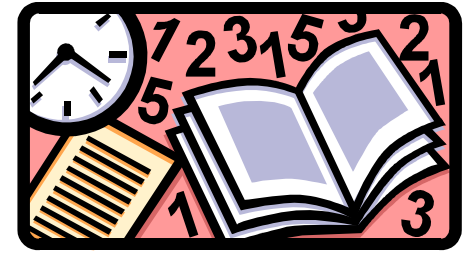
- Moodle system

- <http://moodle.thei.edu.hk/>

- Related modules:

- SBS4125 Engineering Drawing and Construction CAD
- SBS5322 Basics of Building Information Modelling



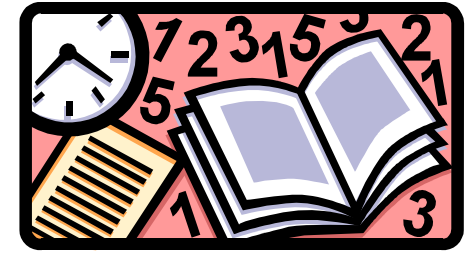


Background

- Assessment Components:
- Assignments (50%)
 - Assignment by Dr. Hui (25%)
 - Assignment by Dr. Pan (25%)
- Examination (50%) (3 hours)
 - Section A by Dr. Hui (5 out of 6 questions @ 10 marks)
 - Section B by Dr. Pan (5 out of 6 questions @ 10 marks)
- (***) Attendance to lectures, tutorials & practical sessions is important.)



Background



- Study topics:

- 1. Introduction
- 2. Revit MEP basics
- 3. Revit Mechanical
- 4. Revit Electrical

Dr. Hui

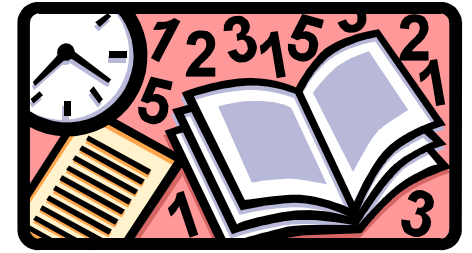


-
- 5. Revit Plumbing
 - 6. Revit Fire Protection
 - 7. MEP Design Management
 - 8. MEP Coordination

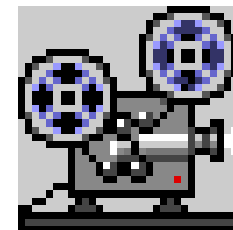
Dr. Pan

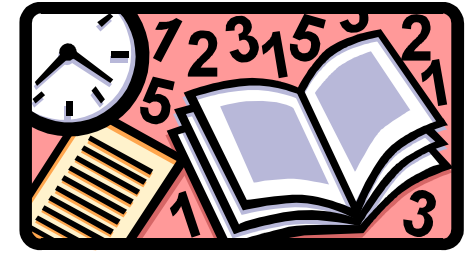


Background



- Learning Methods:
 - Lectures + Further reading
 - Practical training
 - Individual assignments
 - Technical talks
- Resources:
 - Videos + ebooks
 - Web links + References



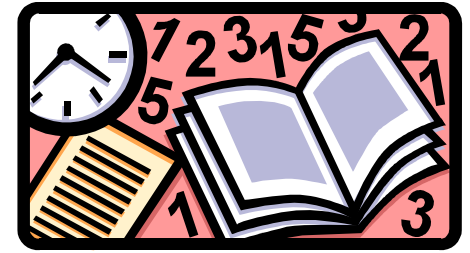


Background

- Remarks:
 - The BIM knowledge and skills of this module will be applied to your Final Year Projects (FYPs)
 - SBS5397 Final Year Project 1 (BSE Conceptual Design)
 - SBS5499 Final Year Project 3 (MEP Design)
 - Practical examples of FYPs will be used in the assignments and exercises

BIM >>> FYPs

- Conceptual design
- Detailed design



Background

- Useful Websites:

- Revit 2018 Learning

- <http://help.autodesk.com/view/RVT/2018/ENU/>

- Autodesk® Revit®: Free online course

- <http://www.learningrevitonline.com/>

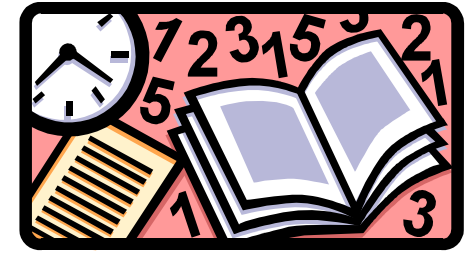
- Free Online Classes and Tutorials | Autodesk University (AU)

- <http://au.autodesk.com/au-online/overview>

- Autodesk Knowledge Network

- <https://knowledge.autodesk.com/>

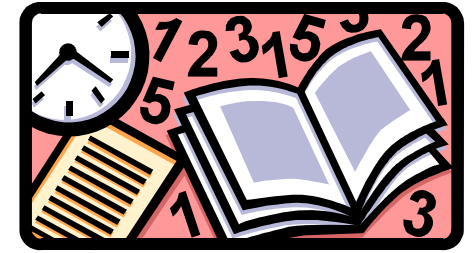




Background

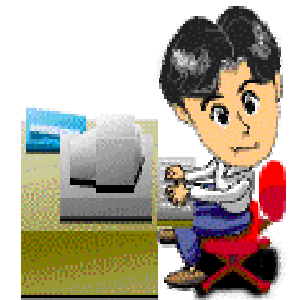
- Useful References:

- Bokmiller, D., Whitbread, S. and Hristov, P., 2013. *Mastering Autodesk Revit MEP 2014*, Sybex, Indianapolis, Ind. [[TH 6010 .B65 2013 \(ebook\)](#)]
- Wing, E., 2016. *Autodesk Revit 2017 for Architecture No Experience Required*, Sybex, Indianapolis, Indiana. [[VTC ebook](#)]
- 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.
<https://www.sciencedirect.com/science/article/pii/S0926580515002083>



Background

- Training courses in Hong Kong or online:
 - Building Information Modelling (BIM) Advanced Modelling Course (MEP) - Revit (30 hrs)
 - <https://www.hkic.edu.hk/eng/course/bie>
 - Form.Welkin 天行凝方
 - Revit MEP <https://www.formwelkin.com/revitmep/>
 - VTC short courses <https://cpe.vtc.edu.hk>
 - Building Information Modelling (BIM) Certified Expert Level II MEP Training Course
 - Building Information Modelling (BIM) Advanced Mechanical, Electrical and Plumbing (MEP) Training Course
 - Revit Training and Tutorials (Lynda.com)
<https://www.lynda.com/Revit-training-tutorials/>



BIM for MEP



- **Building Information Modelling (BIM)**
 - It is a **model-based technology** linked with a database of project information
 - BIM builds a **virtual model** of the building so that architects, engineers, and contractors can all access at anytime (enhance **collaboration**)
 - With BIM, architects and engineers are able to efficiently generate and exchange information, create **digital representations** of all stages of the building process, and simulate real-world performance
 - Many errors are eliminated in the field which increases productivity and improves quality

