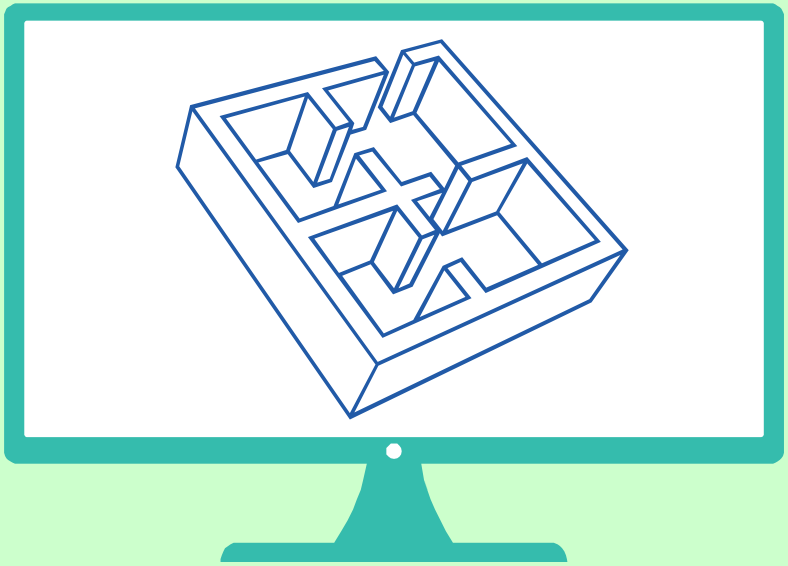
Building Information Modelling (BIM) Training

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



1.3 Computer modelling and BIM software

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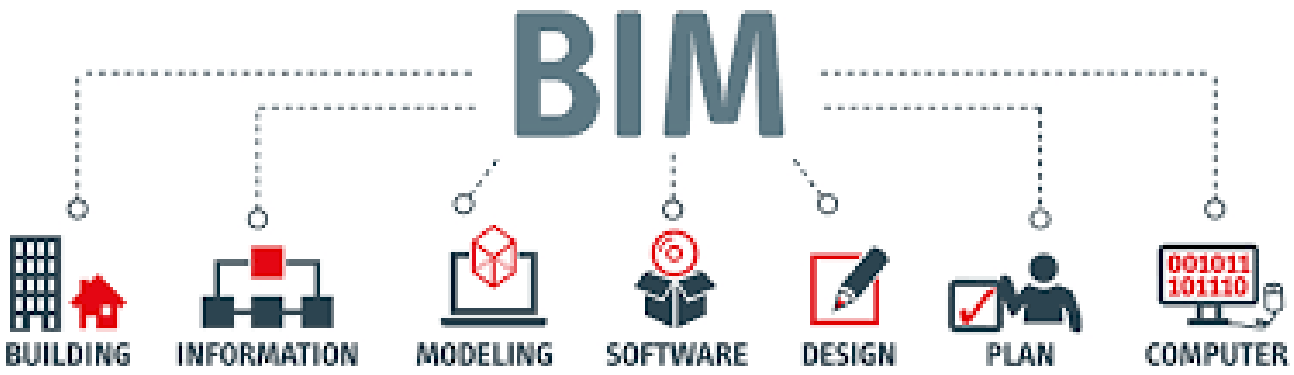
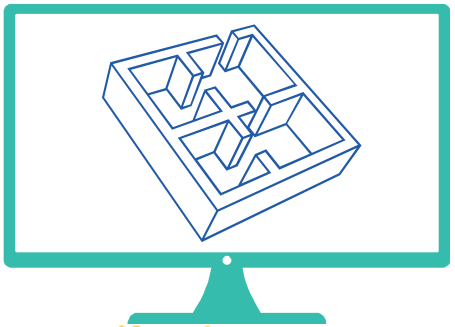
Contents

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

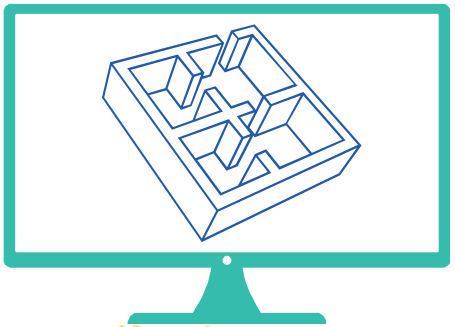


Modelling

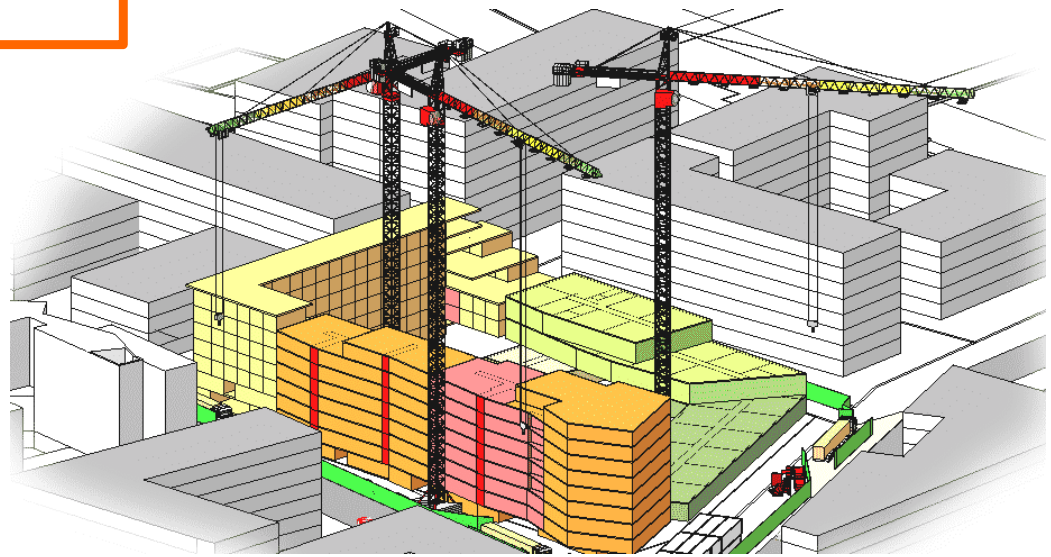


- In BIM, every project is built TWICE
  - Once in a virtual environment to make sure that everything is just right and once in a real environment to bring the project to life
- BIM model is the overview of every other aspect of the building and its information
  - It provides an analogy or smaller-scale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

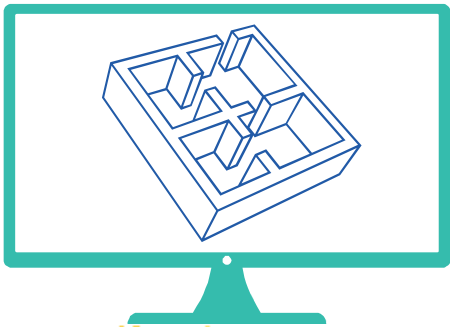
Modelling



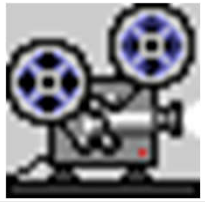
- Information modelling for BIM:
  - 3D model
  - 4D model - time
  - 5D model - time and cost
  - Energy model
  - Business model
  - Financial model
  - Safety plan
  - Maintenance plan



