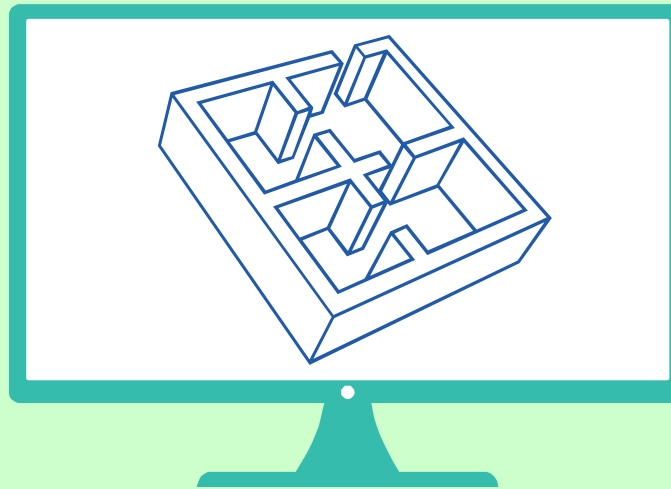


SBM5101/SBS5322 BIM Technology

<http://ibse.hk/SBM5101/> | <http://ibse.hk/SBS5322/>



# Computer modelling and BIM software



*Ir. Dr. Sam C. M. Hui*

Faculty of Science and Technology

E-mail: [cmhui@vtc.edu.hk](mailto:cmhui@vtc.edu.hk)

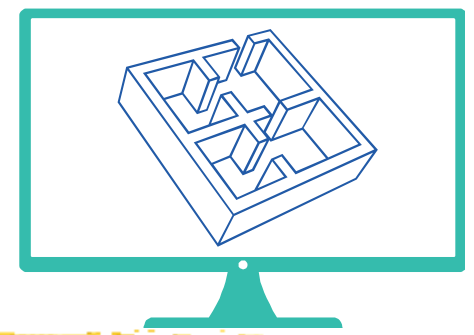
May 2019

# Contents



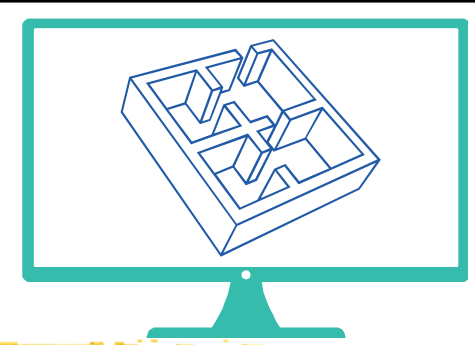
- Modelling
- Purpose of the model
- Hardware and software requirements
- Computer modelling techniques
- BIM software
- Latest trends

# Modelling



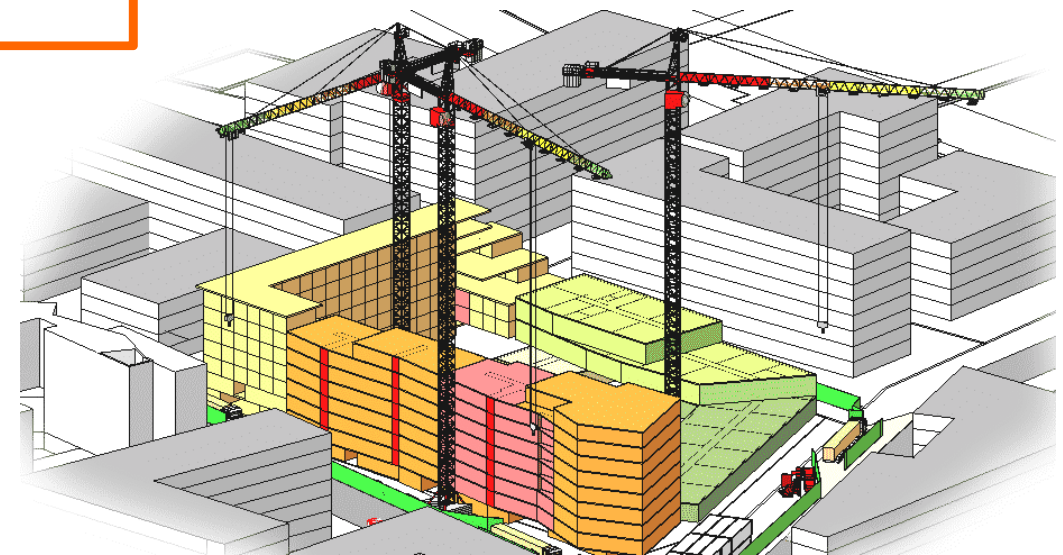
- In BIM, every project is built **TWICE**
  - Once in a **virtual** environment to make sure that everything is just right and once in a **real** environment to bring the project to life
- BIM model is the overview of every other aspect of the building and its information
  - It provides an **analogy** or smaller-scale representation of the final appearance and effect
  - It will continue to model this representation throughout the building's **lifespan**

# Modelling

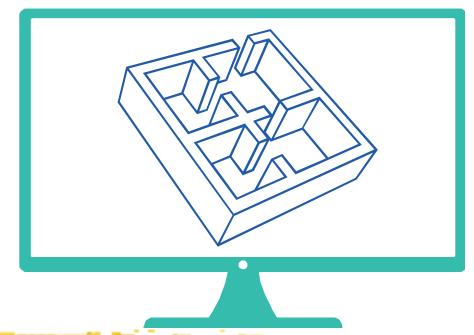


- Information modelling for BIM:

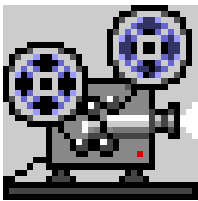
- 3D model
- 4D model - time
- 5D model - time and cost
- Energy model
- Business model
- Financial model
- Safety plan
- Maintenance plan



# Modelling



- Practical types of BIM models:
  - Design models
    - Arch, Structure, MEP, Civil/Infrastructure
  - Construction document models
    - Arch, Structure, MEP, Civil/Infrastructure
    - Specifications
  - Contractor model (for construction & installation)
  - Facility management model (for O&M)
  - Green/Sustainable design model

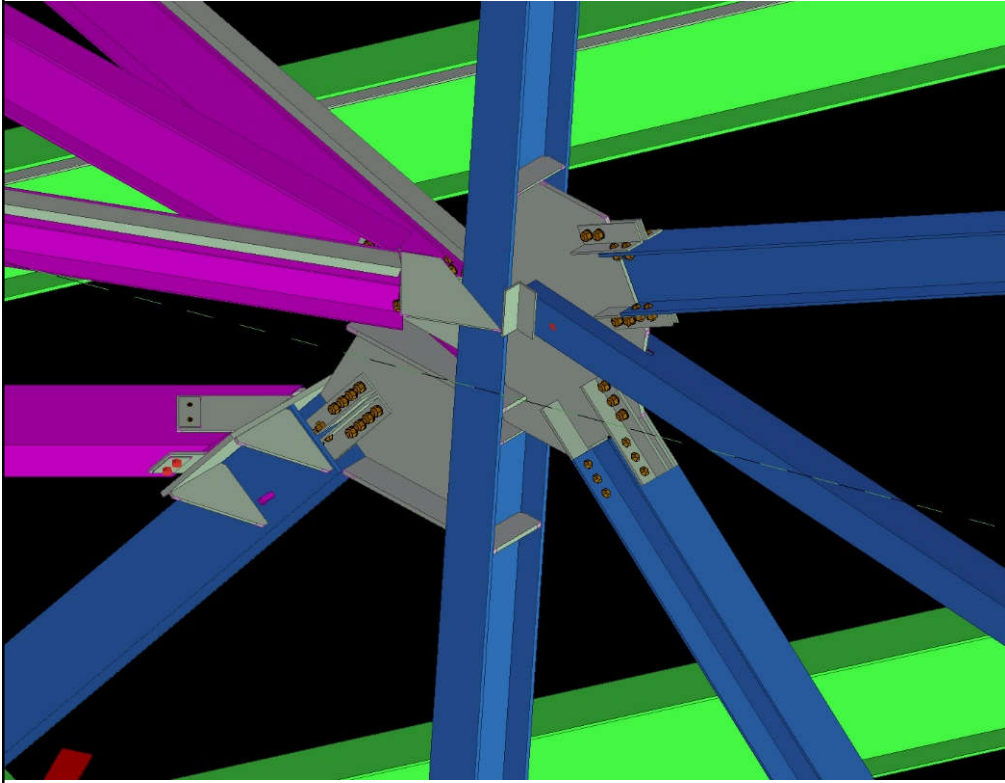


(Example: Video: Building Information Modelling - BIM (3:02) [https://youtu.be/MWmJtqP1\\_XA](https://youtu.be/MWmJtqP1_XA))

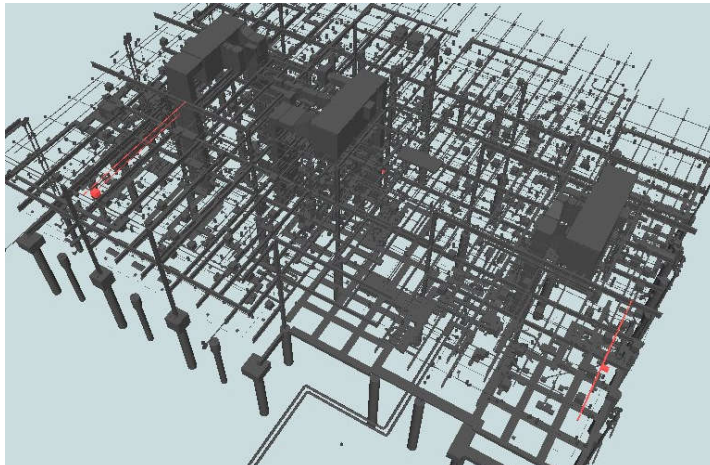
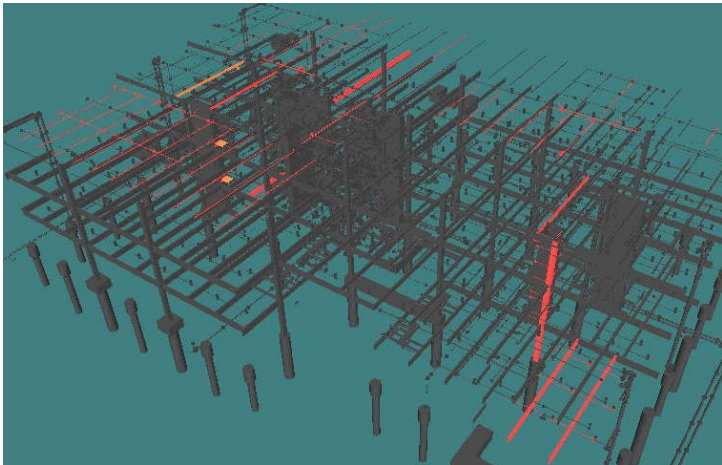