**Facility
Manager**

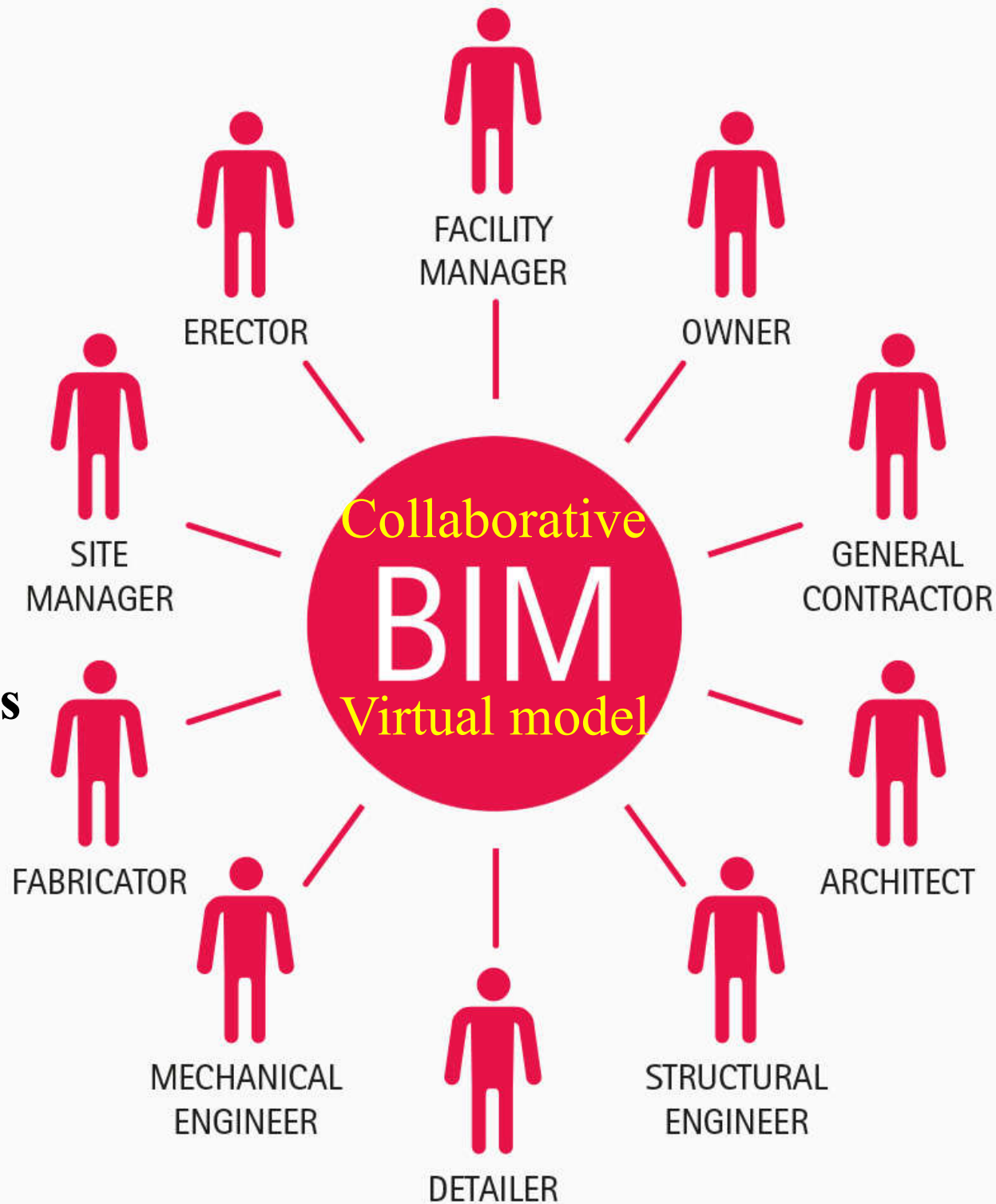
**Building
Owner**

**Suppliers/
Manufacturers**

Contractors

Engineers

Architect



BIM offers automatic coordination of changes to eliminate mistakes and improve the overall quality

**BIM
Virtual
Model**

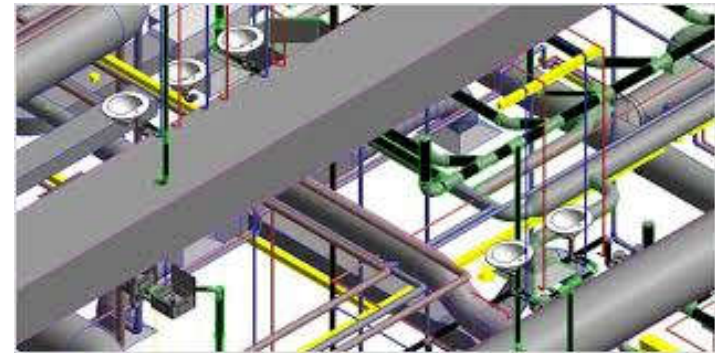
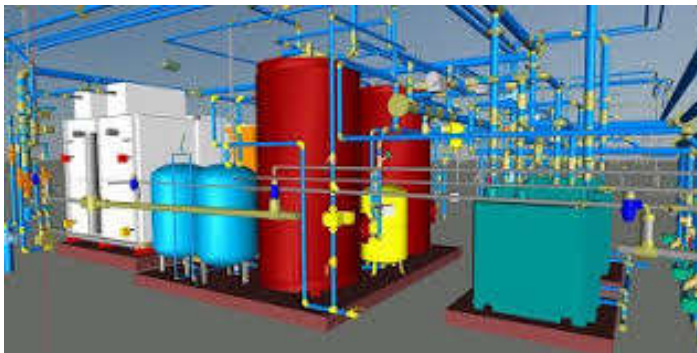
**Excel
Spread-
sheet**

Similar to the Excel spreadsheet (with automatic recalculation), whenever a change is made to the project, all the consequences of that change are updated throughout the entire project. This means that the design and documentation are captured at the point of creation and embedded throughout the project.



BIM for MEP

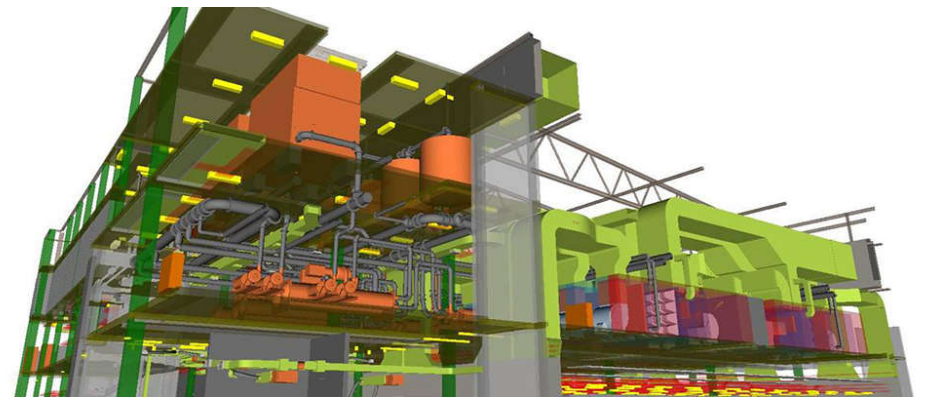
- BIM for BSE or MEP Engineering
 - It is the purpose-built building information modelling (BIM) developed to incorporate non-conflicting design of **Mechanical, Electrical, and Plumbing (MEP)** engineering in an architectural design of building and to identify the material requirements for complete construction