Modelling



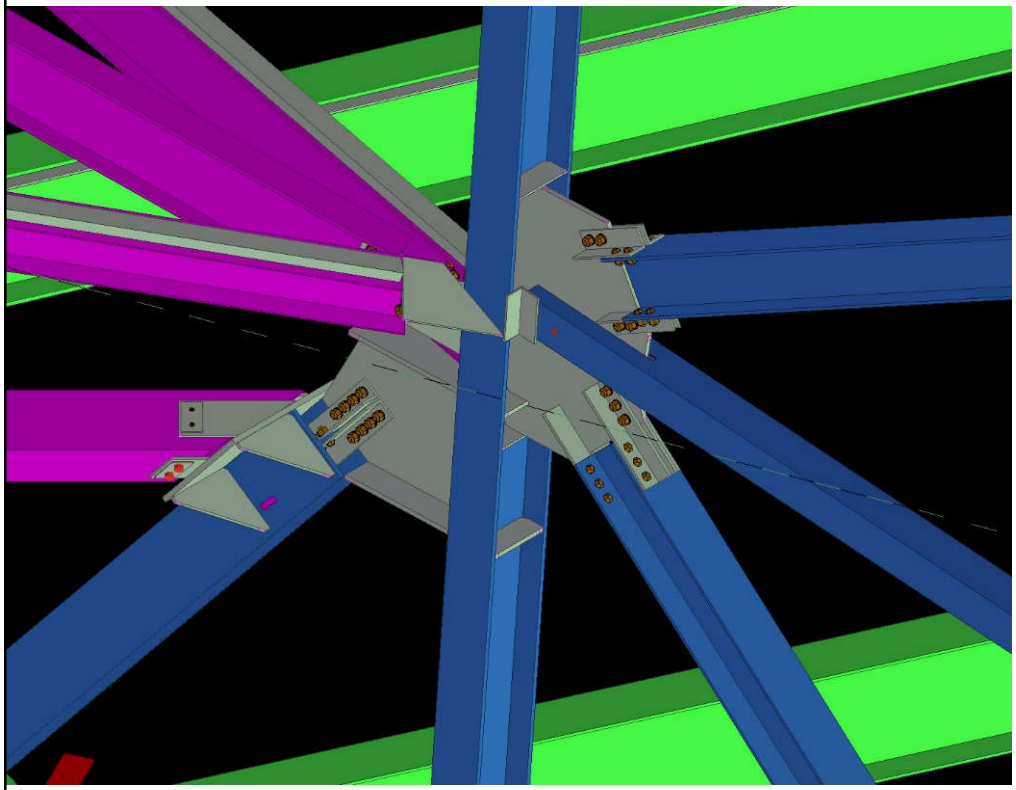
- Practical types of BIM models:
  - Design models
    - Arch, Structure, MEP, Civil/Infrastructure
  - Construction document models
    - Arch, Structure, MEP, Civil/Infrastructure
    - Specifications
  - Contractor model (for construction & installation)
  - Facility management model (for O&M)
  -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



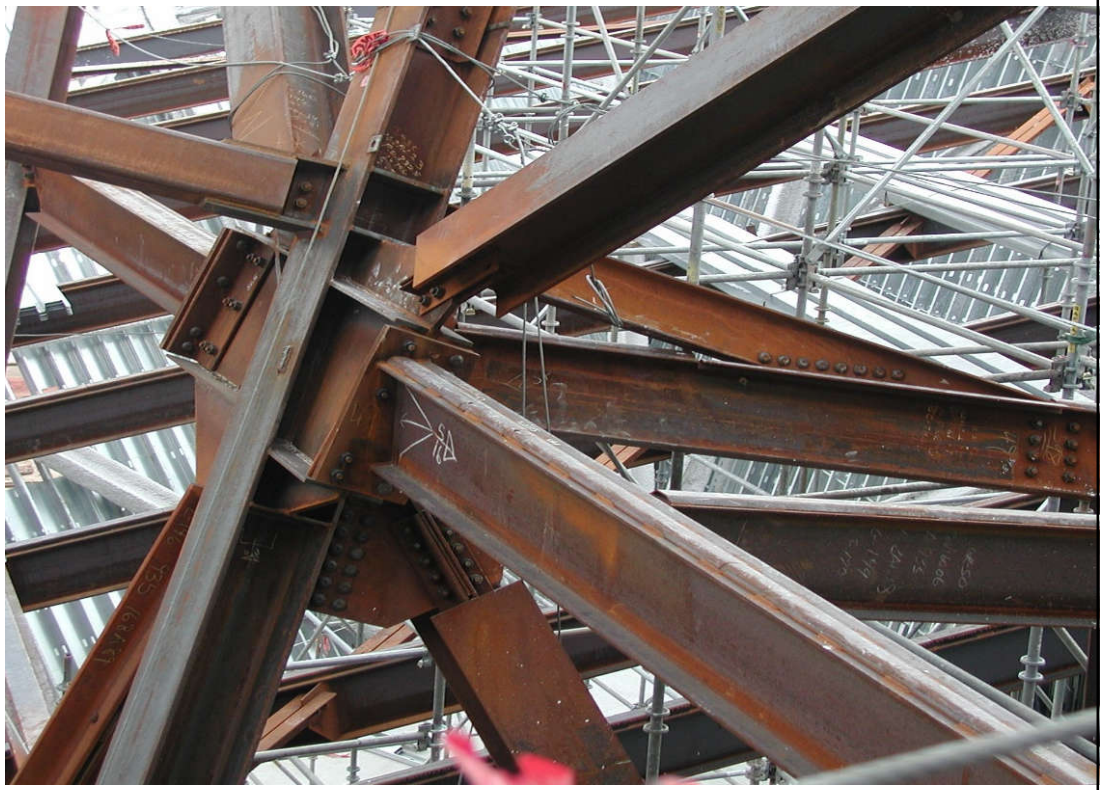
(Example: Video: Building Information Modelling - BIM (3:02) https://youtu.be/MWmJtqP1_XA)

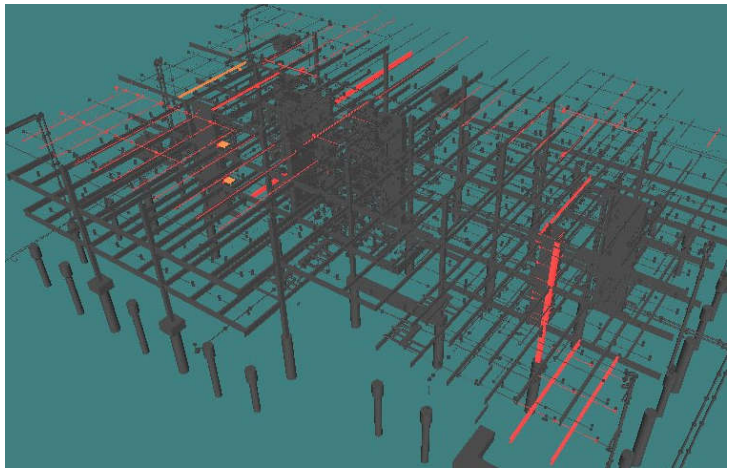
BIM design models for structural engineering and clash analysis