# BIM design models for structural engineering and clash analysis

BIM 3D model



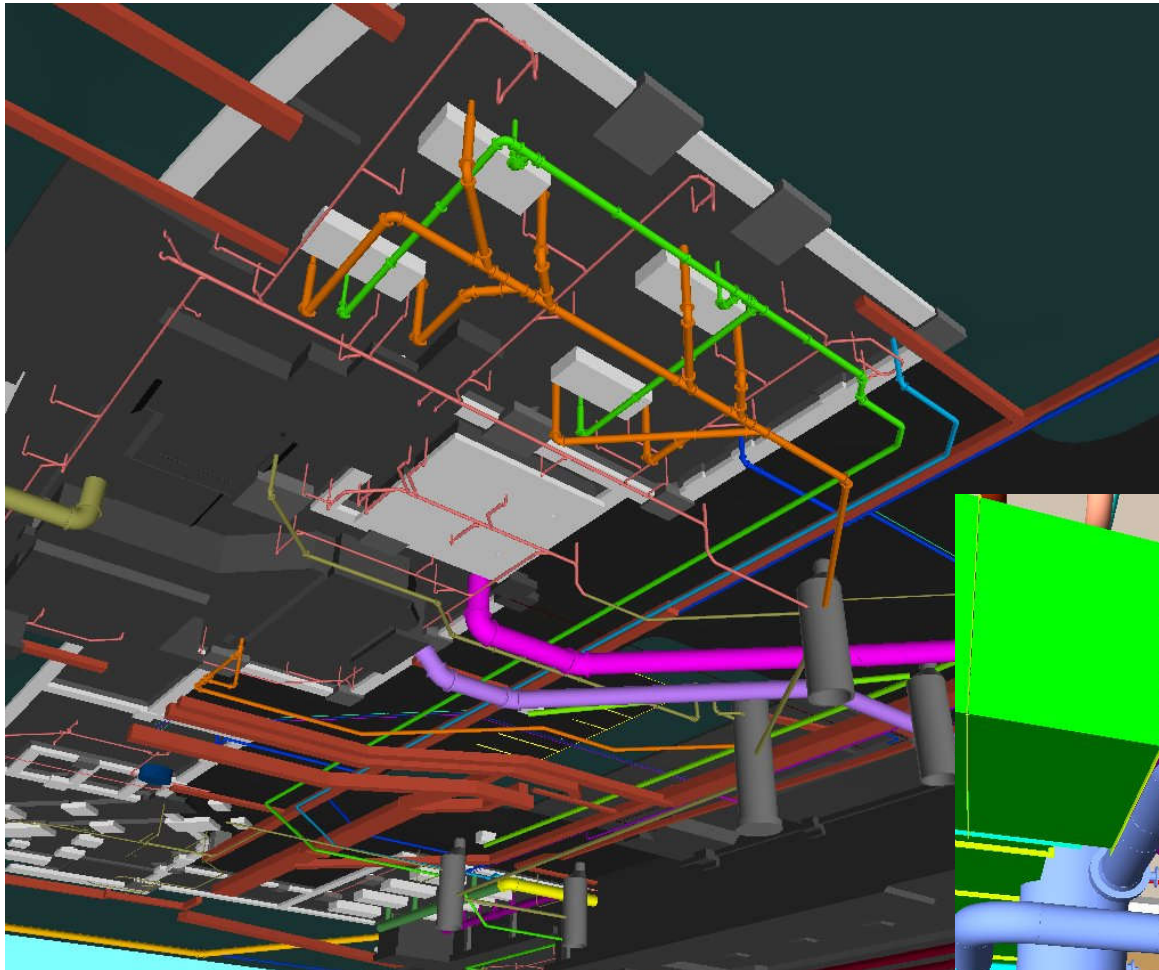
Actual installed



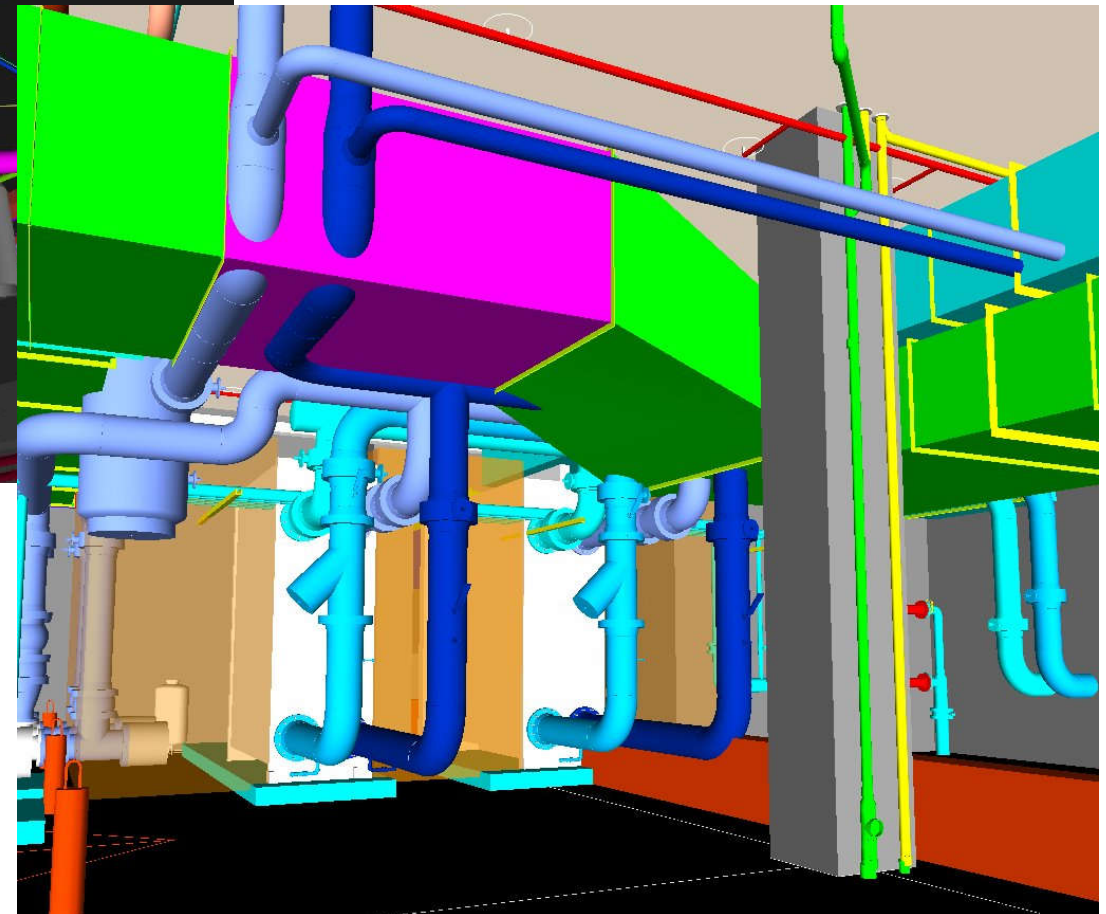
Clash analysis  
and coordination



# BIM design models for building services engineering

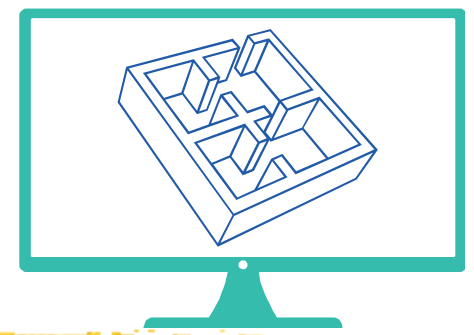


On the ceiling



Inside plantroom

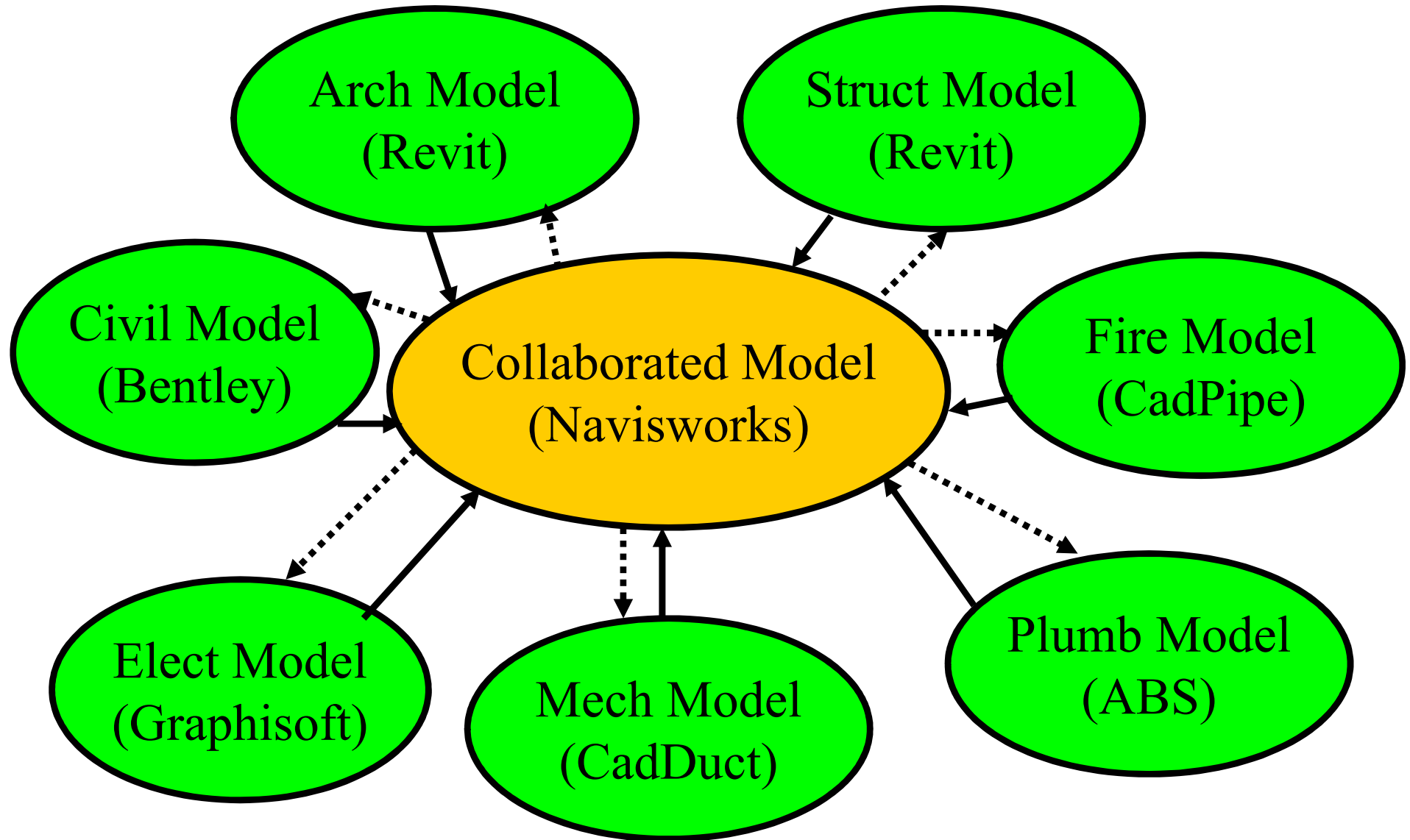
# Modelling



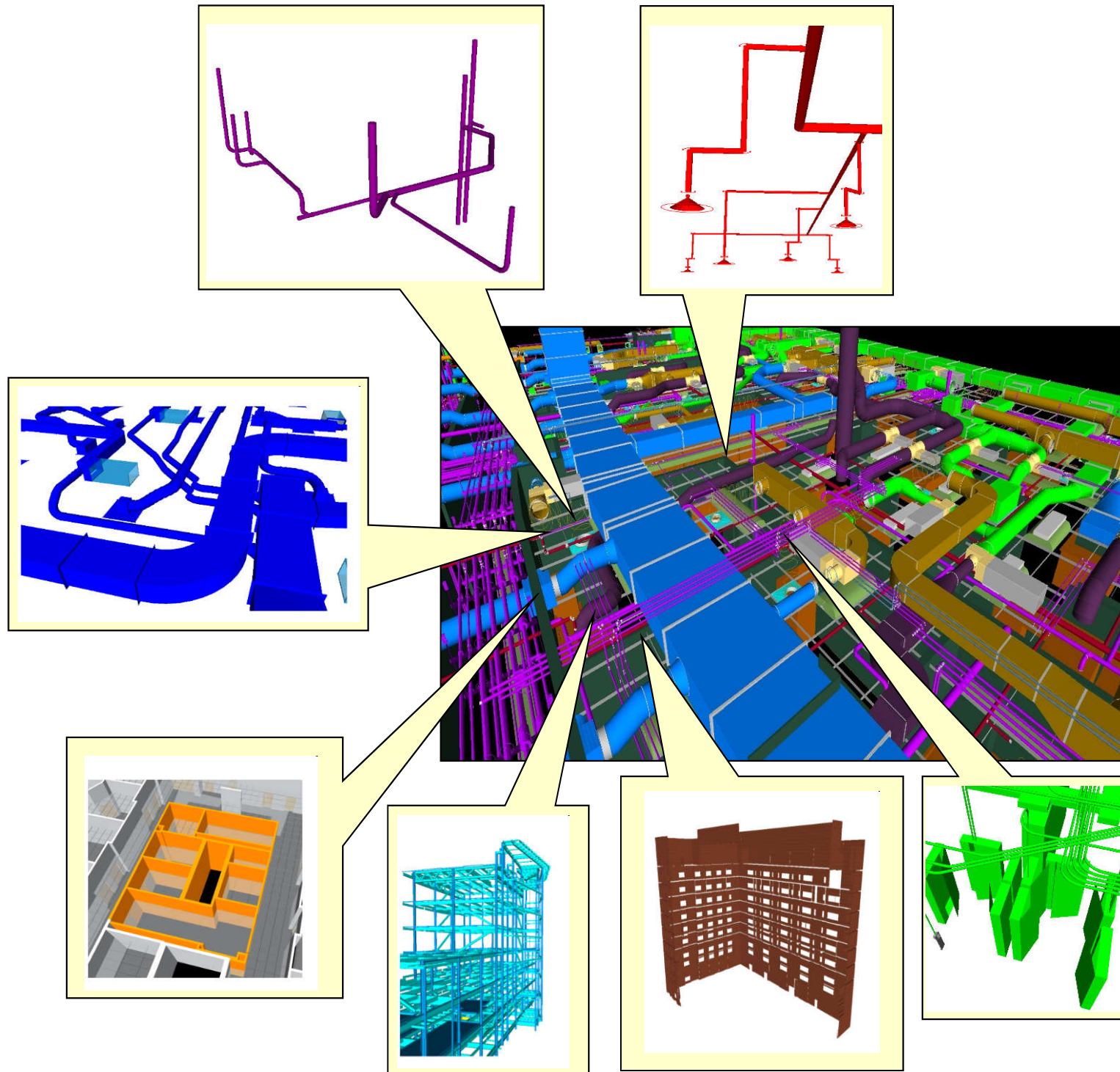
- Common uses of BIM for Building Services:
  - 1. Collaboration and access
    - Clash detection and coordination
    - Conceptual design and feasibility evaluation
    - Field management (on-site)
  - 2. Simulation and analysis
    - Mechanical/HVAC simulation
    - Air, fluid, flow, and thermal comfort
    - Energy analysis, green building design
  - 3. Visualization (rendering)



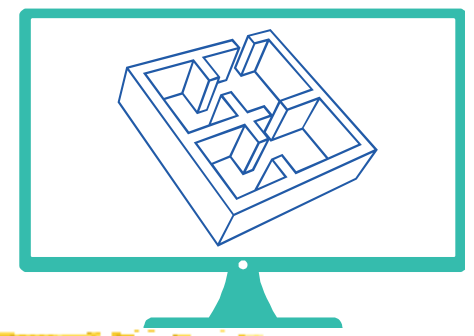
# Collaborated model for BIM and common software tools



# Individual scopes to consolidated model



# Modelling



- Simulation 模擬

- The process of developing a representative model of a system and using it to analyze and predict system behaviour and performance

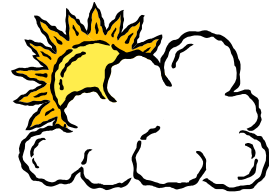
- Modelling 建模 / 建立模型

- Deals primarily with the relationship between actual dynamic processes and models
- Usually involves iterations
- >> Support decision making

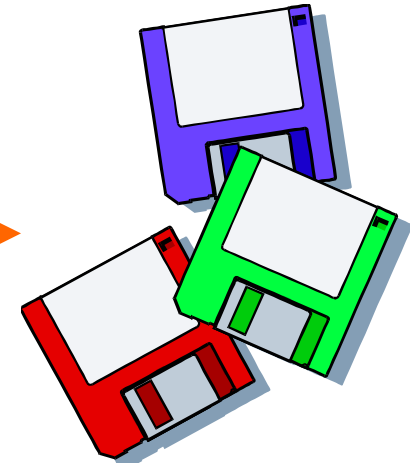
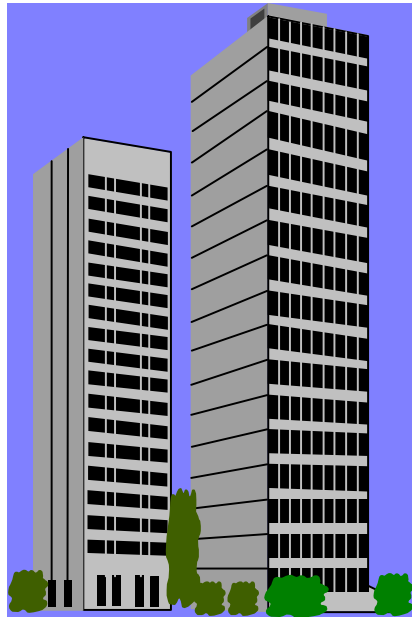
Do you know the difference between simulation and modelling?