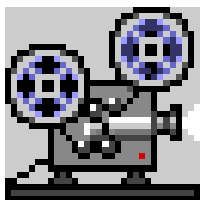
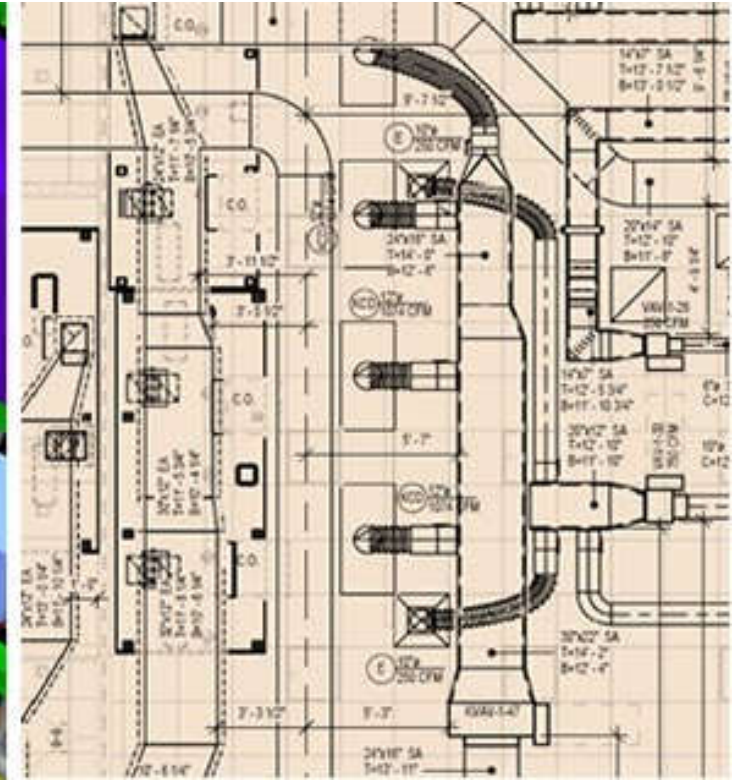
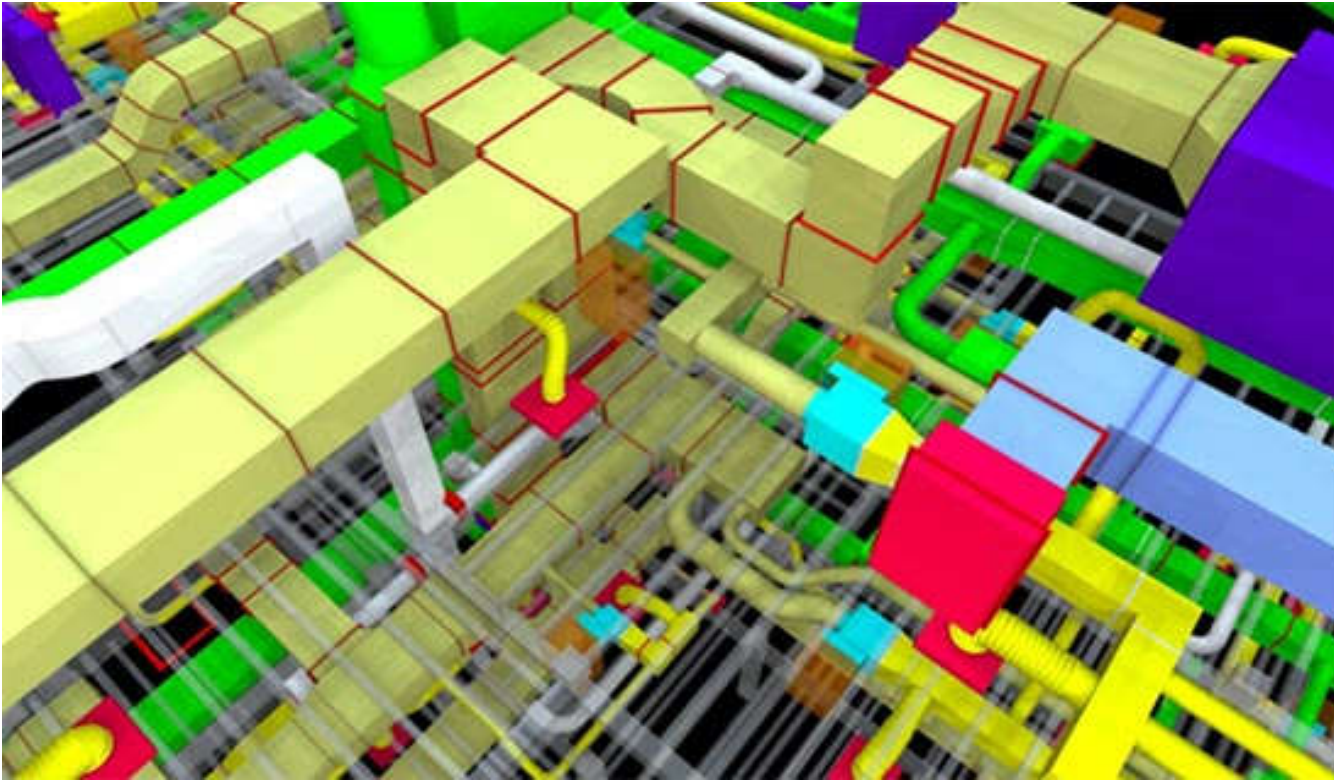


BIM for MEP

- How BIM can help BSE/MEP engineers?
 - BIM (建築資訊模型) 技術如何持續協助MEP工程人員？ <http://itacademia.com/bim-mep-workflow/>
 - Early conceptual design 前期概念設計
 - Detailed design and modeling 詳細設計
 - Energy analysis 能量分析
 - Collaboration 協同設計
 - Visualization 可視化



BIM: integrated tools for connection workflows for MEP engineering and design; use tools for conceptual design, analysis, and detailing coordination of building systems.



Video: What can MEP engineers do with the Autodesk AEC Collection? (3:20)

<https://youtu.be/V6CiZzG5Qsk>



BIM for MEP

- Using BIM to improve BSE/MEP design
 - 1. Computable building model
 - A (virtual) model in software that can be operated on by a computer as a building
 - 2. Holistic BSE/MEP design
 - Such as automatically configure electrical load requirements to dynamically change in mechanical equipment specifications
 - 3. Parametric change management
 - Schedule, cost, building performance, and so forth
 - 4. Avoiding interferences
 - To overcome the challenges of fitting the components into tight spaces, and then provides interference checking to detect collisions



BIM for MEP

- Computable building model
 - Test the performance of their design, eliminating the time-consuming task of transferring data manually
 - Support performance-based design (to meet certain codes/standards)
- BIM for MEP design
 - The data centric design
 - Increase design insight
 - Increase coordination
 - Enhance communication
 - Parametric change management





BIM for MEP

- BIM in the design process
 - The BIM approach offers access to critical design, schedule, and budget information as well as the integrated automatic updates, that create savings in time and money
- BIM in construction
 - With easy retrieval of information using BIM, contractors are able to quickly produce estimates, propose value-engineer items for projects, produce construction planning details, understand and coordinate construction documents, increase in speed of delivery and improve visualization of the project

BIM for MEP



- BIM in building management

- BIM can be used to collect information on the use and performance of the actual building once it is built
- It provides a digital record of renovations and any changes to the building
- The access to this information improves both revenue and cost management of the building management phase
- By ensuring that all of the information about the building is available, the amount of time and money spent on managing the building is decreased considerably

BIM for MEP



- 10 BIM Trends in the MEP Industry for 2018

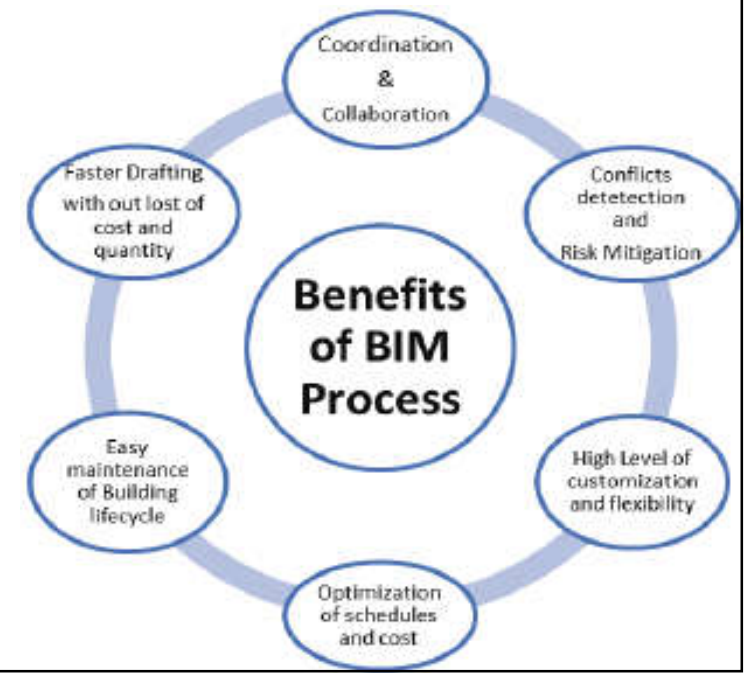
- <https://constructible.trimble.com/construction-industry/10-bim-trends-in-the-mep-industry-for-2018>
- 1. Modular construction & prefabrication
- 2. Internet of Things (IoT)
- 3. Augmented/VR Reality
- 4. Order directly from the model
- 5. Mobile cloud applications
- 6. BIM to the building site: 3D laser scans and drones
- 7. Mix and match or all-in-one solutions
- 8. BIM Goes Green
- 9. 3D Printing
- 10. 4D, 5D, and 6D-BIM