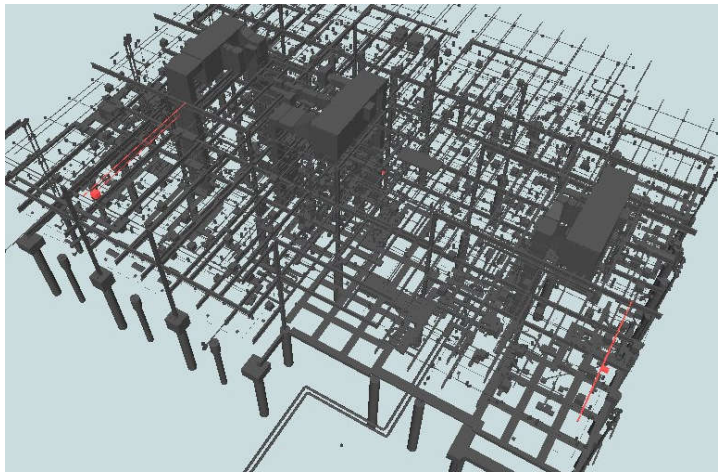
BIM 3D model



Actual installed

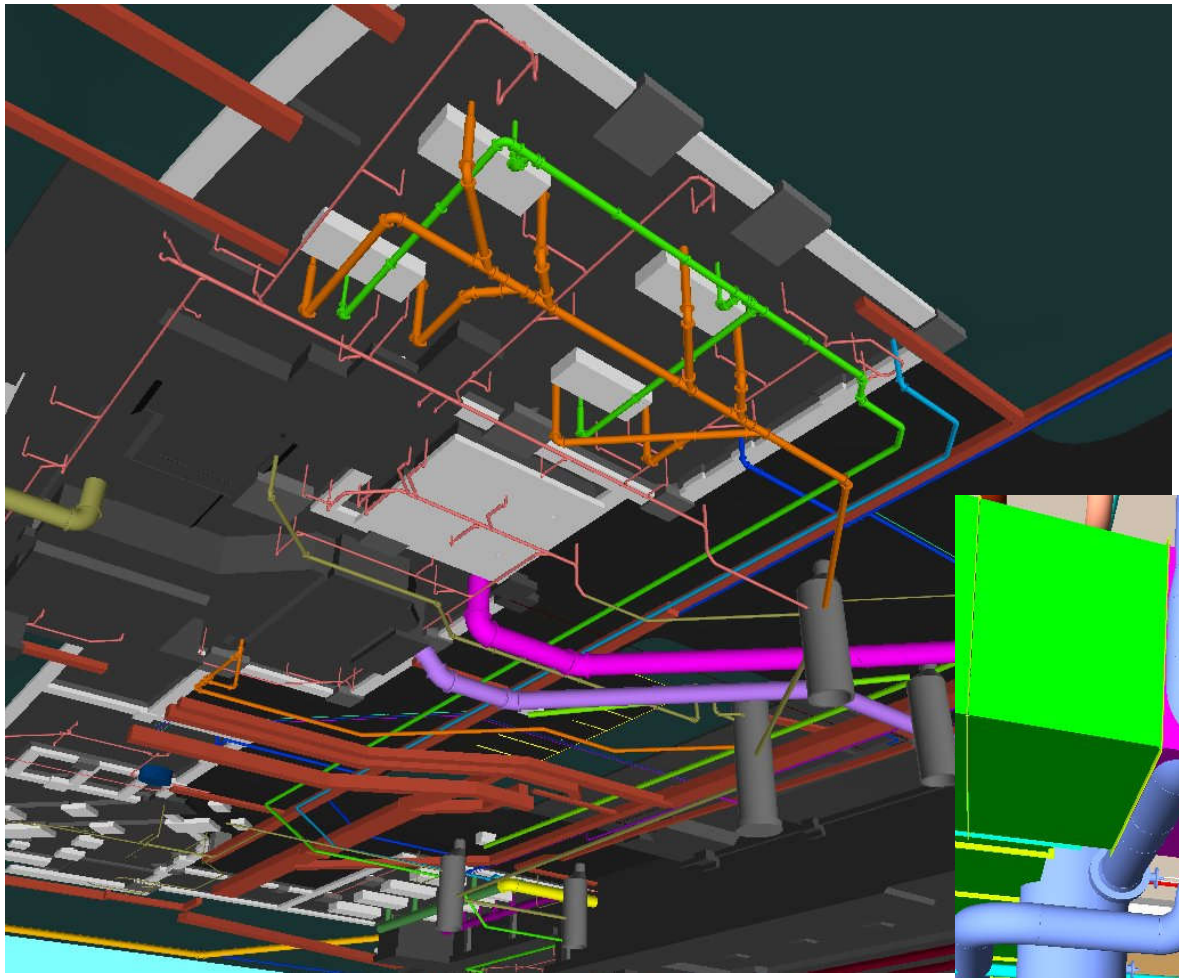




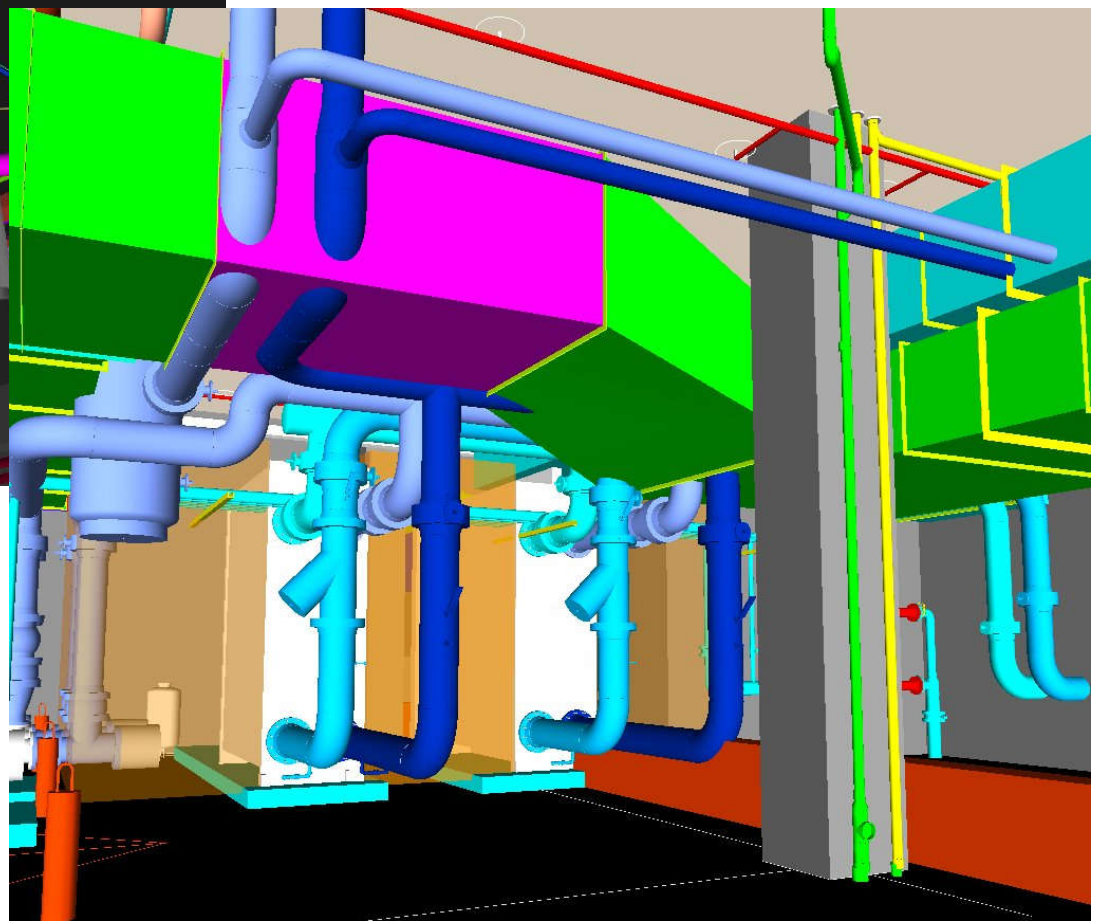


Clash analysis
and coordination

BIM design models for building services engineering



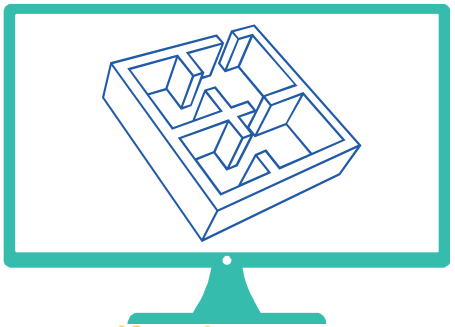
On the ceiling



Inside a plantroom

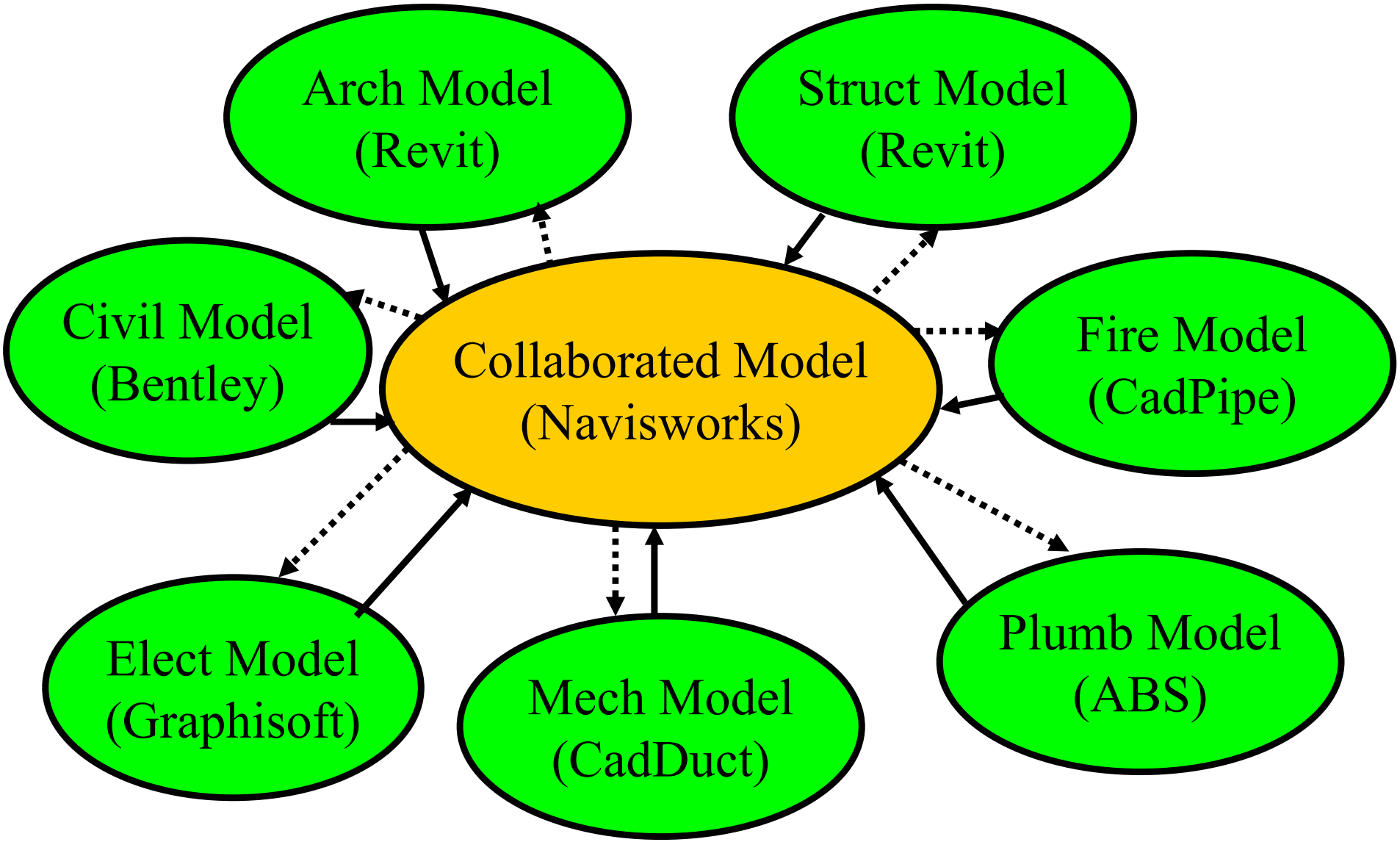
(Source: Butler Treatment Plant and Cronkite School of Journalism, UK)

Modelling

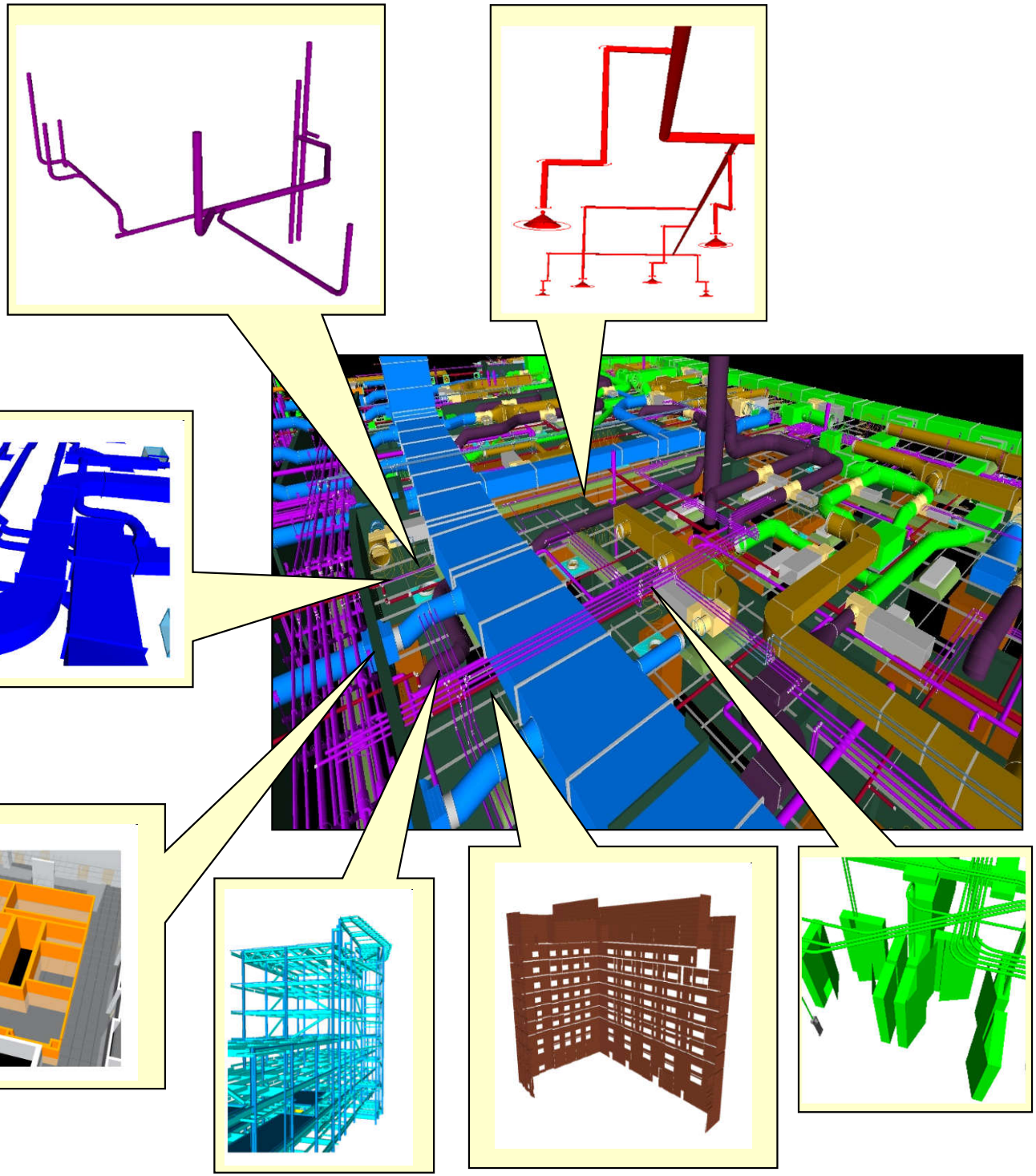


- Common uses of BIM for Building Services:
  - 1. Collaboration and access
    - Clash detection and coordination
    - Conceptual design and feasibility evaluation
    - Field management (on-site)
  - 2. Simulation and analysis
    - Mechanical/HVAC simulation
    - Air, fluid, flow, and thermal comfort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

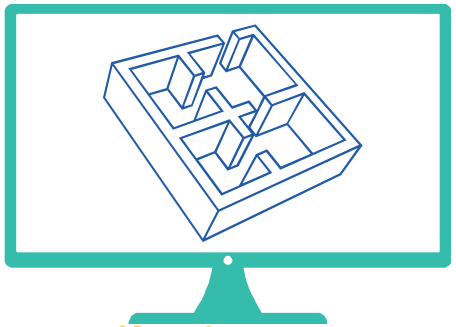
Collaborated model for BIM and common software tools



Individual scopes to consolidated model



Modelling



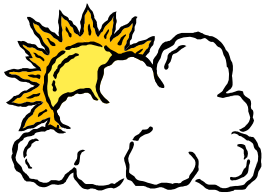
- Simulation 模擬
  - The process of developing a representative model of a system and using it to analyze and predict system behaviour and performance
- Modelling 建模 / 建立模型
  - Deals primarily with the relationship between actual dynamic processes and models
  - Usually involves iterations
- >> Support decision making

Do you know the difference between simulation and modelling?