# Building energy simulation and modelling

(Building energy simulation - Wikipedia [https://en.wikipedia.org/wiki/Building\\_energy\\_simulation](https://en.wikipedia.org/wiki/Building_energy_simulation))



Weather  
data



**Building  
description**

- physical data
- design parameters

**Simulation tool  
(computer program)**

**Simulation  
outputs**

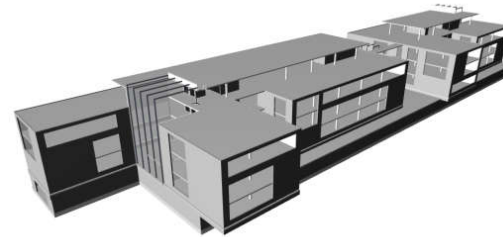
- energy consumption (MWh)
- energy demands (kW)
- environmental conditions



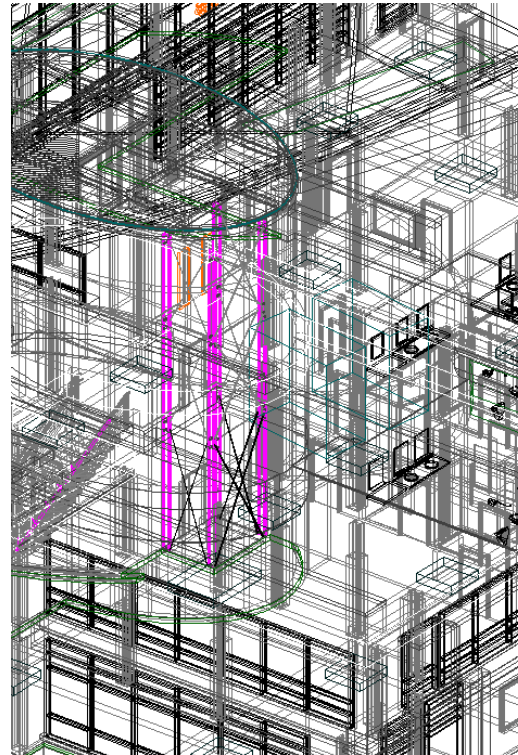
# Decisions

The following factors largely influence the successful modelling approach:

- Purpose of the model

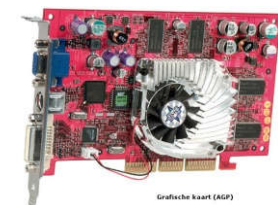
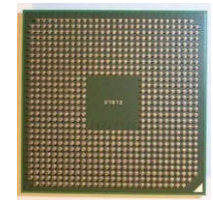
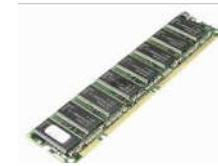


- Complexity



- Model Size

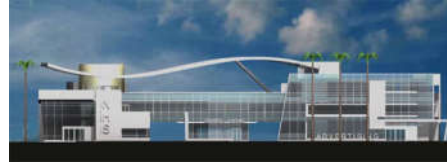
- Hardware



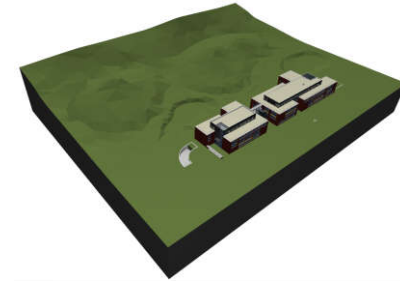
# Purpose of the Model



Conceptual  
Design



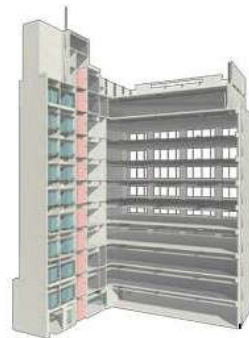
Visualization



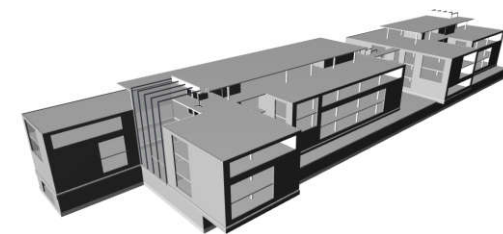
Site  
Planning



BIM  
Modelling



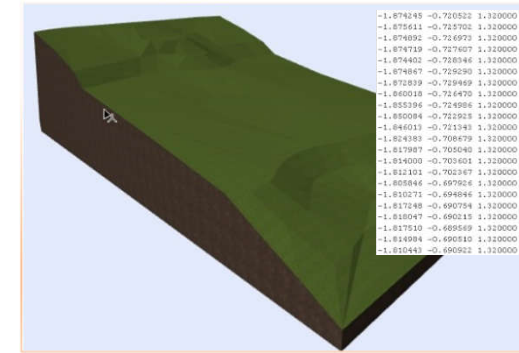
Construction  
Coordination



Structural  
Design

# Digital Surveys

- Direct import of site survey data from XYZ coordinates automatically convert into a mesh element.
- Refurbishment projects typically start with 3D laser scanning, which generate “point-clouds”. Some BIM software, like ARCHICAD, can read the most commonly used point-cloud file formats and create the corresponding 3D geometry instantly.



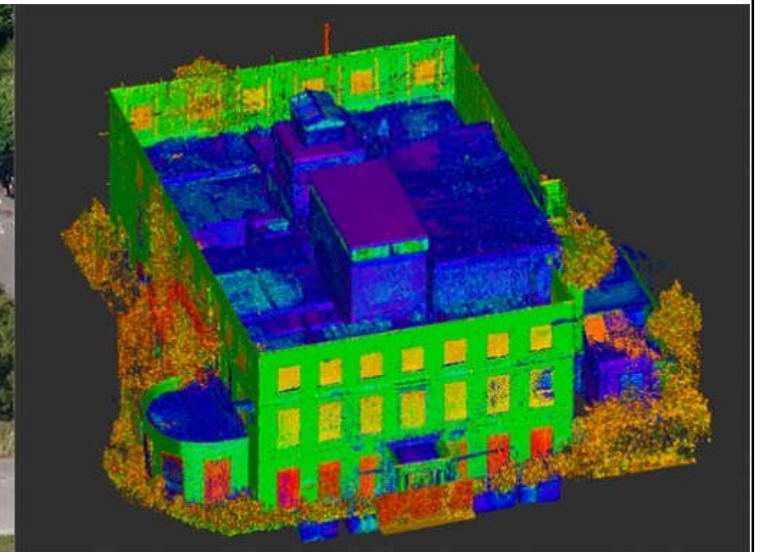
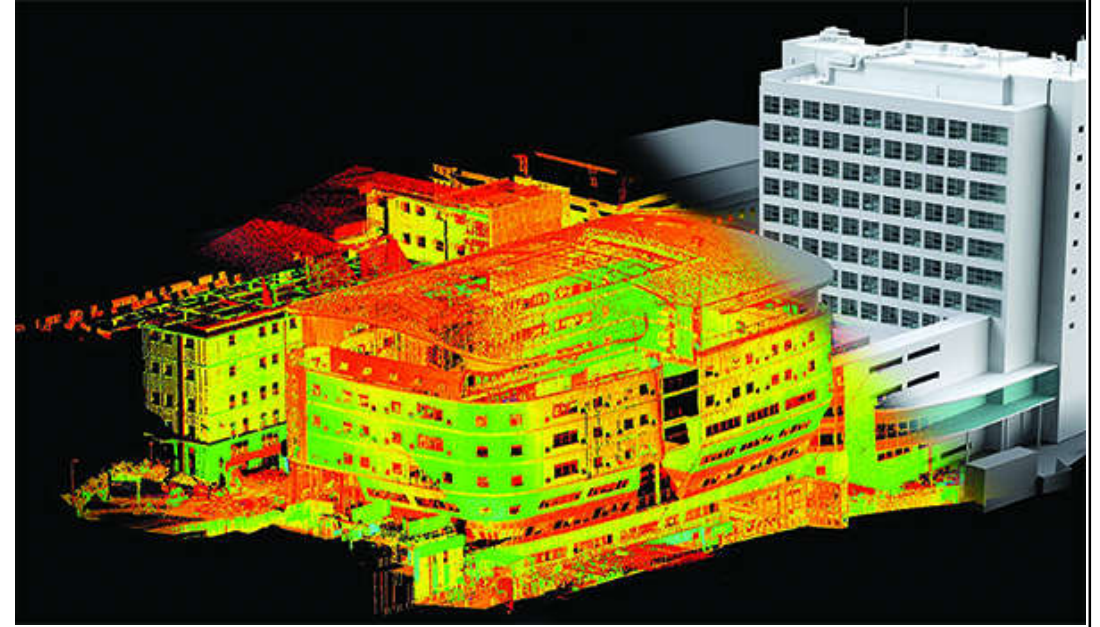
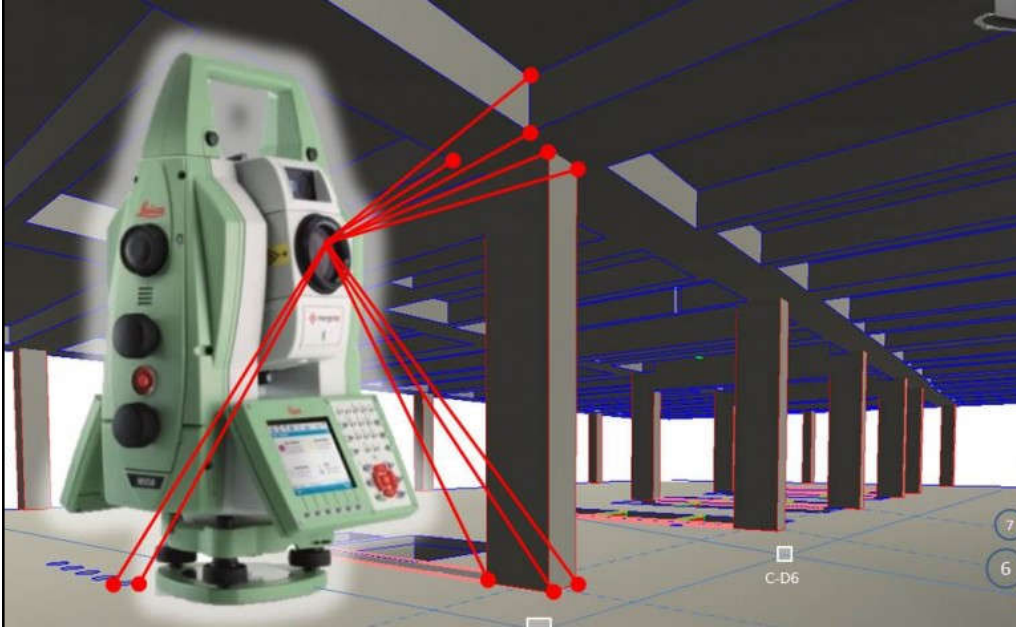
How to put 3D laser survey and **point-clouds** to work:

- Modelling existing buildings before renovation.
- Modelling the surroundings prior to creating a new building.
- Modelling the “as-built” structure to detect deviations from plan.