Potential benefits

- **Benefits of BIM for MEP or BSE:**
 - Video: Benefits of BIM for MEP Engineers (3:31)
<https://youtu.be/C8j4uYF0I-g>
 - 1. 3D modelling & collision detection
 - 2. Rich repository of design data
 - 3. Sustainable design processes
 - 4. Competitive advantages

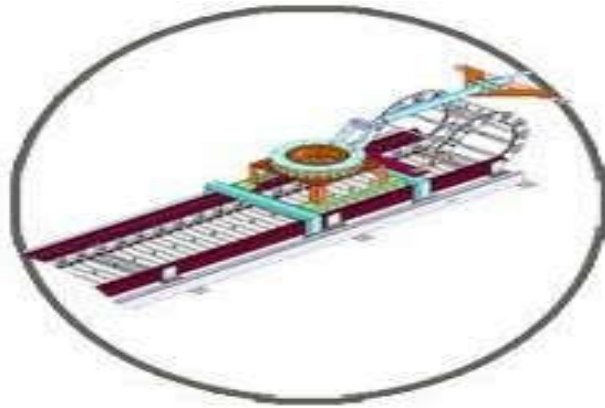




Potential benefits

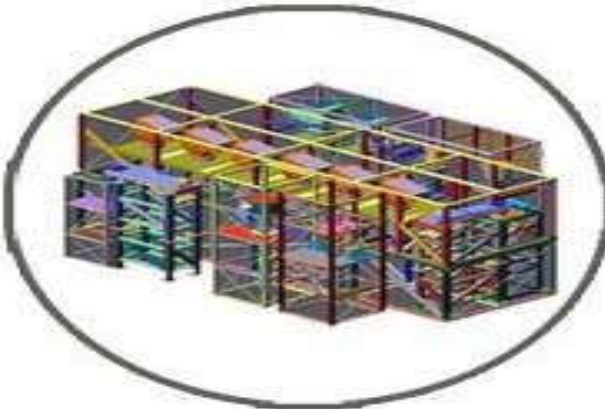
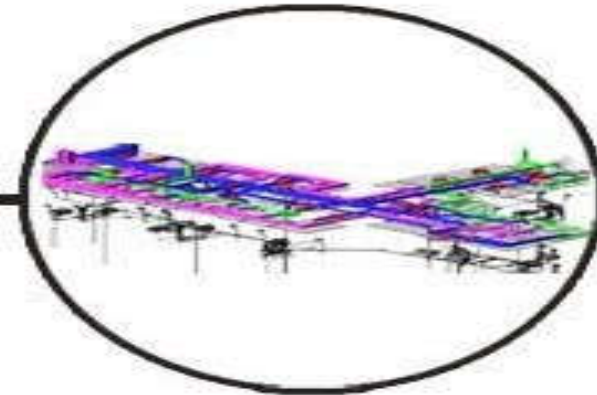
- How BIM can help MEP engineers:
 - 1. Modelling & design: 2D/3D models that helps in identifying loopholes to minimize the cost of reworks
 - 2. Fabrication drawings: by contractors to fabricate building systems & components
 - 3. Construction documentation
 - 4. Sustainable design and building performance analysis

How BIM can help MEP engineers?



Fabrication Drawings
-HVAC Contractors

Multidiscipline Coordination
with Architects, Structural
& Civil Engineers



**Sustainable Design &
Building Performance Analysis**
-MEP Engineers

Construction Documentation
-MEP Designers & Drafters



(Source: Is BIM (building information modeling) actually useful for MEP projects?

<https://www.quora.com/Is-BIM-building-information-modeling-actually-useful-for-MEP-projects>)



Potential benefits

- BIM can be used for **sustainable design**:
 - Optimize design (using analysis software/tools)
 - Daylighting (analyze & promote natural light)
 - Energy analysis (such as solar/sun study, HVAC systems, building energy simulation)
 - Computation of materials (reduce waste of materials & environmental impacts)
 - Reducing waste and inefficiency (at the construction site or during building in use)

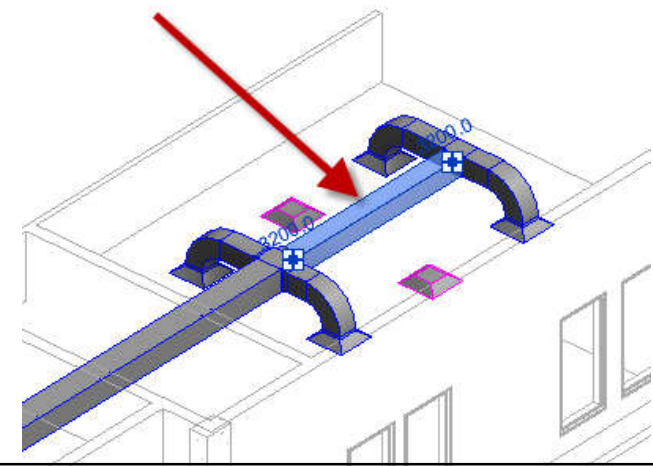
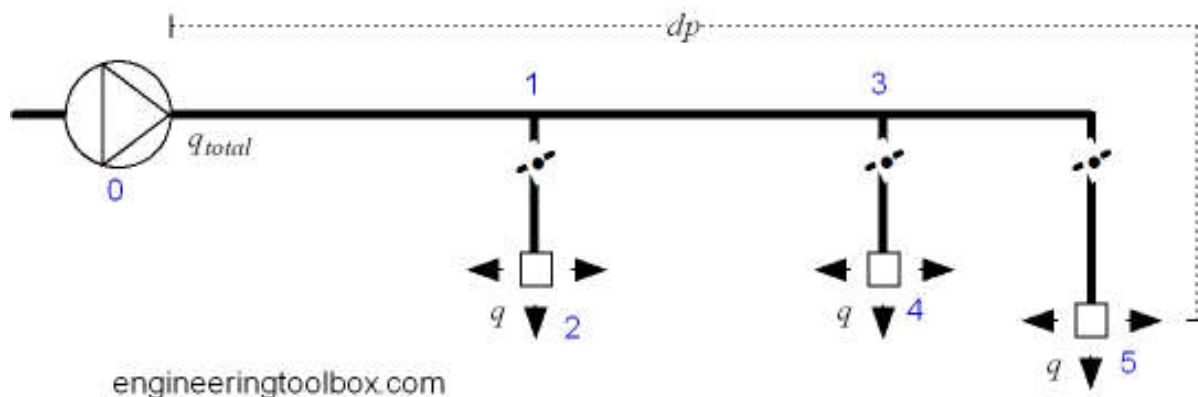


Potential benefits

- Sustainable design support:
 - Provides integrated cooling and heating load analysis tools to help you perform
 - Energy analysis, green building assessment (e.g. LEED, BEAM+)
 - Evaluate system loads
 - Produce heating and cooling load reports
- Duct and pipe sizing/pressure loss calculations:
 - Built-in tools to perform sizing & pressure calculations
- HVAC/Electrical space design:
 - 3D modeling of ductwork and piping
 - Electrical color schemes for power loads & lighting

Potential benefits

- Example (1):
 - System inspector (critical path): Identify and adjust high pressure loss areas in your system, enhancing economy and efficiency
 - The software displays critical flow path for branches, main trunks or entire systems