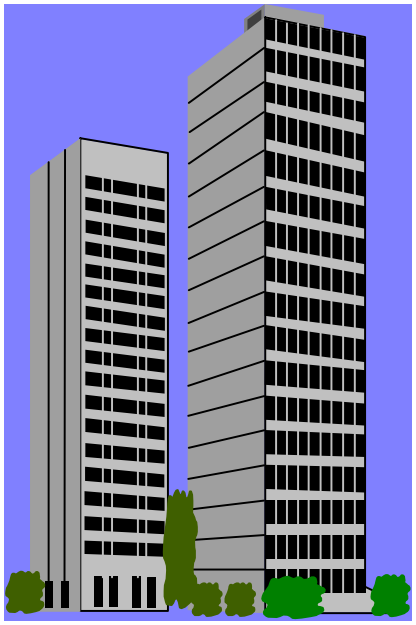
(See also: Simulation modeling - Wikipedia https://en.wikipedia.org/wiki/Simulation_modeling)

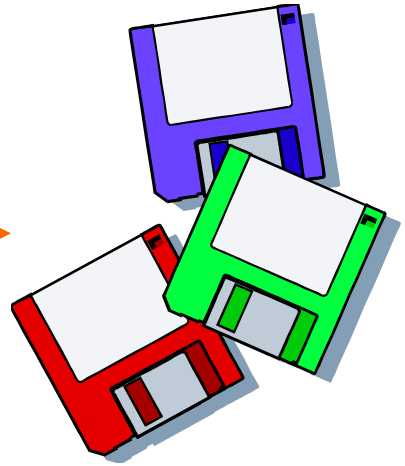
Building energy simulation and modelling

(Building energy simulation - Wikipedia https://en.wikipedia.org/wiki/Building_energy_simulation)



Weather data





Building description

- physical data
- design parameters

Simulation tool (computer program)

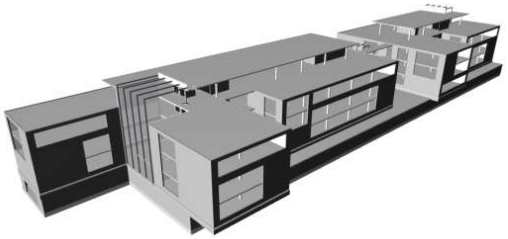
Simulation outputs

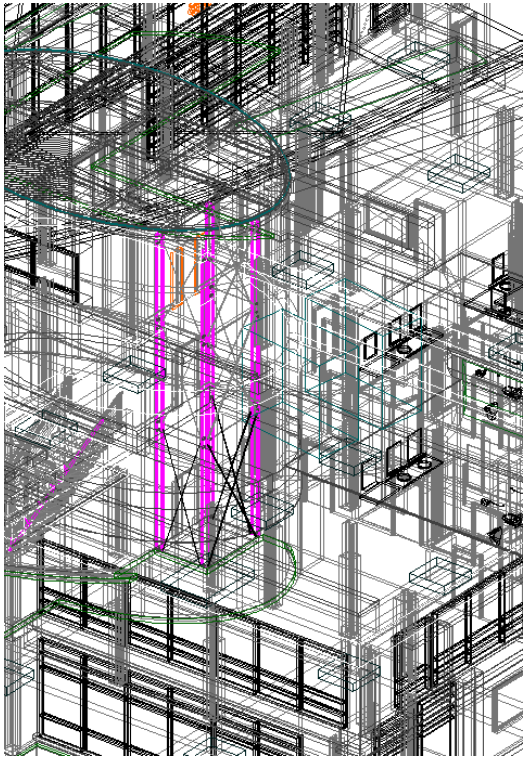
- energy consumption (MWh)
- energy demands (kW)
- environmental conditions

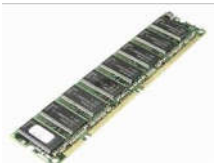
Decisions

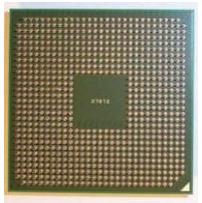
The following factors largely influence the successful modelling approach:

- Purpose of the model
- Complexity
- Model Size
- Hardware







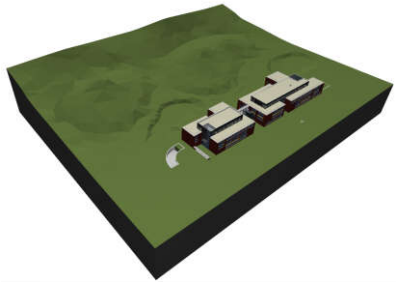


(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Purpose of the Model

Conceptual Design

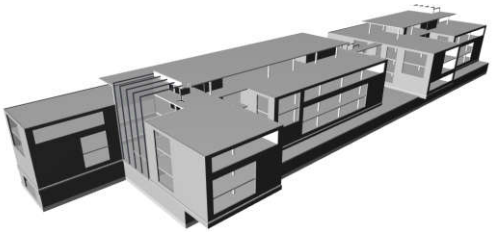
Visualization



Site Planning

BIM Modelling

Construction Coordination

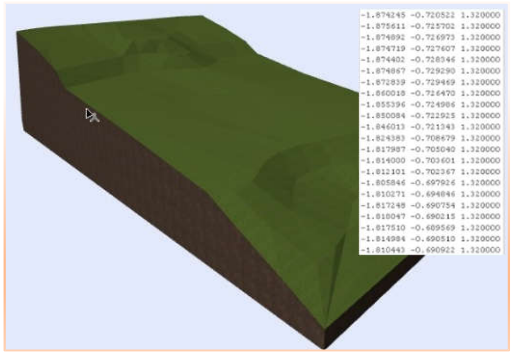


Structural Design

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

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.

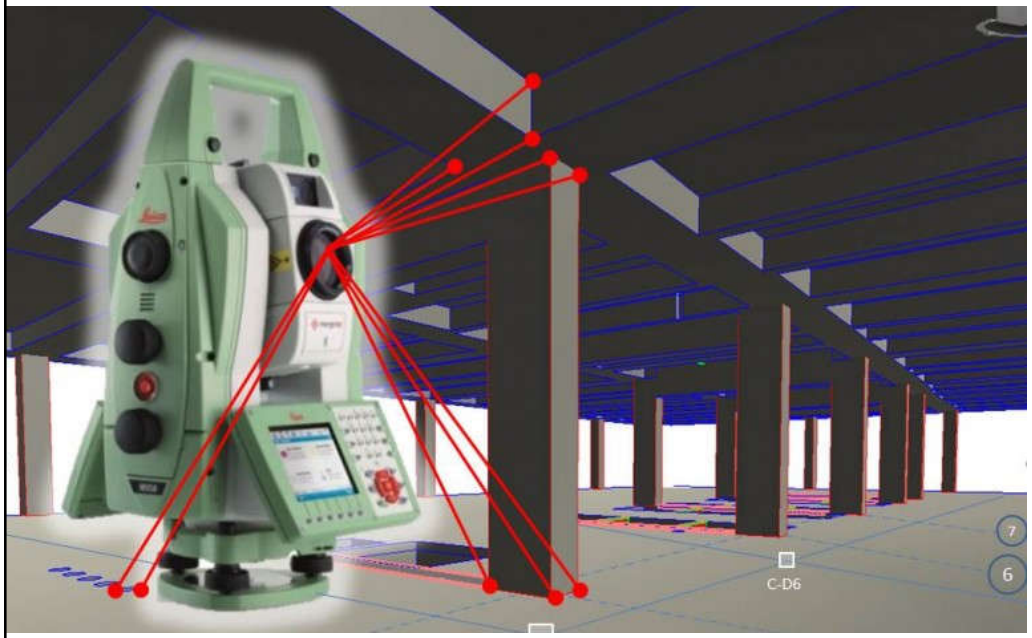


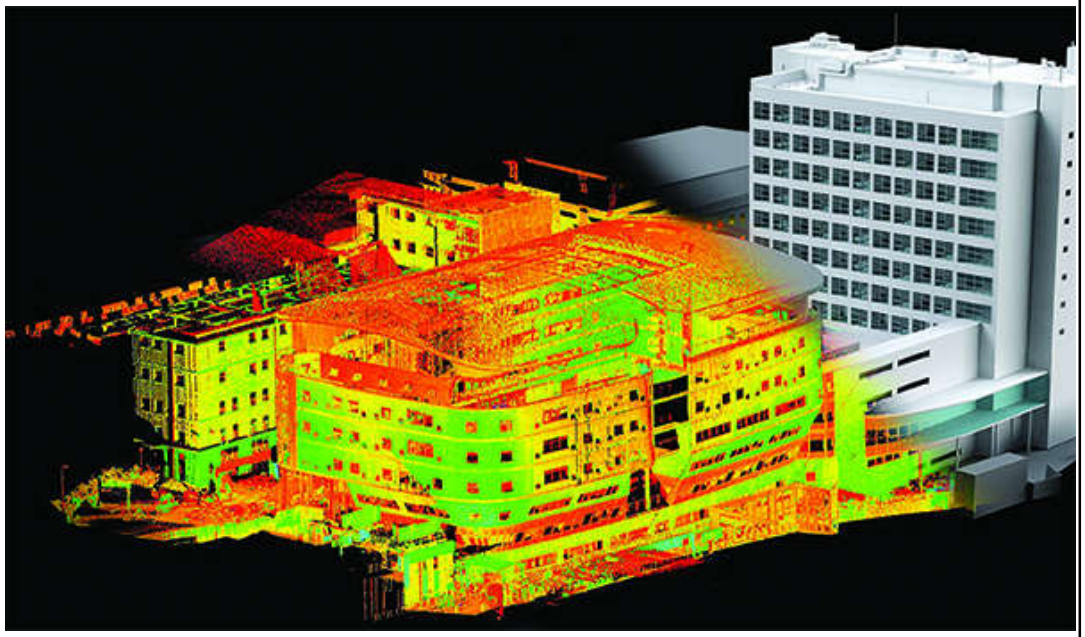
How to put 3D laser survey and **point-clouds** to work:

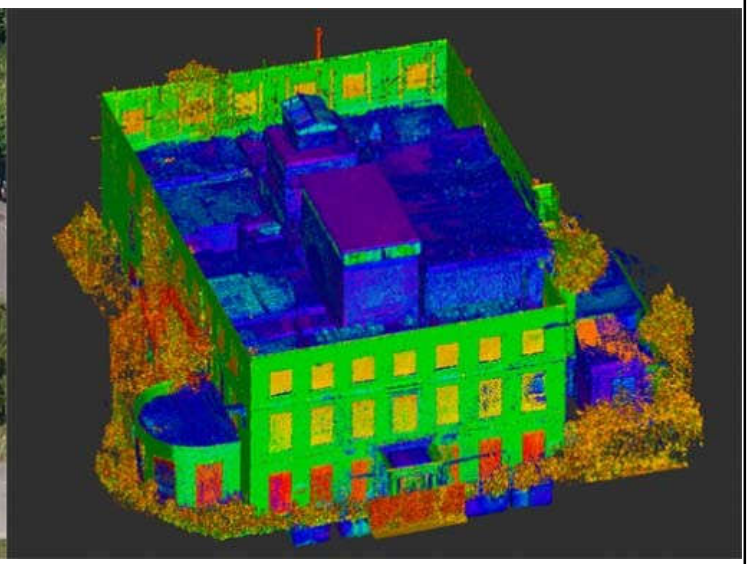
- Modelling existing buildings before renovation.
- Modelling the surroundings prior to creating a new building.
- Modelling the “as-built” structure to detect deviations from plan.

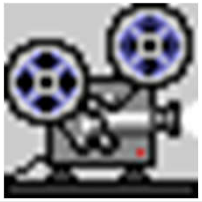
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Scan to BIM by digital survey and laser scanning





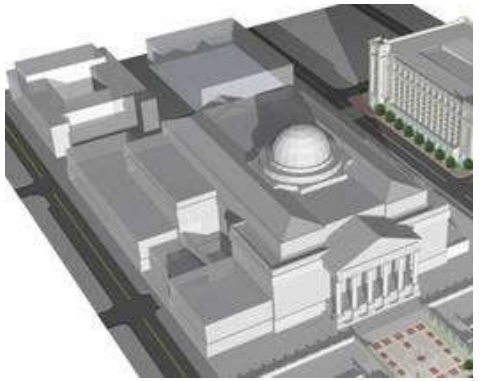




(Video: Laser Scanning & BIM or Scan-to-BIM (4:41) https://youtu.be/fqoNXUymGko)

Conceptual Modelling

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

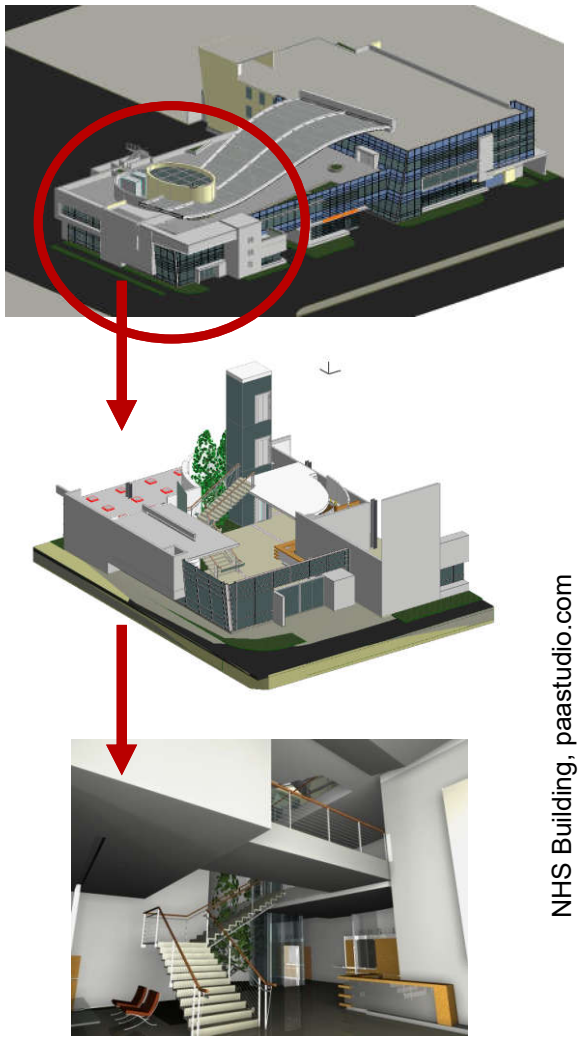


http://www.sketchup.com

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

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



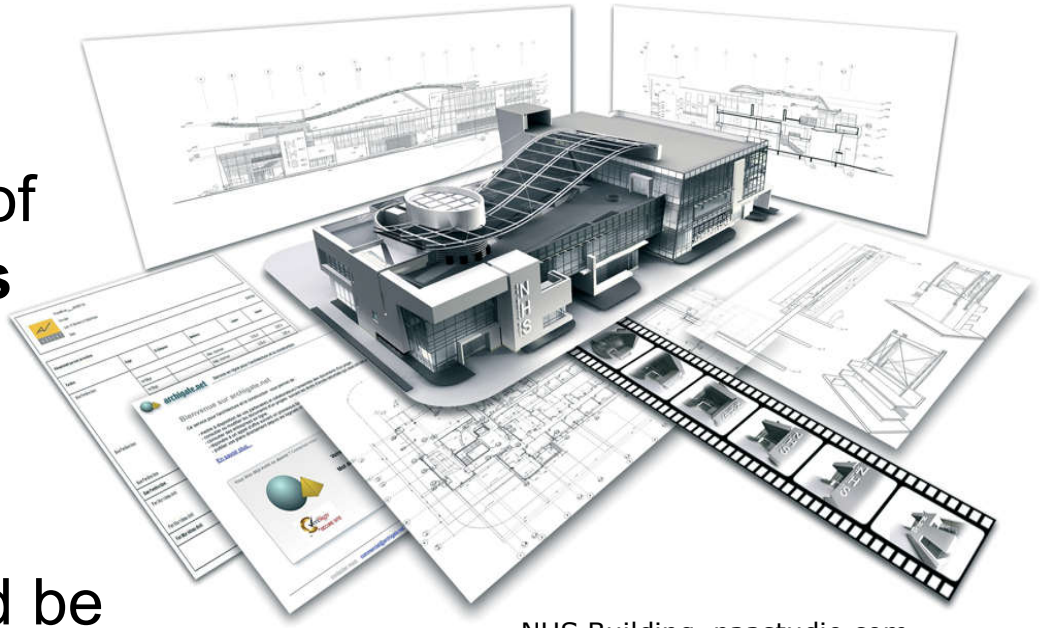
NHS Building, paastudio.com

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

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.