# Scan to BIM by digital survey and laser scanning

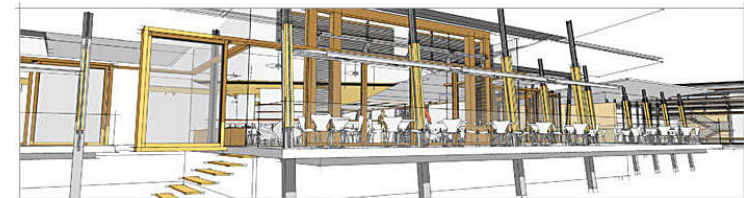


(Video: Laser Scanning & BIM or Scan-to-BIM (4:41) <https://youtu.be/fqoNXUymGko>)



# Conceptual Modelling

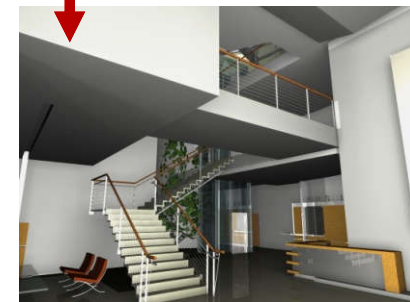
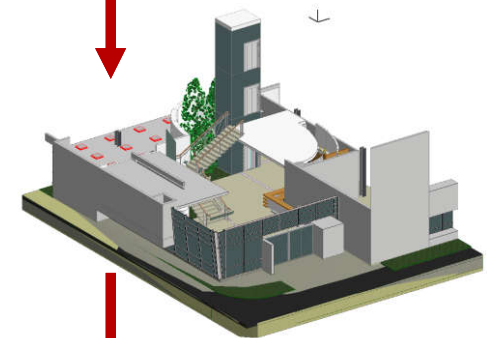
- Main purpose of the model is to help making design decisions
- The model not necessary includes the entire building (e.g. internal structures can be missing)
- Accuracy is not relevant
- Level of detail is typically lower then in BIM models (mass modelling)
- Materials can be symbolic or missing



<http://www.sketchup.com>

# Modelling for Visualization

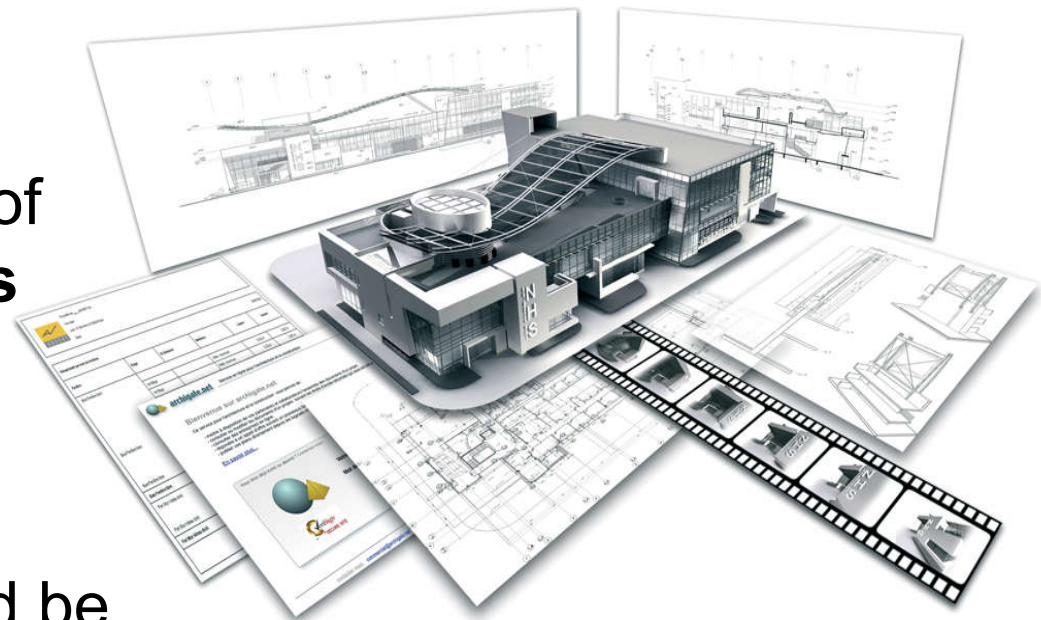
- Not necessary to model the entire building
- Only the elements of the actual view need to be shown
- Level of modelling detail should depend on the image quality and the distance from the camera
- Accurate texture coordination and lighting is essential



NHS Building, paastudio.com

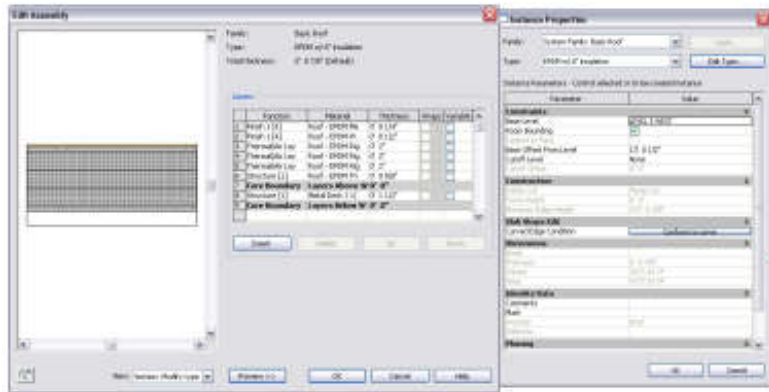
# BIM Modelling for Architecture

- The entire building has to be modeled with the corresponding **architectural information** (materials, components etc.).
- The model has to be made of
- **real architectural elements**
- (walls, slabs, roofs etc.) for
- correct calculation results.
  
- Modeling **detail level** should be appropriate for the required drawing representations.

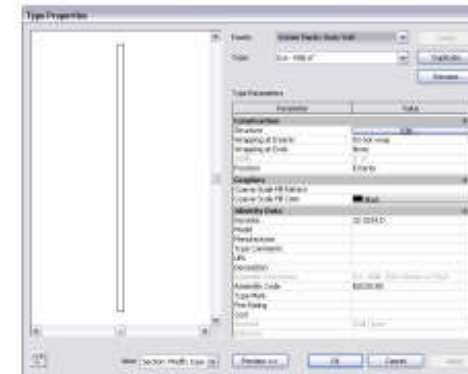


NHS Building, paastudio.com

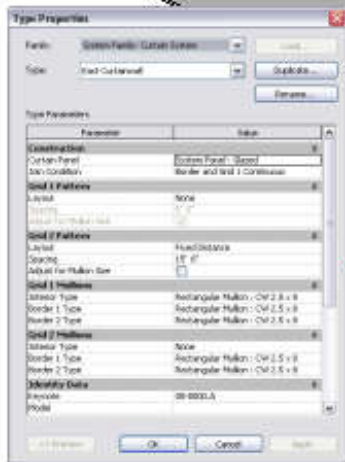
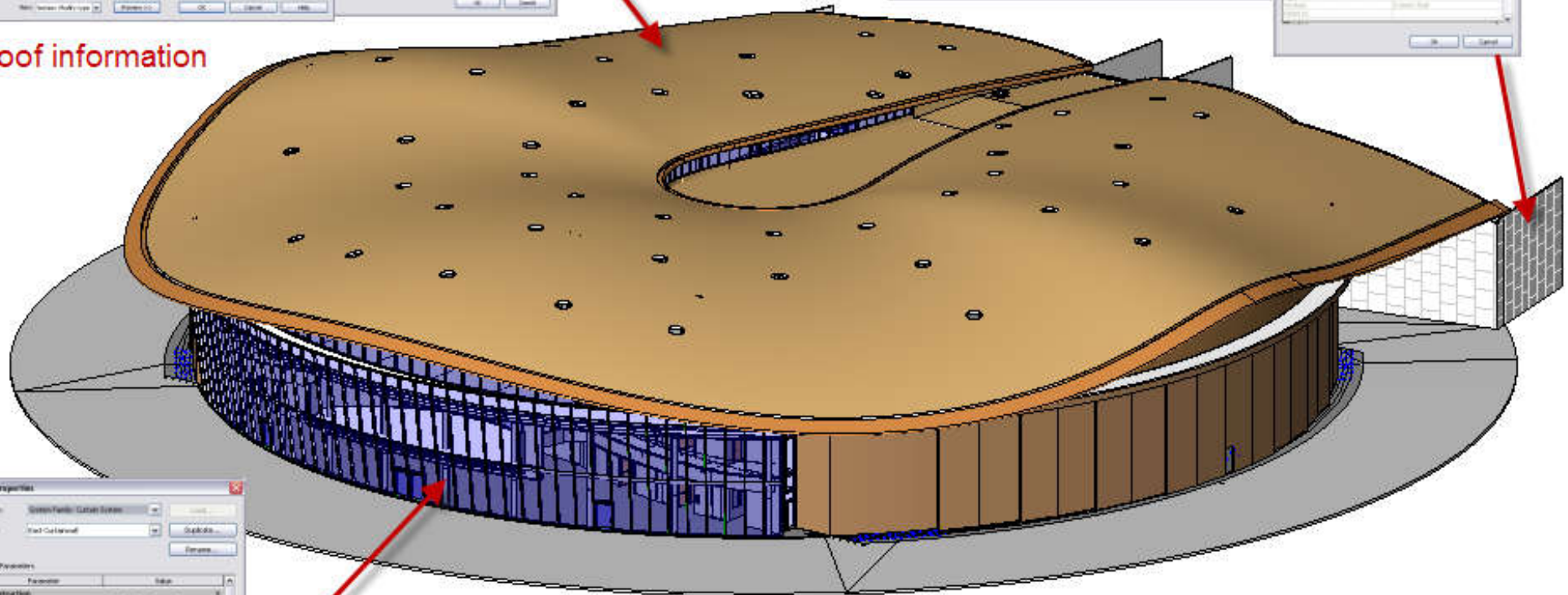
# Example of BIM architecture model and information



Roof information



Wall information



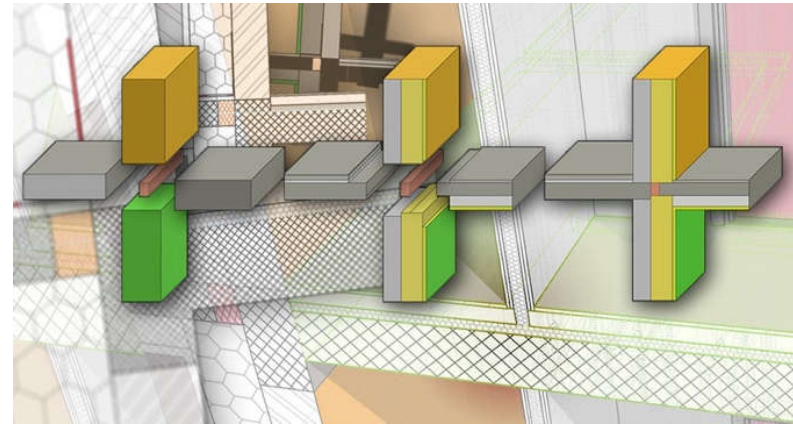
Curtain Wall information



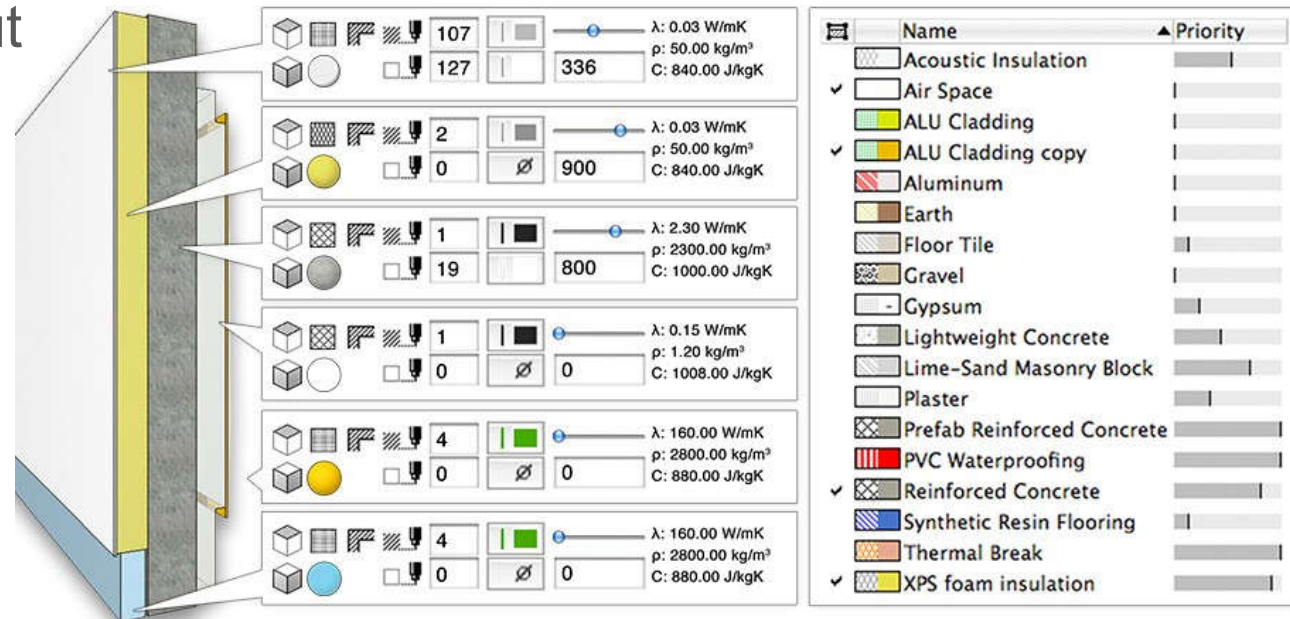
# Real Building Materials

## Priority Based Connections

automatically provide construction documentation level sections and details.



**Intelligent Building Materials** ensure correct graphical representation of materials in sections, element surfaces in 3D views, and thermal properties throughout the building energy evaluations.



Name	Priority
Acoustic Insulation	
Air Space	
ALU Cladding	
ALU Cladding copy	
Aluminum	
Earth	
Floor Tile	
Gravel	
Gypsum	
Lightweight Concrete	
Lime-Sand Masonry Block	
Plaster	
Prefab Reinforced Concrete	
PVC Waterproofing	
Reinforced Concrete	
Synthetic Resin Flooring	
Thermal Break	
XPS foam insulation	

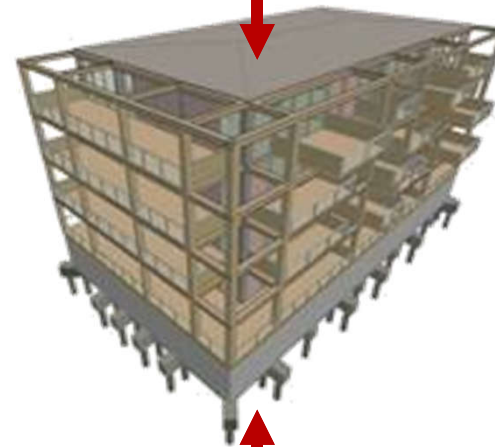
Material ID	Thermal Conductivity ( $\lambda$ )	Density ( $\rho$ )	Specific Heat ( $C$ )
107	0.03 W/mK	50.00 kg/m <sup>3</sup>	840.00 J/kgK
127			336
2	0.03 W/mK	50.00 kg/m <sup>3</sup>	840.00 J/kgK
0			900
1	2.30 W/mK	2300.00 kg/m <sup>3</sup>	1000.00 J/kgK
19			800
1	0.15 W/mK	1.20 kg/m <sup>3</sup>	1008.00 J/kgK
0			0
4	160.00 W/mK	2800.00 kg/m <sup>3</sup>	880.00 J/kgK
0			0
4	160.00 W/mK	2800.00 kg/m <sup>3</sup>	880.00 J/kgK
0			0

# Modelling for Construction Coordination

- Time and cost information is attached to the BIM model by linking schedules and estimating recipes (4D-5D).
- The main purpose of the 3D model is to calculate the exact quantities of materials and to identify any conflicts, collisions in the construction. Thus model accuracy is critical.
- Elements of composite building structures can be described in estimating recipes instead of modeling them in 3D.