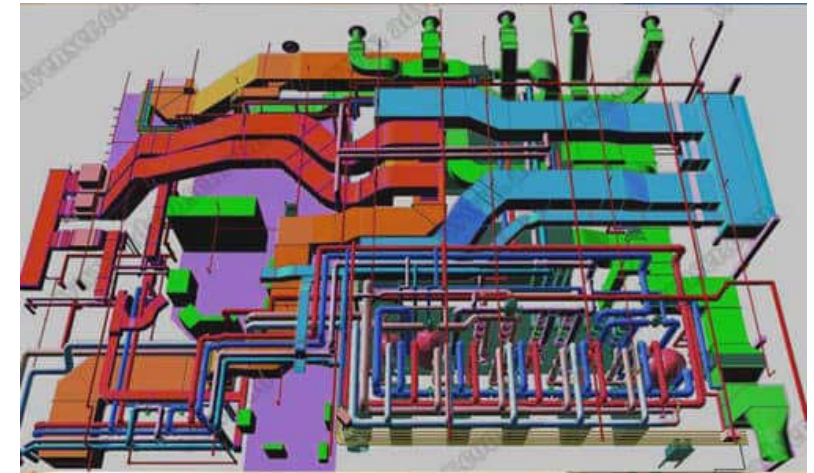


Potential benefits

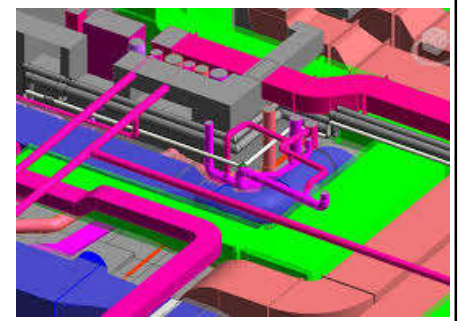
- Example (2):
 - The basic requirement of the project is the material calculations for the best estimated costing
 - Normally due to uncertainties in design safe material estimate requires 20% to 25% increased material which can be exactly calculated here
 - By the development of 3D modeling incorporated with the MEP, more exact estimation of the cost is possible
 - Through this, the project cost could be reduced up to some extent by adding it at the rate of even less than 0.5%

Potential benefits

- Examples of MEP engineering services using BIM
 - <https://www.advenser.com/mep-engineering/>
 - MEP BIM coordination
 - MEP shop drawings
 - MEP 3D modelling
 - Mechanical room modelling
 - Builders work drawing
 - As-built drafting
 - Piping spooling drawing (pipe assembly)
 - MEP quantity take off

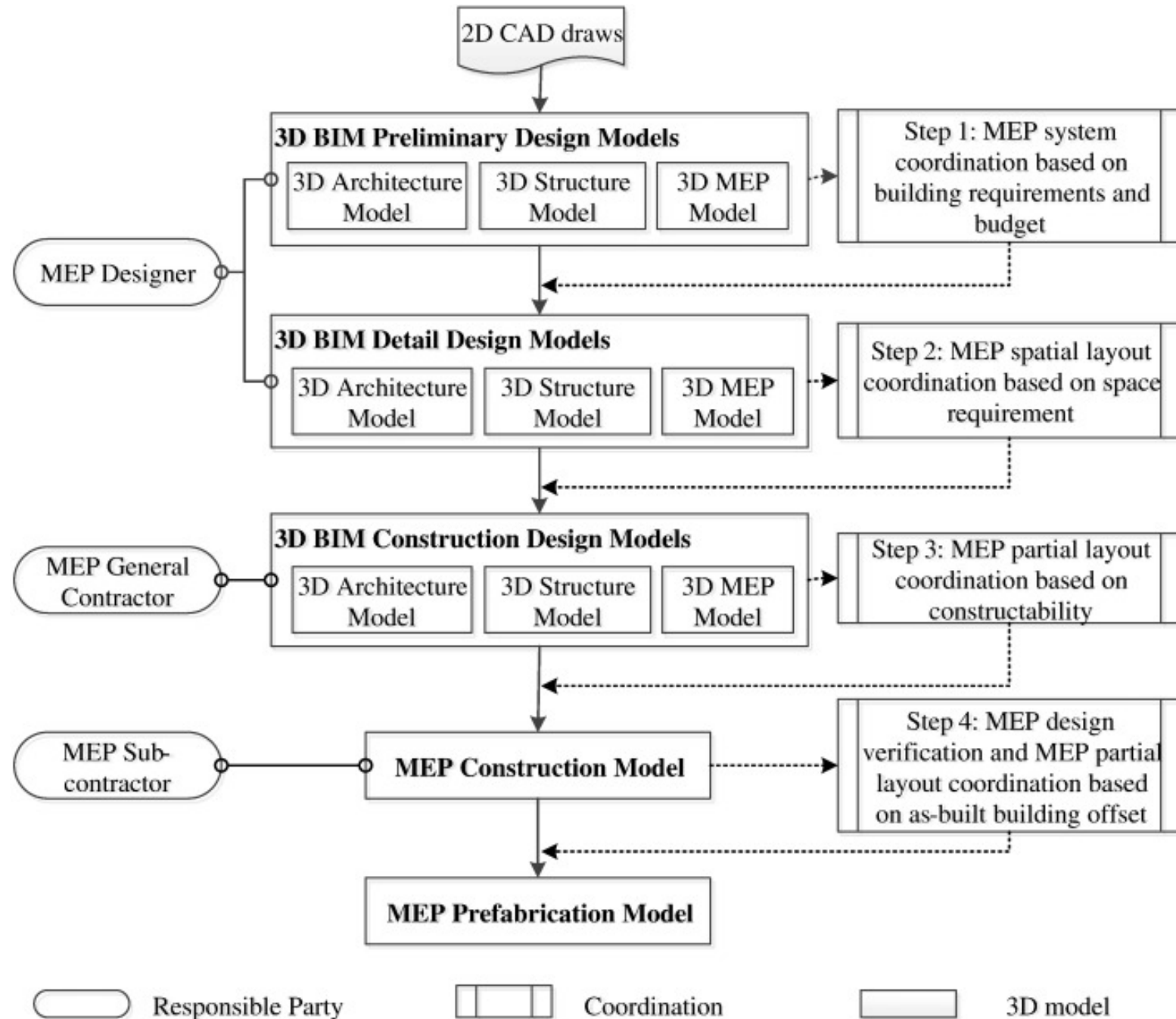


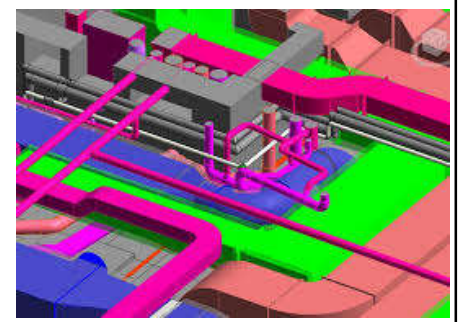
MEP model coordination



- Models of three major disciplines:
 - **Architecture**, **Structure**, **MEP**
- Five types of MEP models:
 - 3D MEP preliminary design model
 - 3D MEP detailed design model
 - 3D MEP construction design model
 - MEP construction model
 - MEP prefabrication model