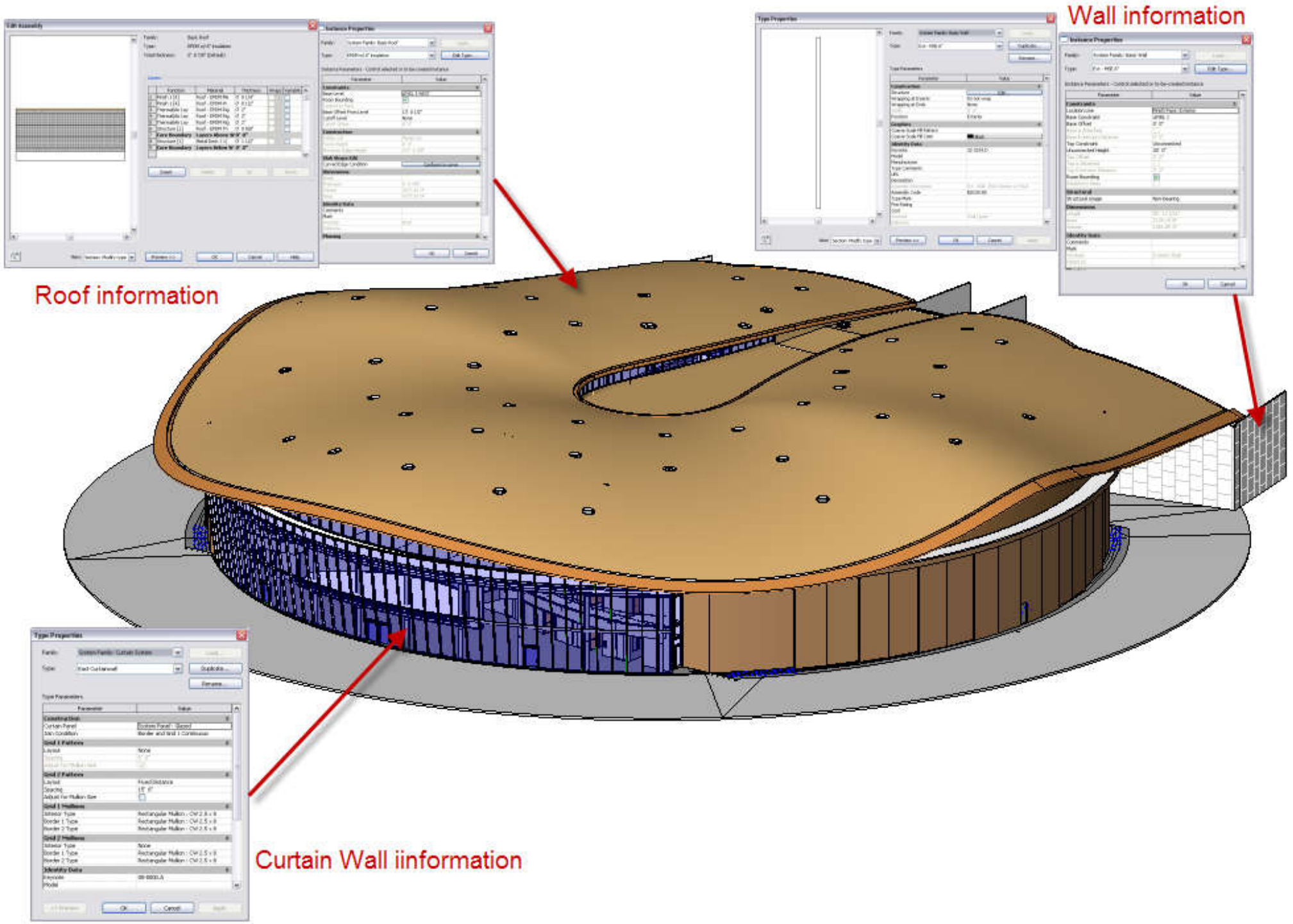


NHS Building, paastudio.com

- Modeling **detail level** should be appropriate for the required drawing representations.

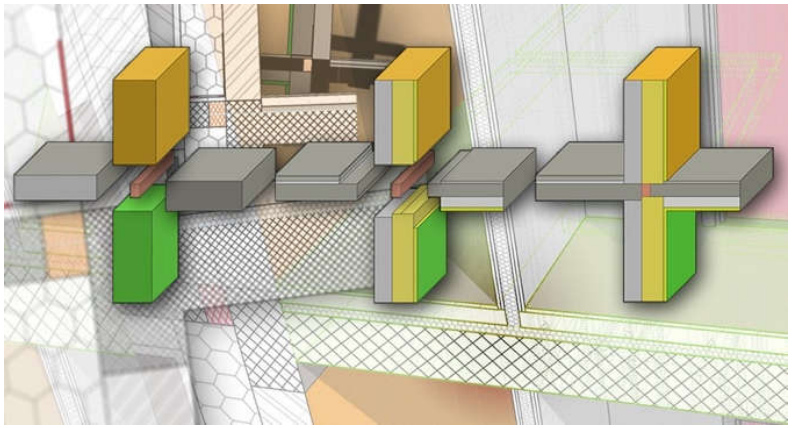
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Example of BIM architecture model and information

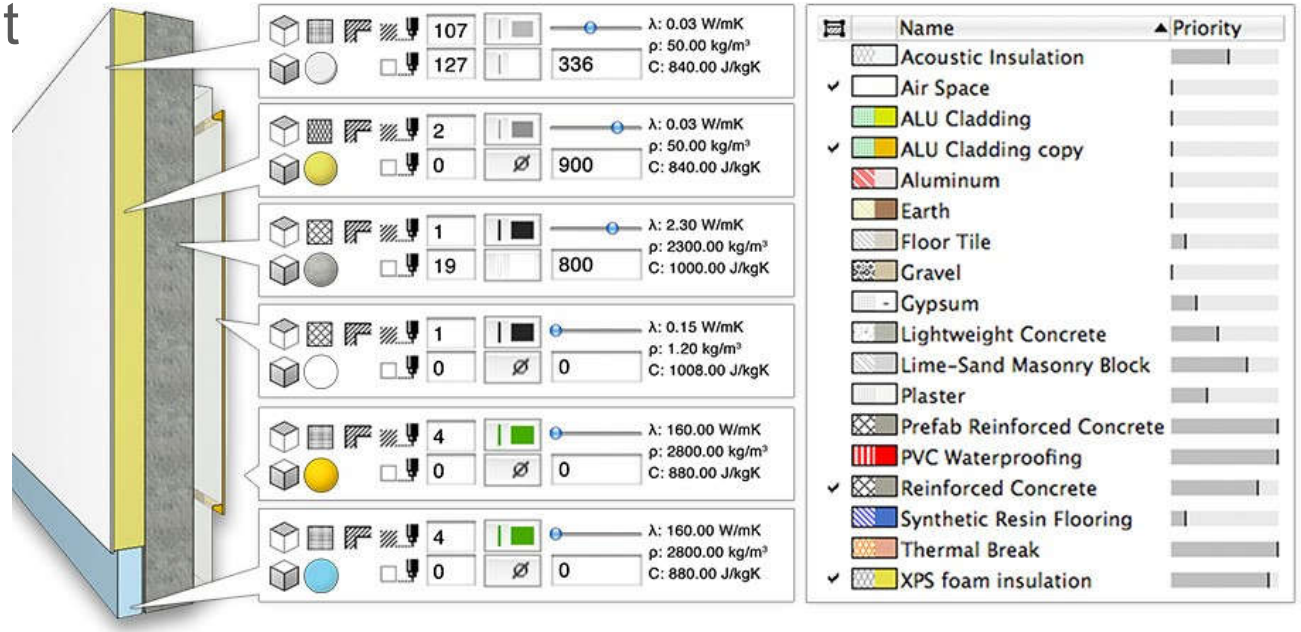


Real Building Materials

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.