**Time**  
(Linked  
schedules)

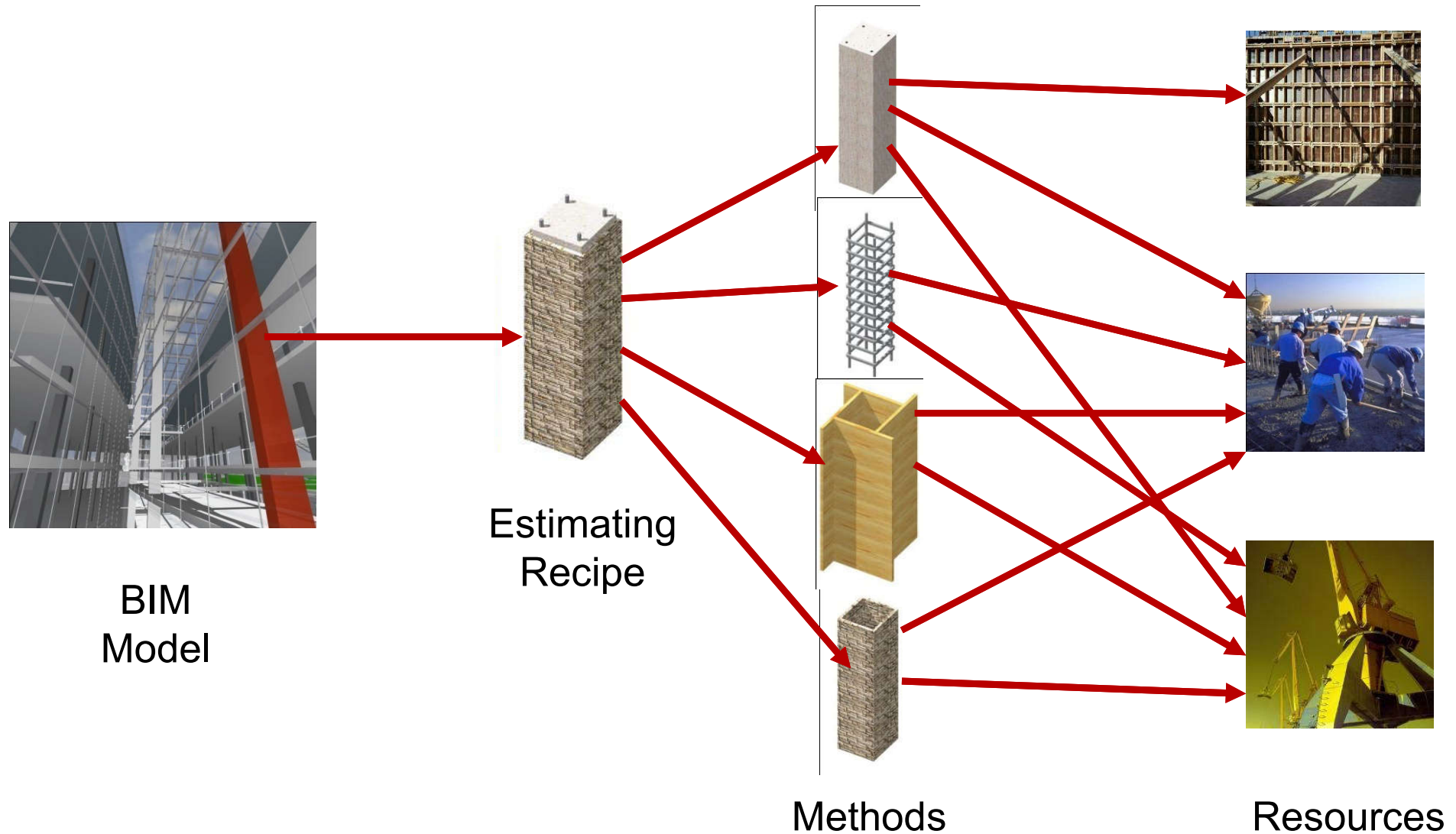


**BIM  
model**

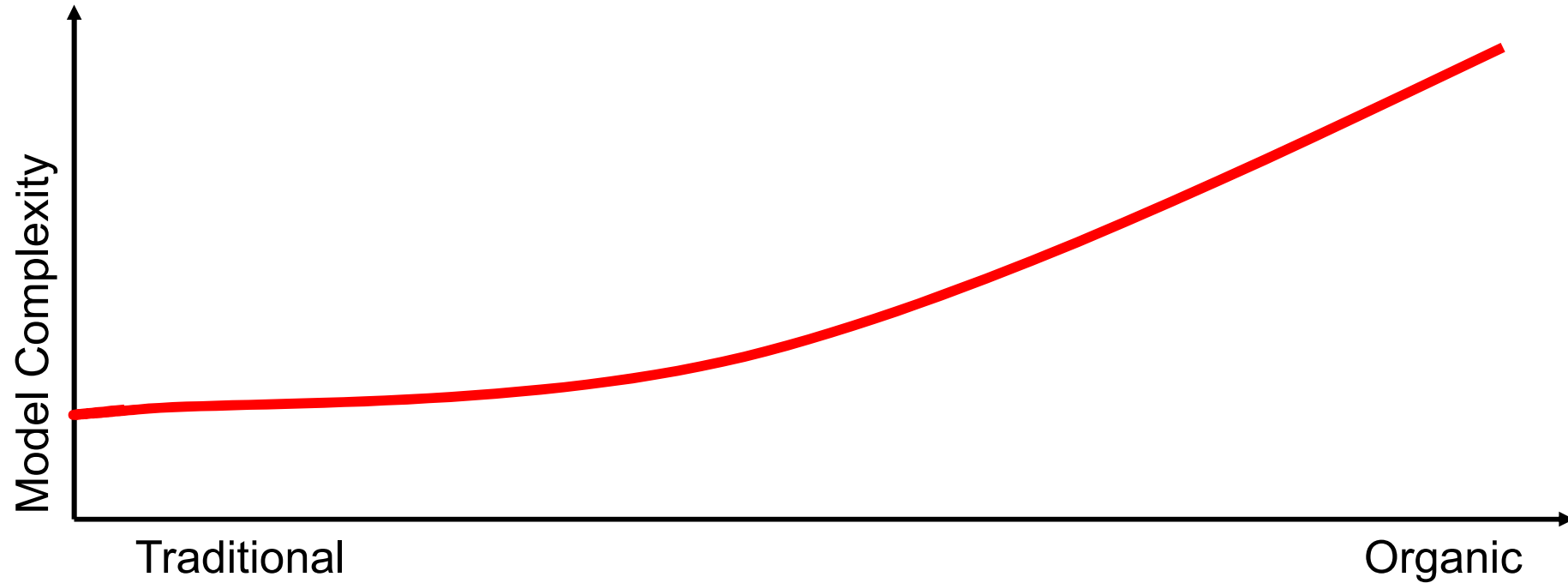


**Cost**  
(Linked  
estimating  
recipes)

# Virtual Construction Model



# Model Complexity



Le Corbusier



Zaha Hadid

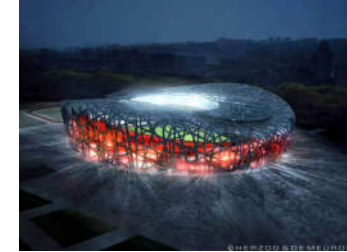


Frank O. Gehry



# Complexity

- How can you model these buildings?
- **Simplify**
  - The level of detail shouldn't exceed the actual requirements
- **Divide**
  - Share the building model between the project team members
- **Use the appropriate tools**
  - Combine several applications for the best result



Herzog & de Meuron



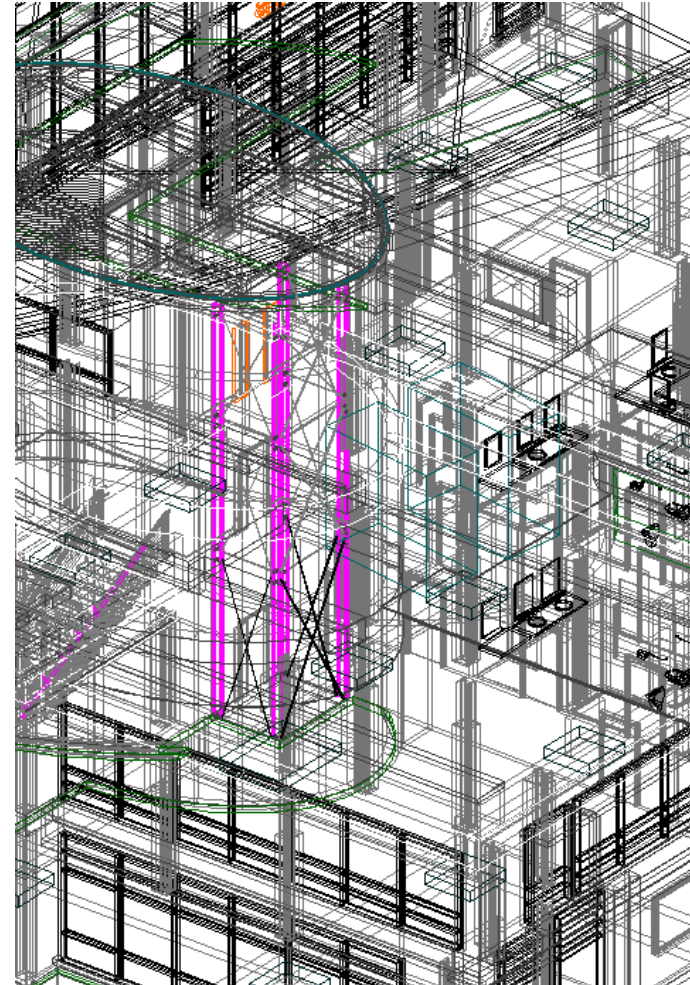
Frank O. Gehry



Santiago Calatrava

# Model Size

- What makes a model big?
- No of building elements
- No of 3D model polygons
- Size of the project
- Lack of teamwork
- Inappropriate computer hardware
- Inappropriate software usage



# Model Size

- How can you work effectively with big buildings?
- Reduce the number of 3D model polygons: simplify the memory excessive model elements
- Turn off the invisible elements: filter the model with layer combinations and selections
- Divide the project: file hotlinking and teamwork solutions help to share the work with other project team members
- Use appropriate hardware

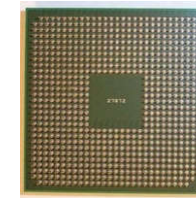
# Hardware Requirements



- The computer configuration has to match with the hardware requirements of the CAD software

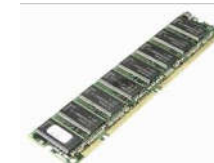
- CPU

- Speed: General latency
- Cores: Complex computations



- Memory

- Size: Project size limit
- Size and Speed: Complex 3D operations



- Hard Disk

- Size: Amount of projects, backups, resources
- Quality: Data safety



- Graphic Card

- Latency in 2D and 3D navigation.



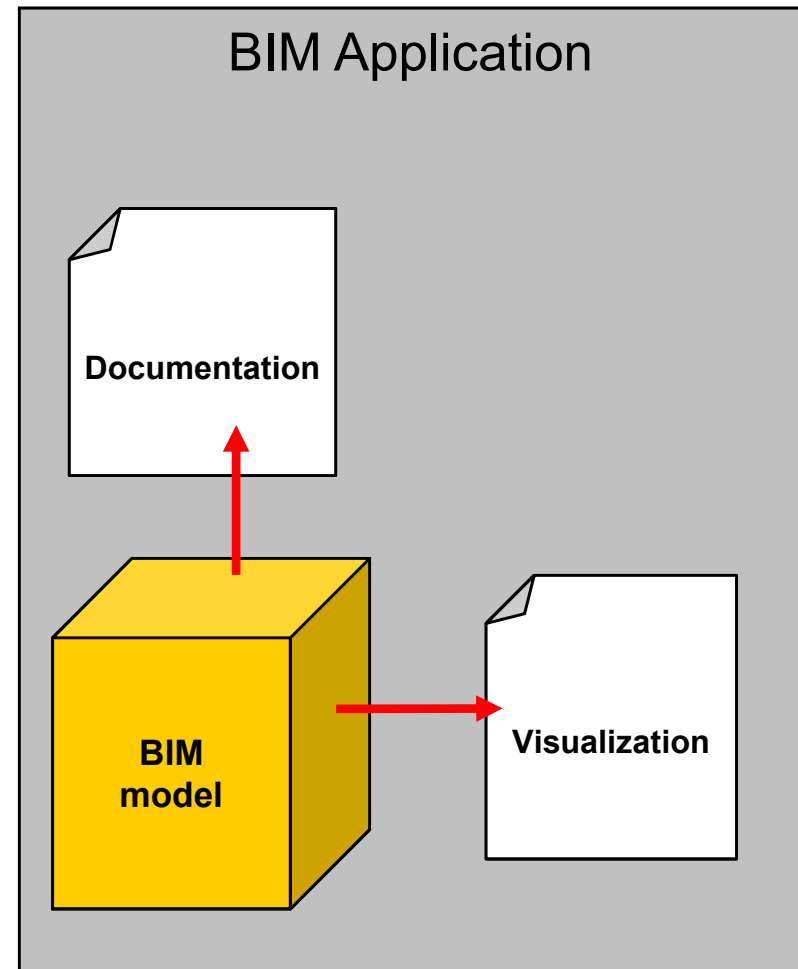


# Software Solutions

Classic BIM modeling approach for small to medium scale projects:

All in one application:

- modeling
- documentation
- visualization

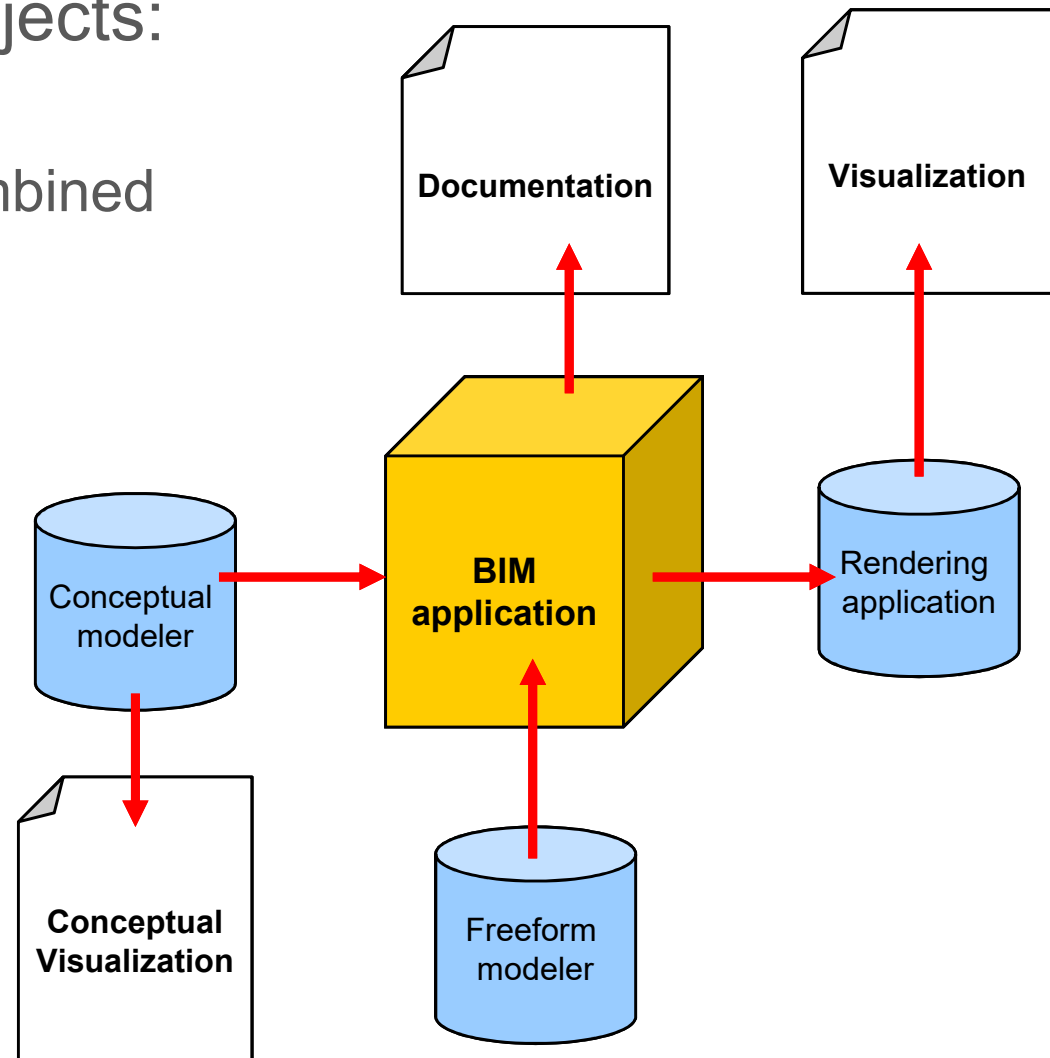


# Software Solutions

Complex modeling and visualization solution for large or complex projects:

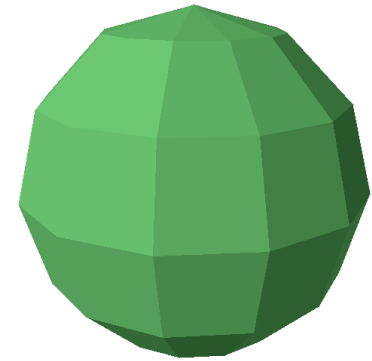
Specialized applications combined with BIM software

Parts of the 3D model are created in external modeling applications

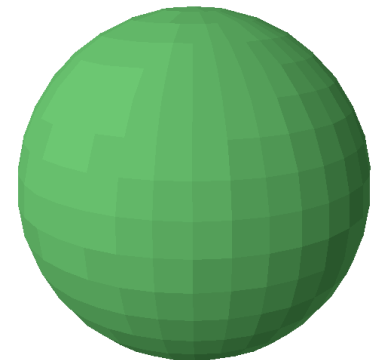


# Computer Modelling Techniques

- **Polygonal modeling** is an approach for modeling objects by representing or approximating their surfaces using polygons.
- The main advantage of polygons are that they are faster than other representations.
- 
- Polygons are incapable of accurately representing curved surfaces, so a large number of them must be used to approximate curves.



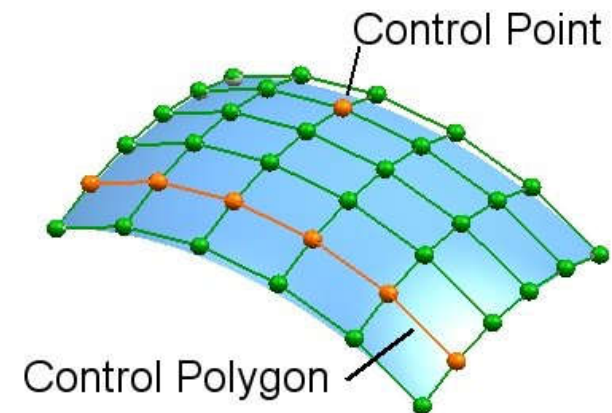
Low Resolution Model



High Resolution Model

# Computer Modelling Techniques

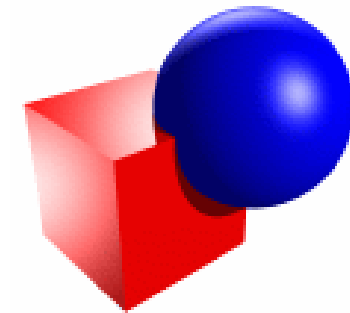
- **NURBS**, short for non-uniform, rational B-spline, is a mathematical model commonly used for generating and representing curves and surfaces. A NURBS curve is defined by its **order**, a set of weighted **control points**, and a **knot vector**.
- They are invariant under affine as well as perspective transformations.
- They offer one common mathematical form for both standard analytical shapes (e.g., conics) and free-form shapes.
- They provide the flexibility to design a large variety of shapes.
- They reduce the memory consumption when storing shapes (compared to simpler methods).



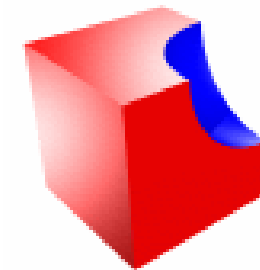


# Computer Modelling Techniques

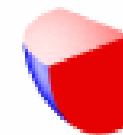
- **Solid modeling** is the unambiguous representation of the solid parts of an object suitable for computer processing.
- **Constructive solid geometry (CSG)** is a technique used in solid modeling. Constructive solid geometry allows a modeler to create a complex surface or object by using Boolean operators to combine objects.
- It is used in cases where simple geometric objects are desired, or where mathematical accuracy is important.
- CSG is popular because a modeler can use a set of relatively simple objects to create very complicated geometry.
- CSG models require strong processing capabilities.



Addition



Subtraction



Intersection

# BIM software



- Three common BIM software packages
  - ArchiCAD by Graphisoft
  - Microstation by Bentley System
  - Revit by Autodesk
- Usually the BIM software packages have distinct environments for architectural, structural, and mechanical, electrical and plumbing (MEP) objects that can all be referenced into a single file



GRAPHISOFT.  
ARCHICAD



# BIM software



- Most popular drawing tools:
  - Autodesk Revit (Architecture/Structure/MEP) 41%
  - Graphisoft ArchiCAD 15%
  - Autodesk AutoCAD 14%
  - Autodesk AutoCAD LT 12%
  - Nemetscheck Vectorworks 9%
  - Bentley Microstation 2%
  - Trimble Sketchup (formerly Google Sketchup) 2%
  - Bentley AECOsim Building Designer 1%
  - Nemetscheck Allplan 0%

Which one you  
have learnt or  
used before?

# BIM software



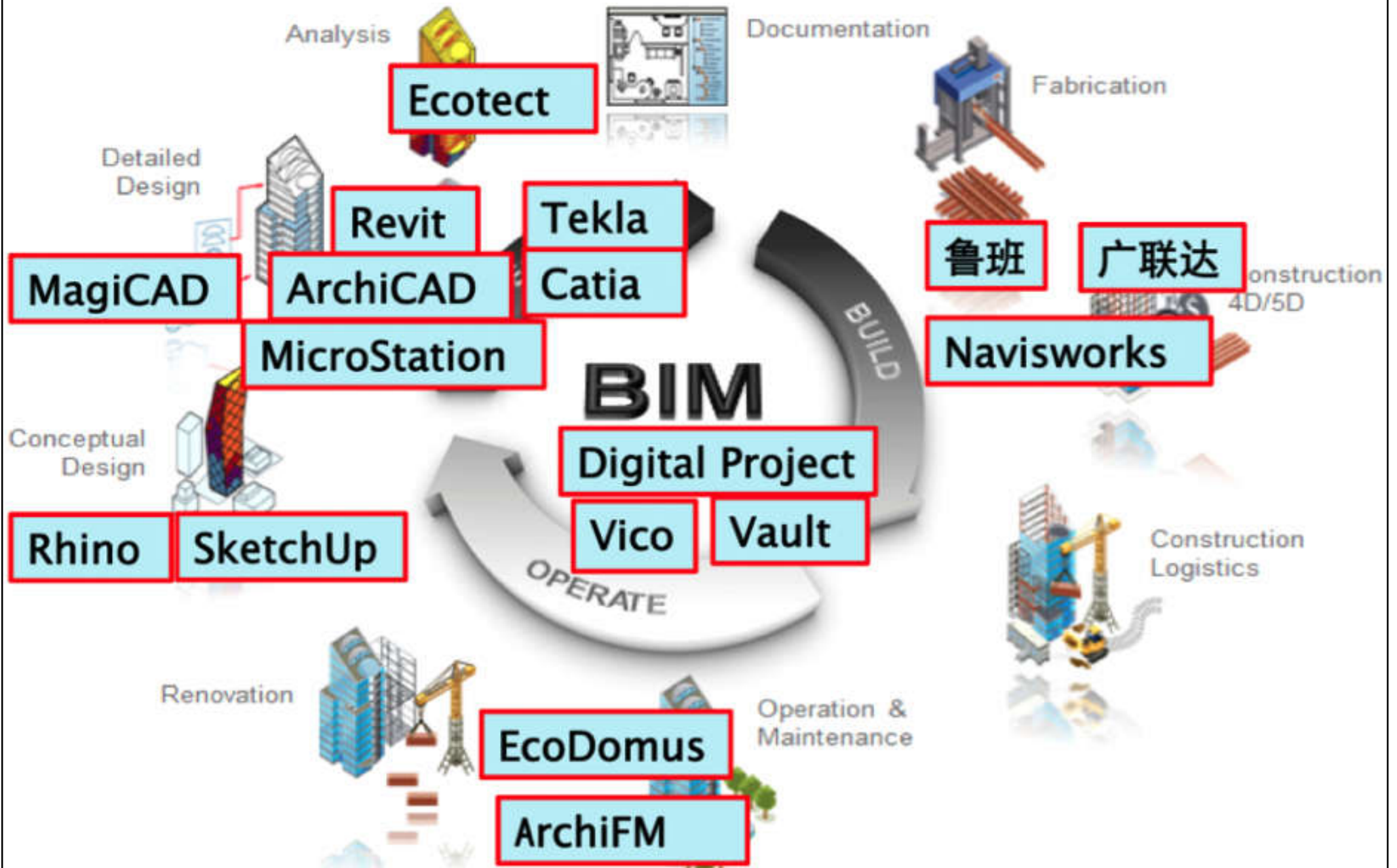


# BIM software



- Types of software based on BIM dimensions:
  - 3D Modelling
  - 4D Scheduling
  - 5D Cost
  - 6D Sustainability
  - 7D Maintenance & Operation
- List of BIM Software & Providers
  - <https://thebimhub.com/2015/08/17/list-of-bim-software-providers>