Framework for BIM-based MEP layout design and constructability





MEP model coordination

- 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

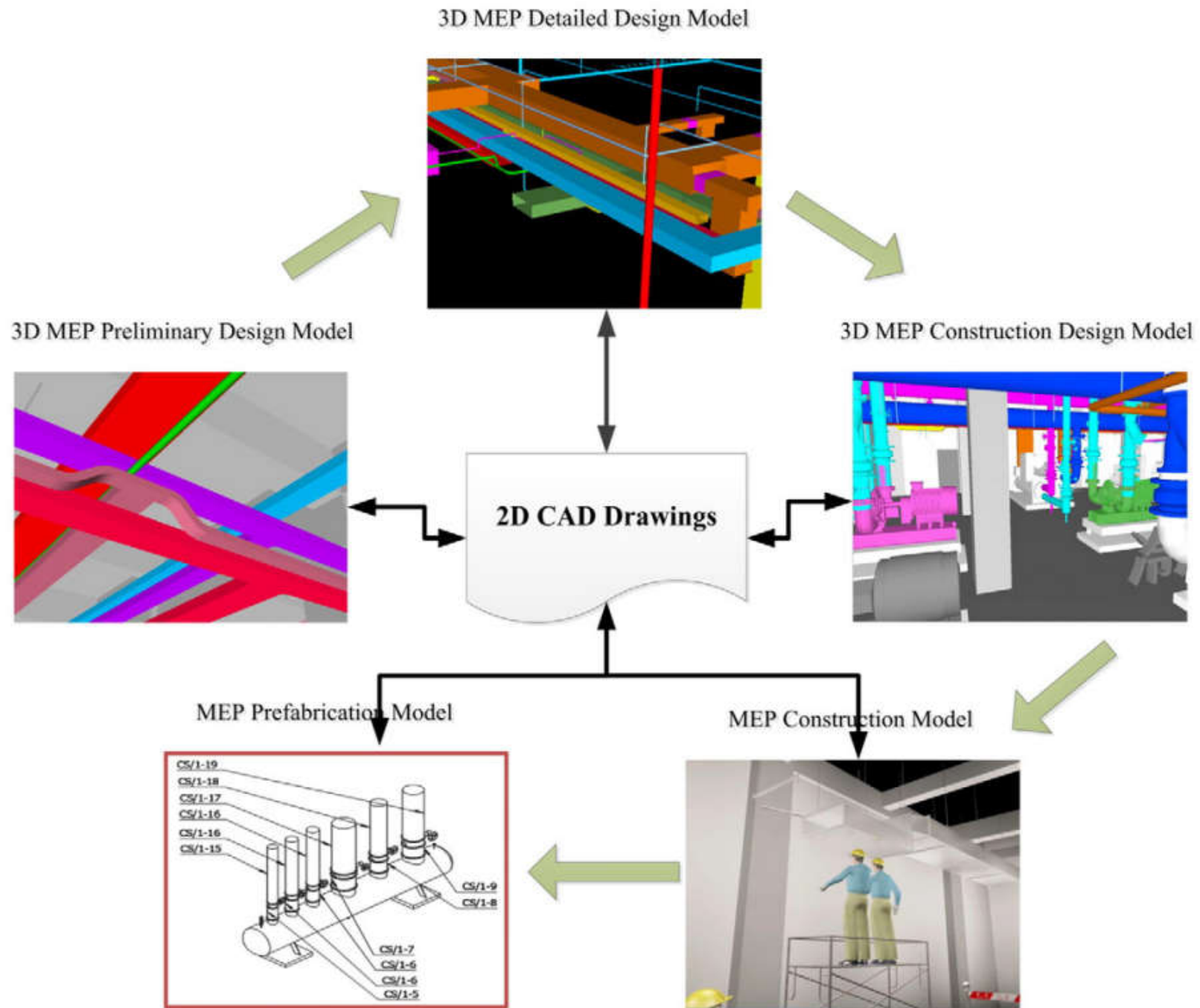
Level of details (LOD) of model elements in the MEP models

Type of models

Model elements	3D MEP preliminary design model	3D MEP detailed design model	3D MEP construction design model	MEP construction model	MEP prefabrication model
Architecture (wall and ceiling)	LOD 200	LOD 200	LOD 300	LOD 300	-
Structure (wall, column, beam, floor and steel)	LOD 200	LOD 200	LOD 300	LOD 300	-
Cable tray	-	LOD 200	LOD 300	LOD 300	LOD 400
Conduit	-	-	LOD 200	LOD 300	-
Device	-	-	LOD 200	LOD 300	-
Lighting fixture	-	-	LOD 300	LOD 300	-
Pipe	LOD 200	LOD 200	LOD 300	LOD 300	LOD 400
Valve	-	-	LOD 200	LOD 300	-
Plumbing fixture	LOD 200	LOD 200	LOD 300	LOD 300	-
Sprinkler	-	-	LOD 200	LOD 300	-
Duct	LOD 200	LOD 200	LOD 300	LOD 300	LOD 400
Air terminal	LOD 200	LOD 200	LOD 300	LOD 300	-
Mechanical equipment	-	LOD 200	LOD 200	LOD 300	-

(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.)

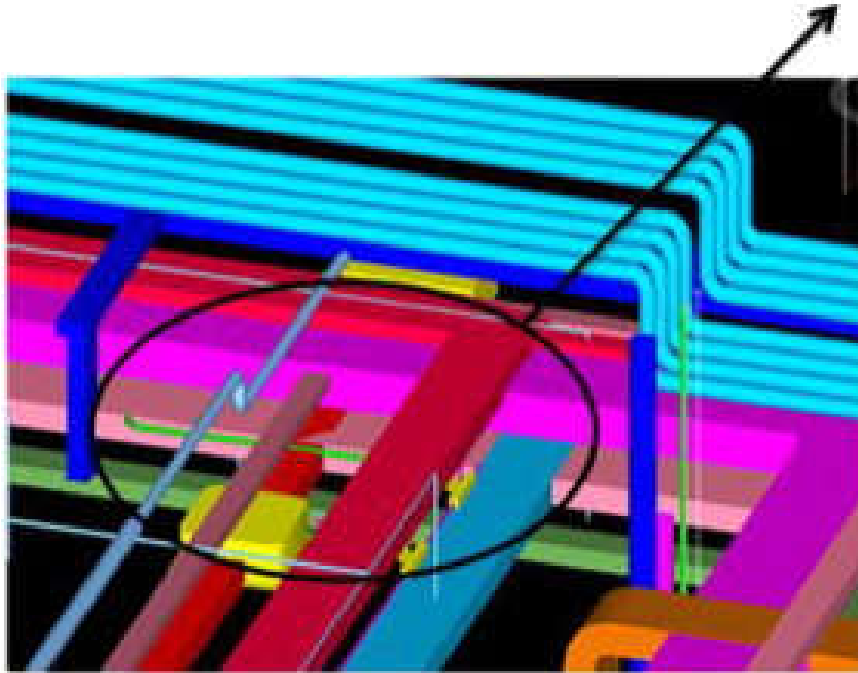
MEP model development process



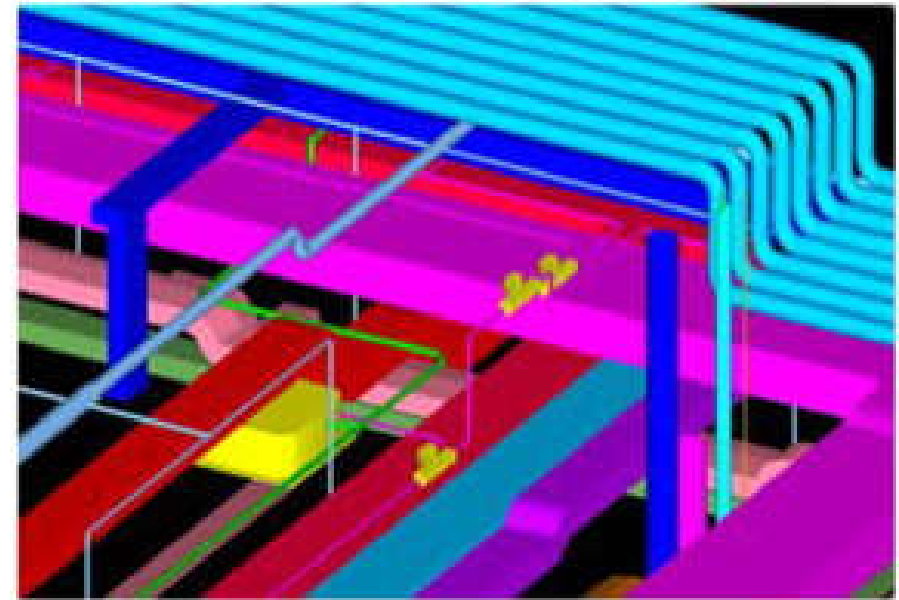
(Source: Wang J, Wang X, Shou W, Chong H.-Y. and Guo J., 2016. Building information modeling-based integration of MEP layout designs and constructability, *Automation in Construction*, 61 (2016): 134-146.)

MEP spatial layout coordination for eliminating collisions

Some Collisions



(a) Original Design



(b) After coordination

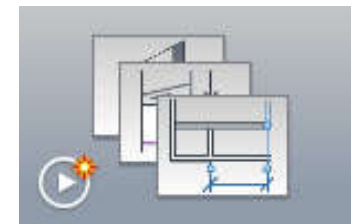
The design experience of the designers was mainly applied to solve the clashes:

- (1) Gravity driven plumbing system was firstly considered because of limited space to adjust;
- (2) HVAC system usually was secondly to be considered due to the large size of components and high price;
- (3) Electrical system with large cables was thirdly considered due to inflexible routing and high price;
- (4) Pressure driven plumbing system, fire protection, control system and other small systems were finally considered because of flexible routing; and
- (5) Any other rules, such as a small pipe gave way to a big pipe and a cheap component gave way to an expensive component.

Revit learning



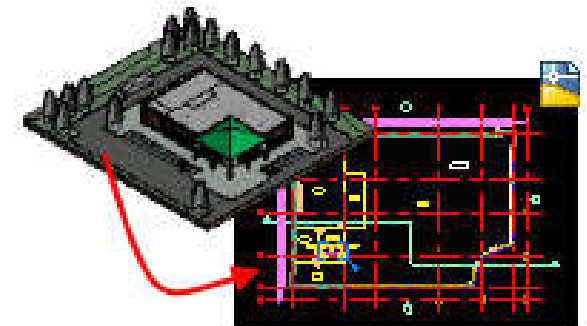
- Overview of Revit Learning:
 - <http://help.autodesk.com/view/RVT/2018/ENU/>
 - Get Started
 - Model the Design
 - MEP Modelling
 - Document and Present the Design
 - Analyze the Design
 - Collaborate with Others
 - Revit Cloud Worksharing



Get Started

Remark: It is assumed you understand the basic concepts of BIM and know the fundamentals of Autodesk Revit. If needed, please study the relevant information in the “Get Started” section as shown below.

- Revit Fundamentals (parametric modelling, element behavior & properties)
- Beginner Workflows (Architecture, MEP)
- Advanced Workflows (complex tasks)
- Essential Skills (the basics of using Revit)
- User Interface (how to use and customize the user interface)
- Cloud Services (to collaborate on projects with distributed teams, perform analysis and simulations, render images)
- Creating Projects (begin a new design)
- Opening Files
- Saving Files
- Licensing (free software for students and teachers)
- Sample Files



Model the Design

Create the building model by adding architectural elements, structural elements, and MEP systems. Also add design options and custom components (Revit families).

- Create Modeling Views (plan, elevation, section, callout, schedule)
- Model Layout (level, grids, positioning, site design)
- Massing Studies (explore design ideas by using shapes to conceptualize a building model)
- Architectural Modeling (architectural elements)
- Structural Modeling (structural elements)
- **MEP Modeling (MEP or building services elements)**
- Construction Modeling (parts, assemblies, construction workflows)
- Design Options (to explore alternative designs)
- Revit Families (create/modify elements with families)
- Tools and Techniques (how to sketch and edit elements, set constraints, create parameters, and use other tools of the user interface)



MEP Modelling

Create mechanical, electrical, and piping systems, and define spaces and zones in the building model.

- Mechanical Systems (such as duct system, air terminals and mech. equipment)
- Electrical Systems (electrical circuits, devices, lighting and equipment)
- Piping Systems (for a supply or return system, routing for the piping)
- P&ID (piping and instrumentation diagram) Modeler for Revit (coordinate data between an AutoCAD P&ID drawing and a Revit model)
- Fabrication Detailing in Revit (use Revit and LOD 400 content from the Autodesk Fabrication products, e.g. CADmep, ESTmep, and CAMduct to create a more coordinated model)
- Spaces (for performing heating and cooling load analysis on the building model)
- Zones (use the zone tool to define spaces that can be controlled by environmental control systems; perform load balancing and analysis procedures)
- System Inspector (to view the properties for a selected duct or pipe system)



Document and Present the Design

Create, annotate, and refine project documentation to communicate the design intent to team members, consultants, clients, and contractors.

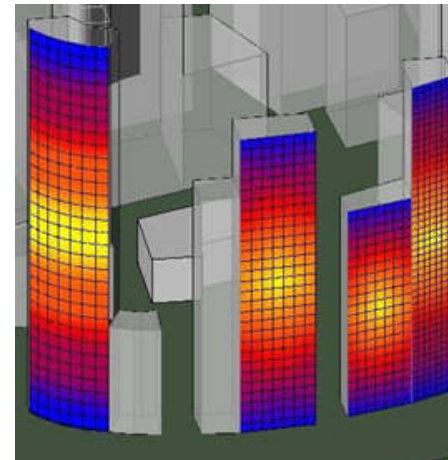
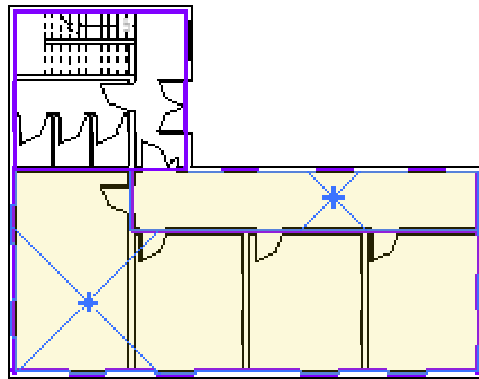
- Project Views (plan, elevation, section, callout, 3D, legend)
- Schedules (to quantify and analyze the components and materials)
- Project Phasing (various stages of work e.g. demolition and renovation)
- Annotation (enhance construction documents with dimensions, text notes, keynotes, tags, and symbols)
- Detailing (create detail views and drafting views)
- Construction Documents (create sheets and add drawings and schedules; customize title blocks, and manage revisions)
- Color Schemes
- Rendering (photorealistic image)
- Walkthroughs (create an animation or a series of images)
- Export and print
- Publishing to Buzzsaw (online collaboration service)
- Suite Workflows (export a model to 3ds Max Design for detailed rendering or animation)



Analyze the Design

Use analysis tools to inform decisions during the design process.

- Area Analysis (define spatial relationships)
- Energy Analysis for Autodesk Revit (optimize building energy performance)
- Heating and Cooling Loads Analysis (Determine the loads/energy demands)
- The Structural Analytical Model (develop the physical building model)
- Structural Analysis Tools for Revit (analyze and check the structure)
- Solar Studies (evaluate the impact of natural light and shadows)
- Display Styles for Analysis Add-In Applications (to visualize the results of analyses)