# Choice of BIM software for different phases

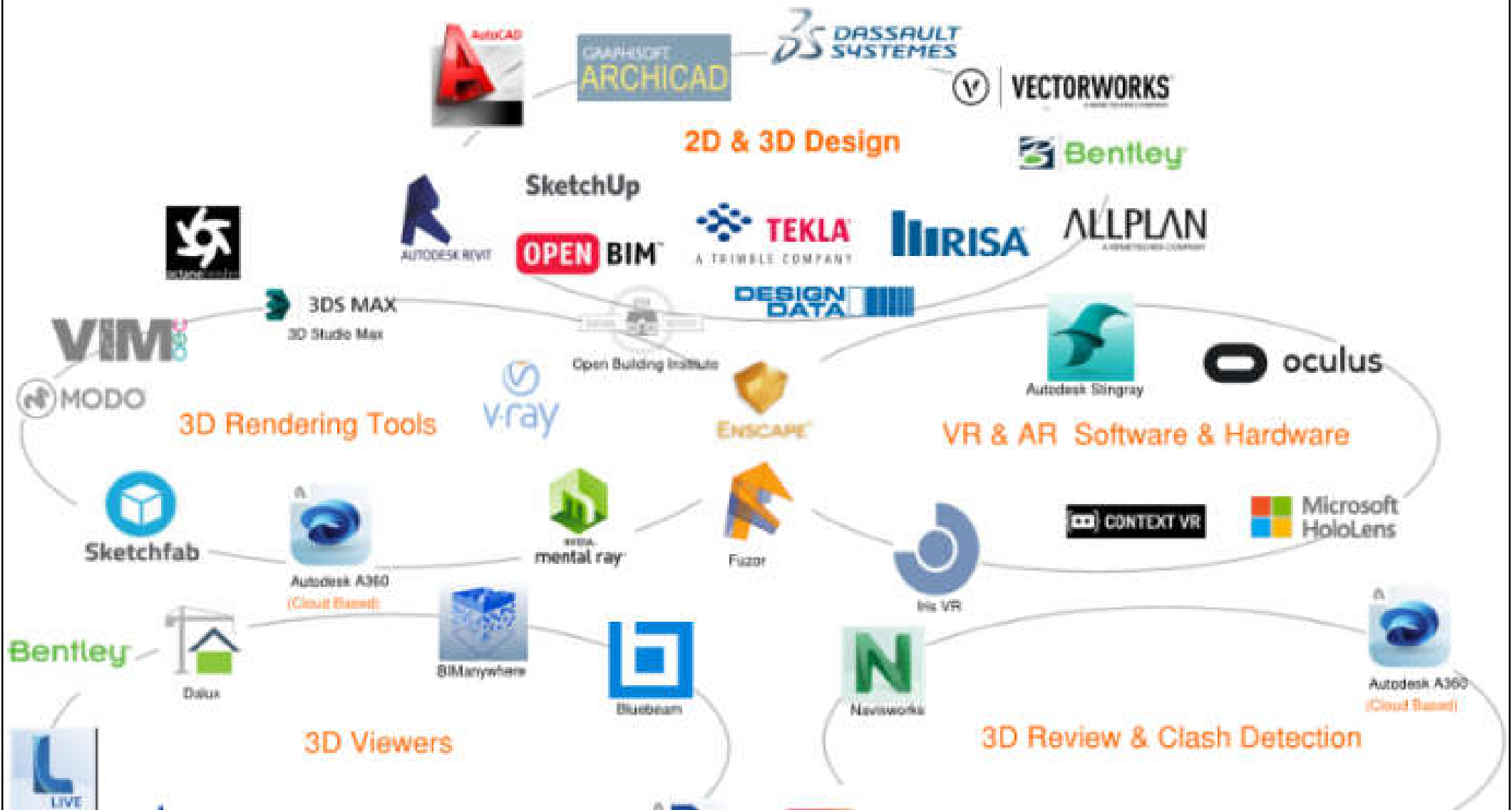


# BIM software



- Types of software based on disciplines and functions:
  - Design authoring tools (2D, 3D)
    - Architecture, Structure, MEP (Building Services)
  - Rendering tools (for visualization)
  - Viewers & clash review (for CAD and 3D models)
  - Management (for documents or projects)
  - Virtual reality (VR) & augmented reality (AR)
- Other building analysis & simulation software

# BIM software classification





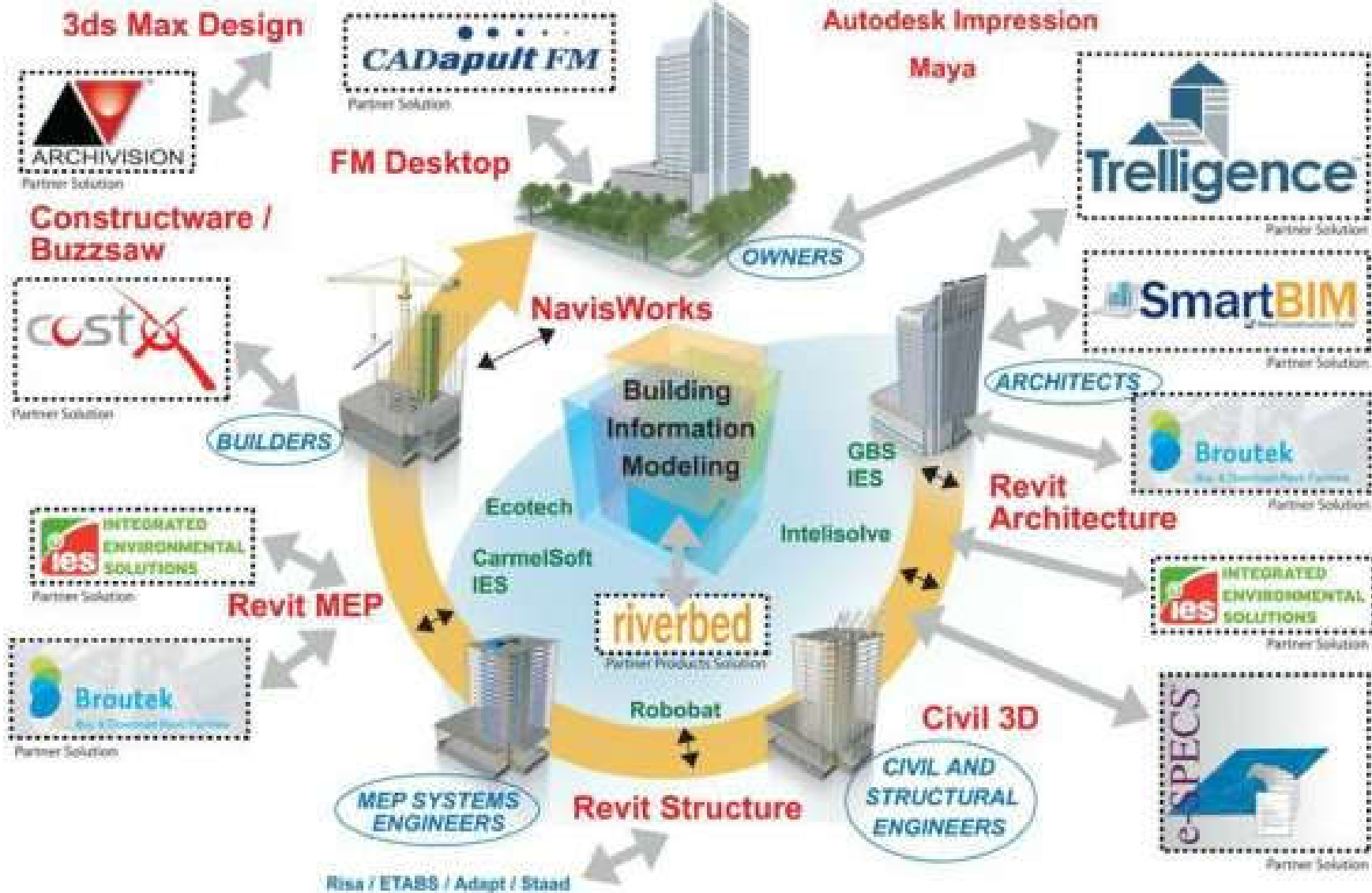
# Design authoring and analysis tools for BIM

## Building Information Modeling (BIM)



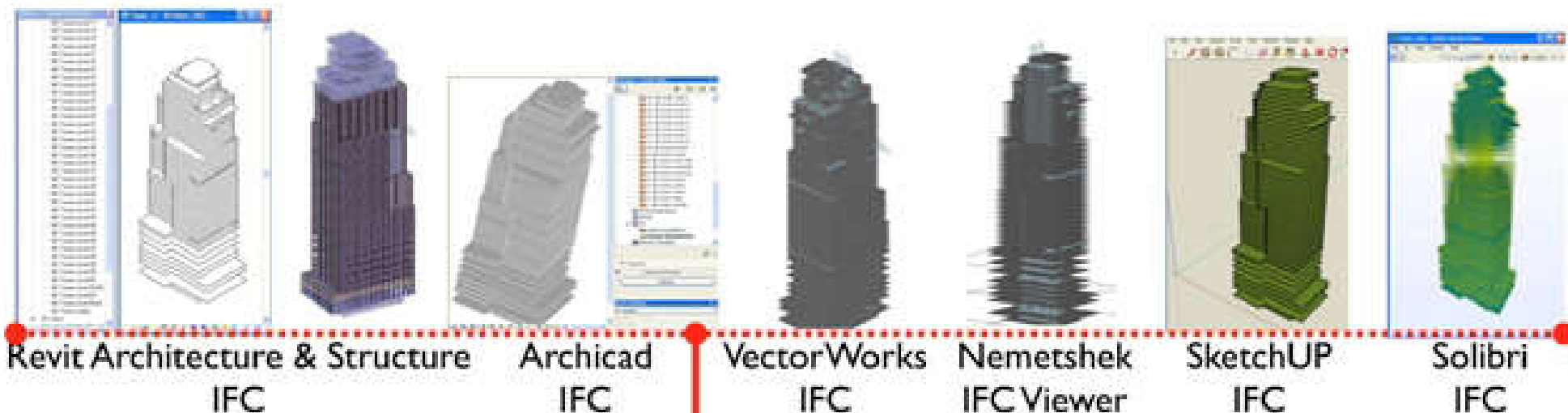
### Design Authoring Tools (Part)

### Analysis Tools (Part)



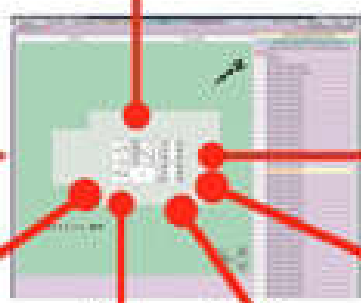
★ COORDINATION ★ ANALYSIS ★ DESIGN ★ VISUALIZATION ★ COLLABORATION ★ SIMULATION ★

# Examples of software tools for supporting the BIM process



Space Name	Floor Number	Space Area
Office	45	4000
Conference	45	2000
Sum	88	10400
Training	88	2400
Storage	88	400
Roof	1	7000
Perimeter	1	10000
Lotus	1	8700
Total SF		307,115

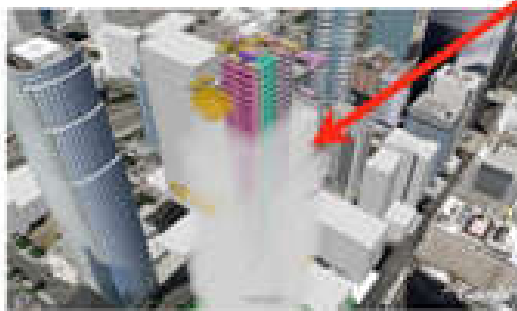
Excel



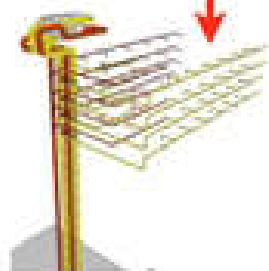
Onuma Planning System  
IFC, KML, GBXML, CSV

Summary	
Total Space NSF:	341,788 SF
Total Energy Use:	6,459,784 kWh

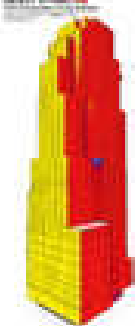
OPS Reports



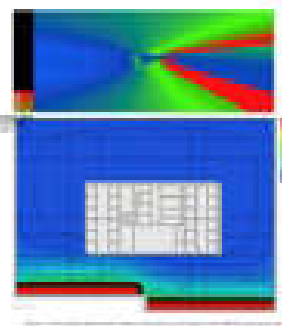
Google Earth - KML



Elite CAD  
IFC



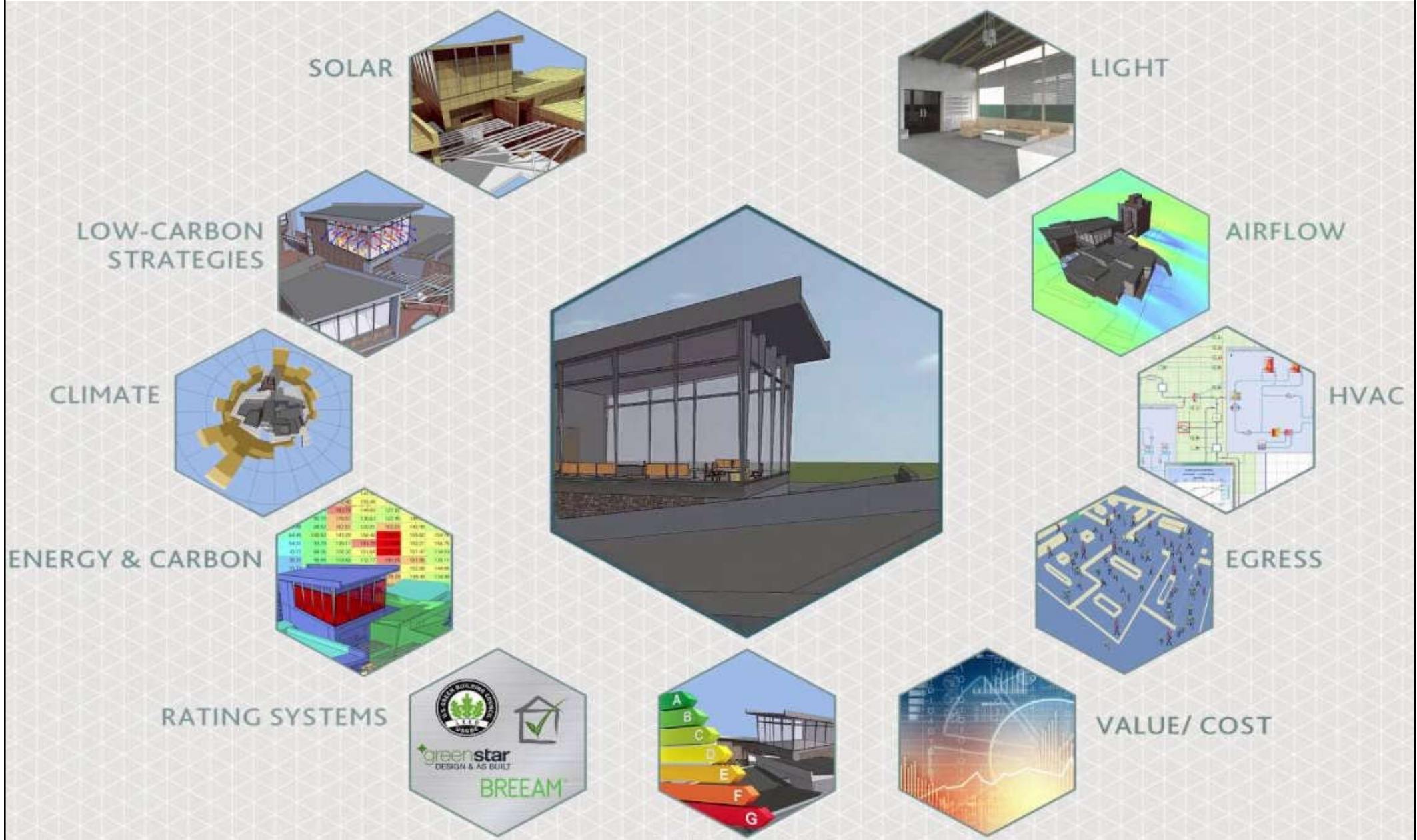
Ecotect  
GBXML & IFC



Whitestone  
O&M  
PDF and Excel



# Analyses using software in the BIM process



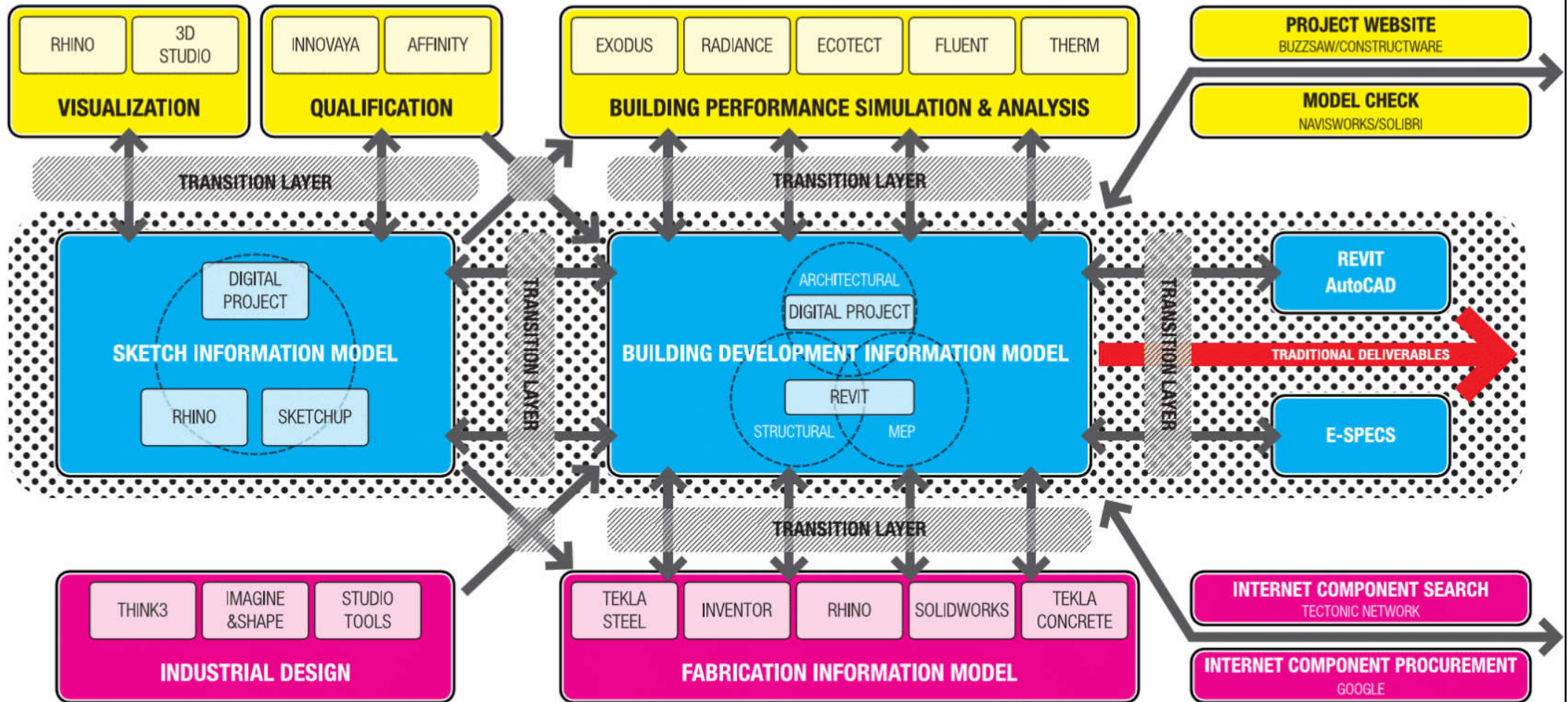
# Latest trends



- Latest trends of BIM software
  - 4D & 5D estimating
  - Code compliance & checking
  - Links to building performance simulation engines
  - E-specifications & tendering
  - Digital prototyping (industrial design, 3D printing)
  - Fabrication information model (automation)
  - Graphical programming for design (e.g. Dynamo)
  - Artificial intelligence (AI) BIM for optimization

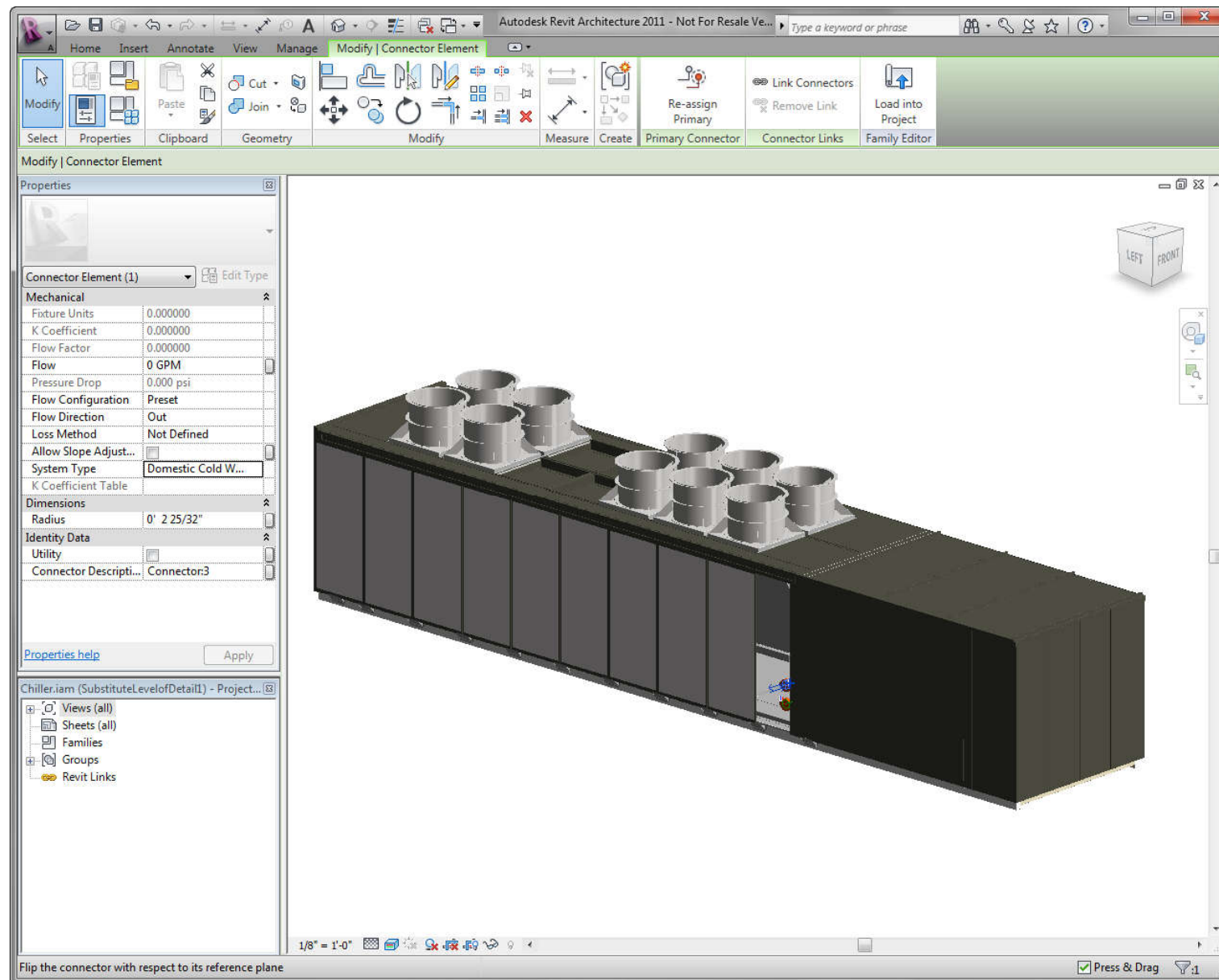


# Typical BIM process and software tools



# Part 6: Digital Prototyping and BIM - Inventor to BIM Demo

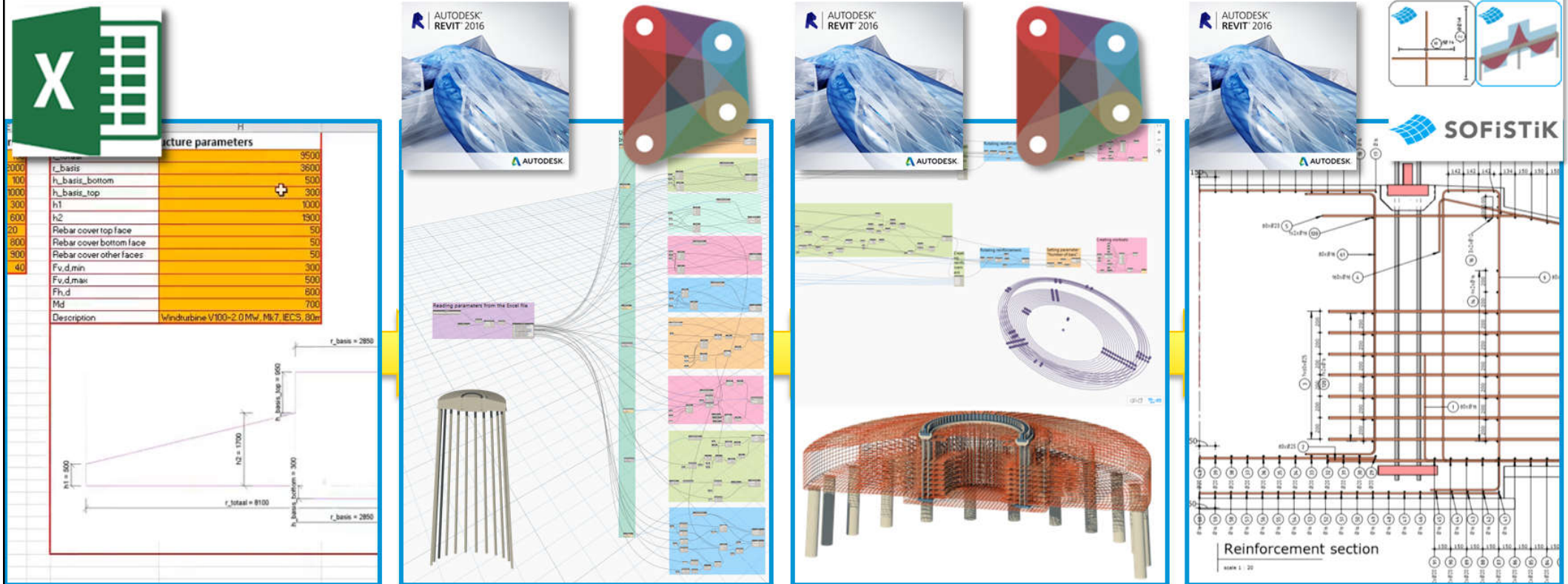
<https://knowledge.autodesk.com/support/inventor-products/learn-explore/caas/video/youtube/watch-v-7JM8GOYAye8.html>



(See also: Linking BIM, manufacturing and digital prototyping [https://redstack.com.au/support/blog\\_posts/the-link-between-bim-and-digital-prototyping](https://redstack.com.au/support/blog_posts/the-link-between-bim-and-digital-prototyping))



# Use of MS Excel with Dynamo and Revit (graphical programming for design or parametric modelling)



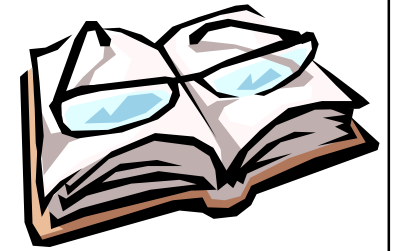
Set parameters for geometry in Excel

Read Excel values and create initial geometry with Dynamo and Revit

Drive Revit geometry and generate rebar

Generate detailed output drawings

See also: Dynamo BIM <http://dynamobim.org/>



# Further reading

- Simulation modeling - Wikipedia
  - [https://en.wikipedia.org/wiki/Simulation\\_modeling](https://en.wikipedia.org/wiki/Simulation_modeling)
- BIM Software guide
  - <https://www.buildingincloud.net/en/bim-software-guide/>
- List of BIM Software & Providers
  - <https://thebimhub.com/2015/08/17/list-of-bim-software-providers>