Revit learning

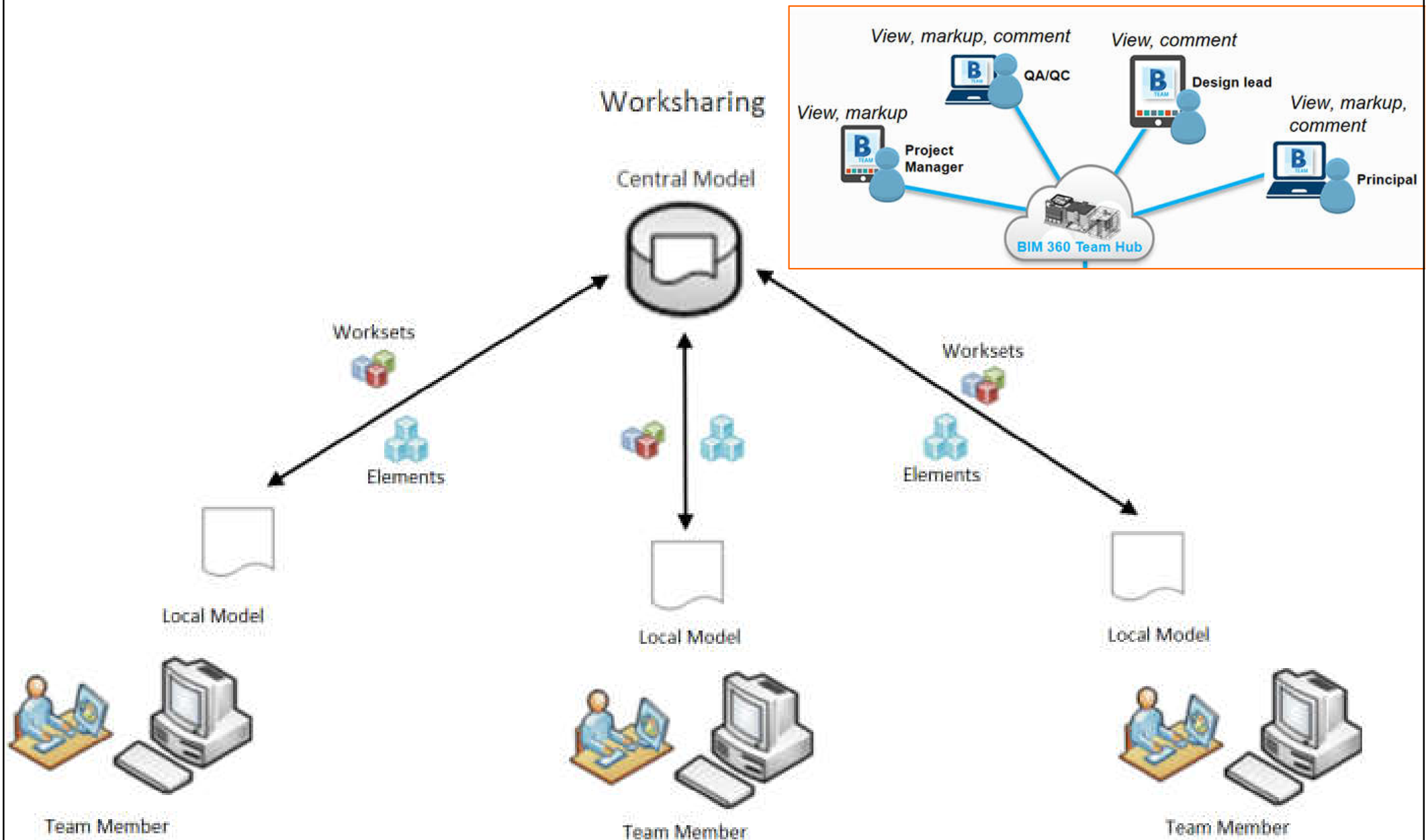


- Collaborate with Others

- Work with team members on Revit projects
- Linked models
- Work in a team (Worksharing)
- Multi-discipline coordination
- Interference checking (locate invalid intersections)
- Shared positioning (shared coordinates)
- Interoperability between Revit and other Autodesk products (e.g. InfraWorks)



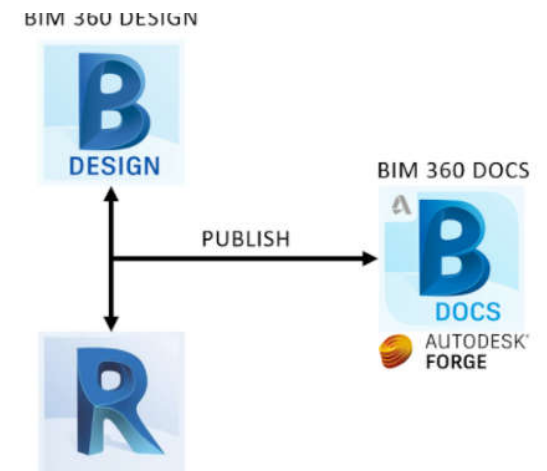
Worksharing is a design method that allows multiple team members to work on the same project model at the same time



Revit learning

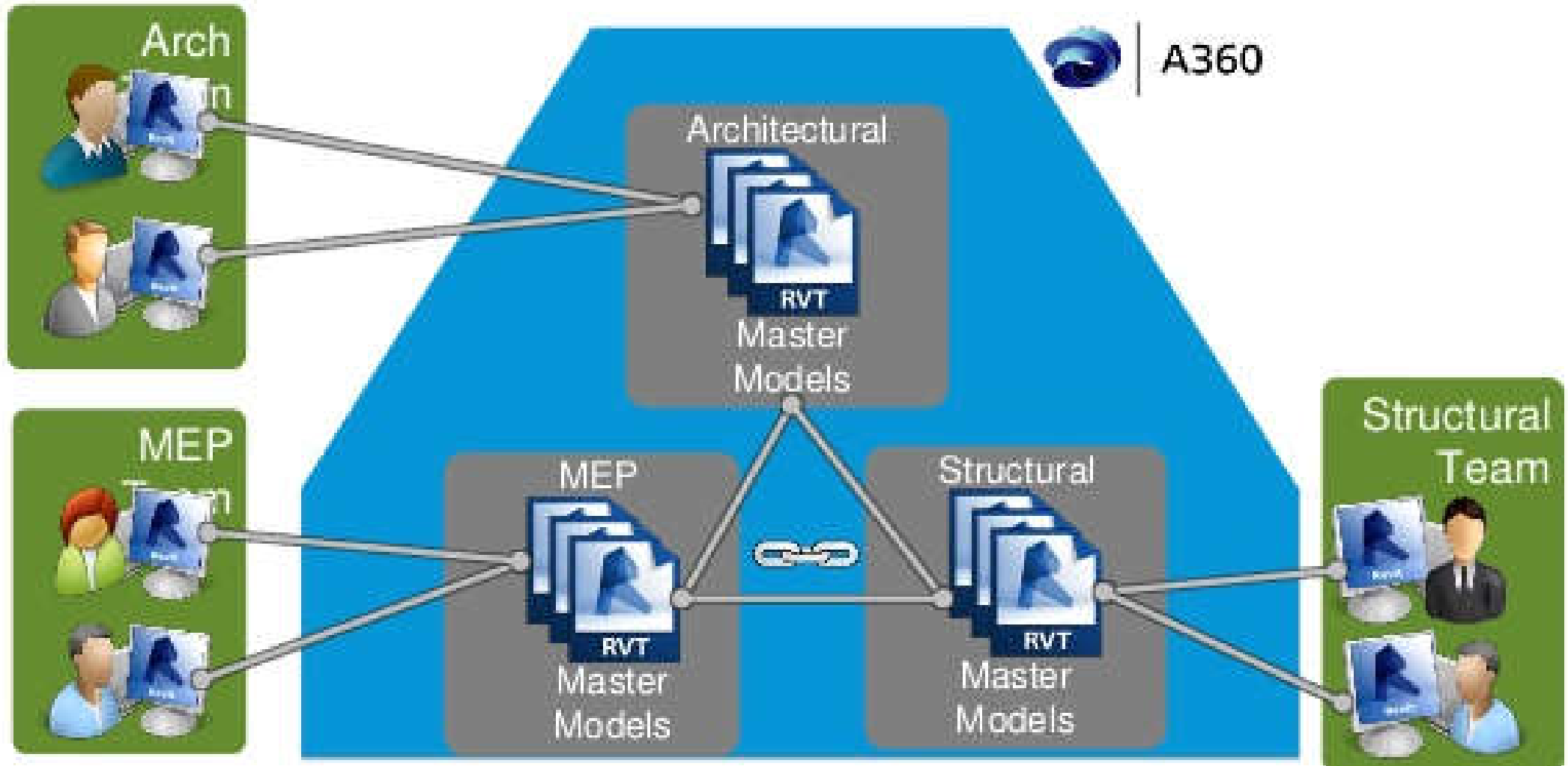


- **Revit Cloud Worksharing** (formerly Collaboration for Revit, C4R)
 - Allows architects, engineers, and contractors to **collaborate** on Revit models in the cloud
 - End users **synchronize** with central to publish their local changes to the central model so other users in the project can see their changes
 - Three distinct layers:
 - 1. Desktop
 - 2. Cloud worksharing service
 - 3. BIM 360 Team service



REVIT 2018.3/REVIT 2019

Multidiscipline Cloud Worksharing



(See also: Workflow: Collaborating with Revit Models

<http://help.autodesk.com/view/RVT/2018/ENU/?guid=GUID-32A10F90-31F8-49CB-A63A-7060B3C99A99>)

Multidiscipline Cloud Worksharing with BIM 360 Design



Co-author cloud-shared Revit models in the BIM 360 platform



View, share, and review 2D and 3D design files in the cloud