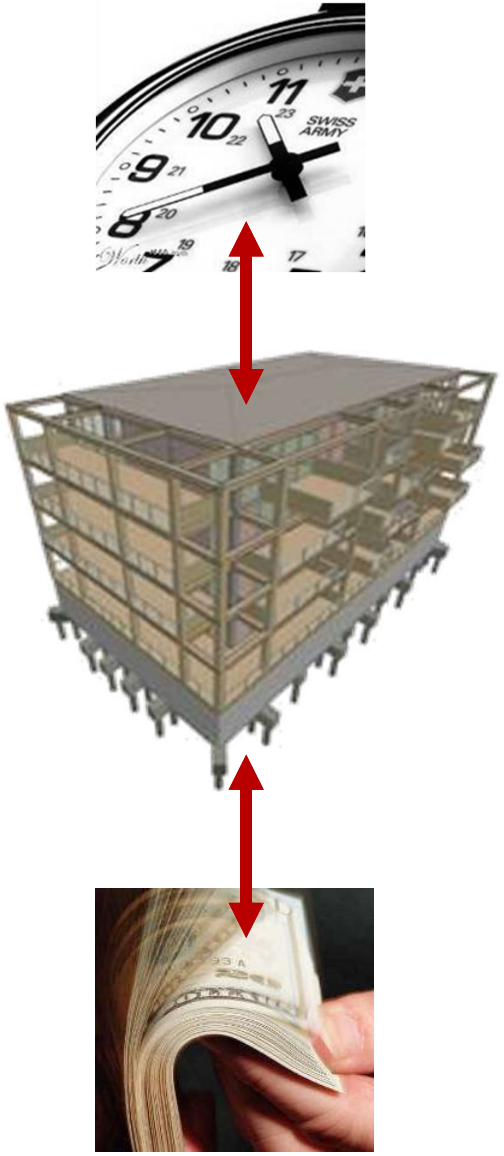
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

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)

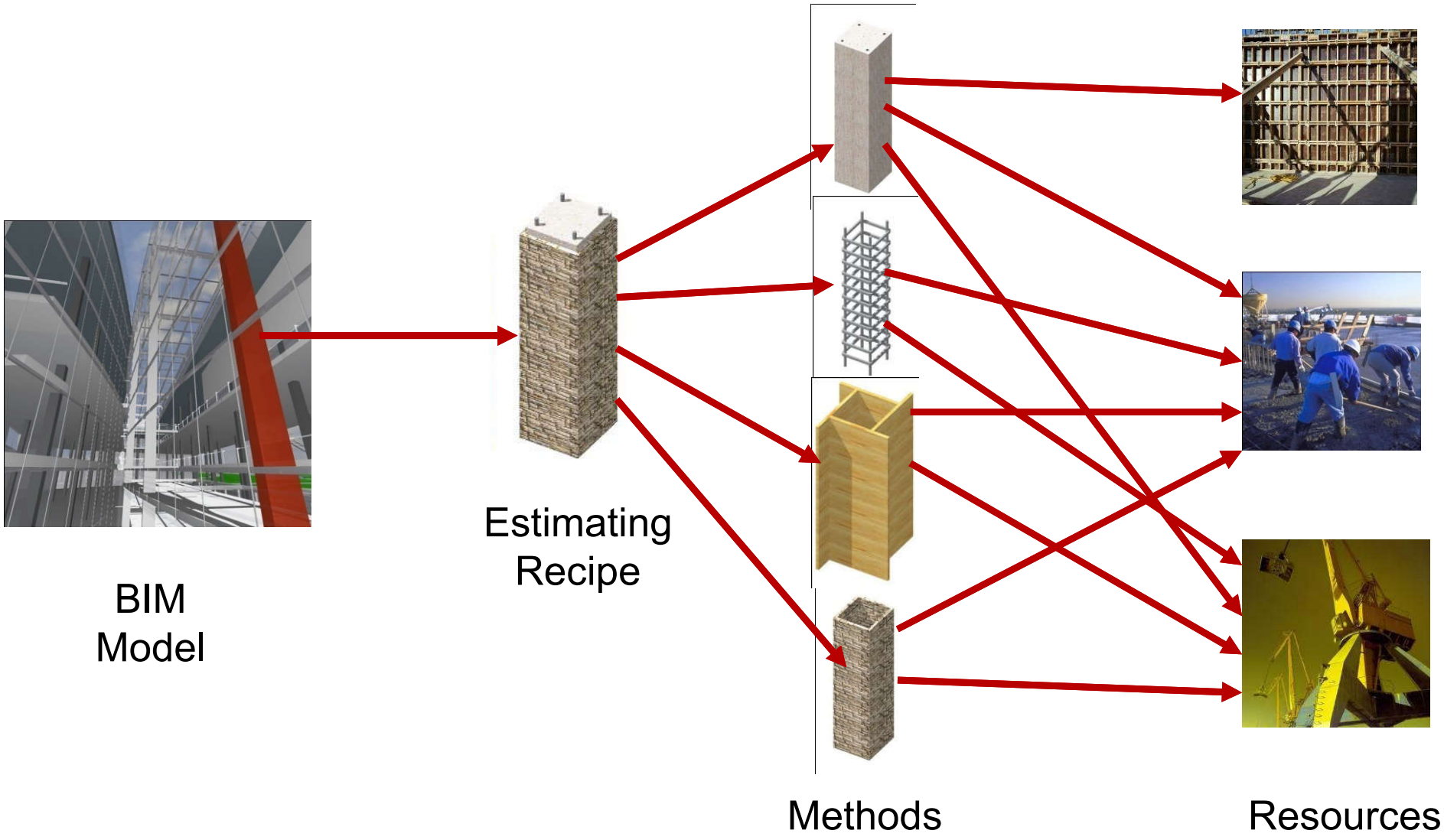
BIM model

Cost

(Linked estimating recipes)

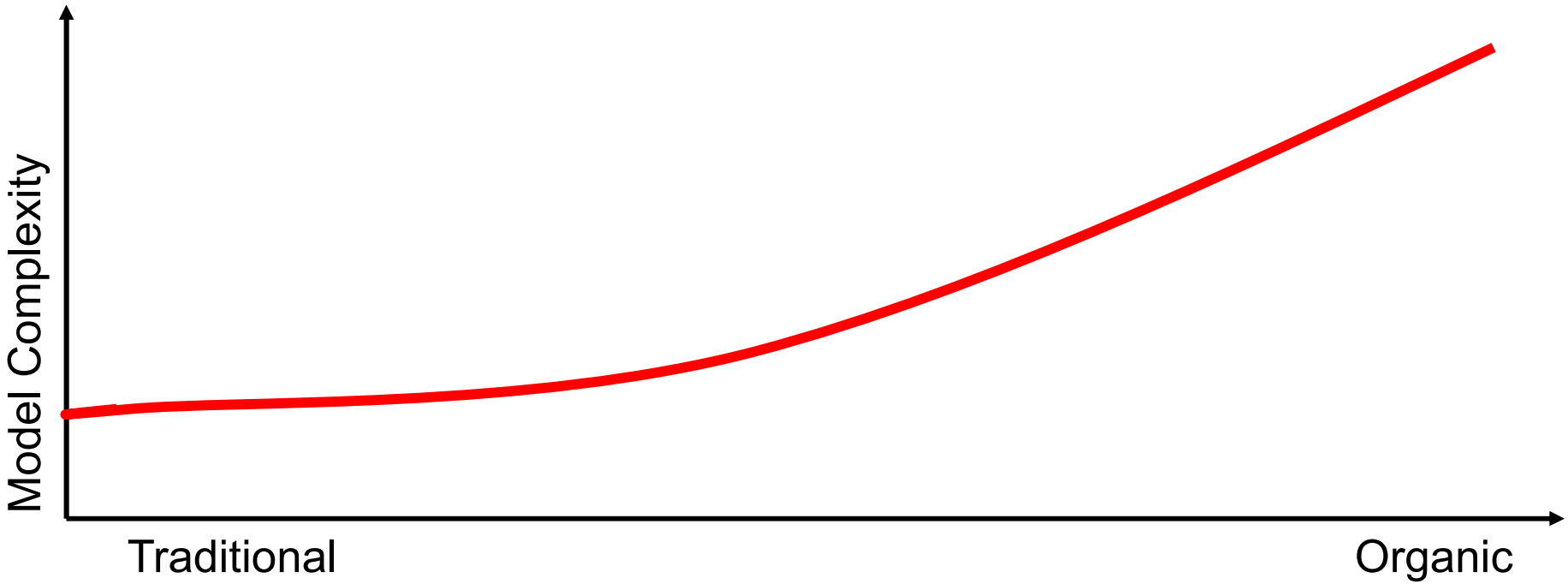
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Virtual Construction Model



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

Model Complexity



Le Corbusier

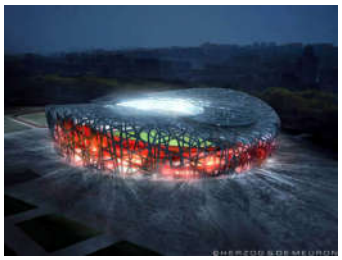
Zaha Hadid

Frank O. Gehry

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

Complexity

- How can you model these buildings?



Herzog & de Meuron

- **Simplify**
  - The level of detail shouldn't exceed the actual requirements

Frank O. Gehry

- **Divide**
  - Share the building model between the project team members

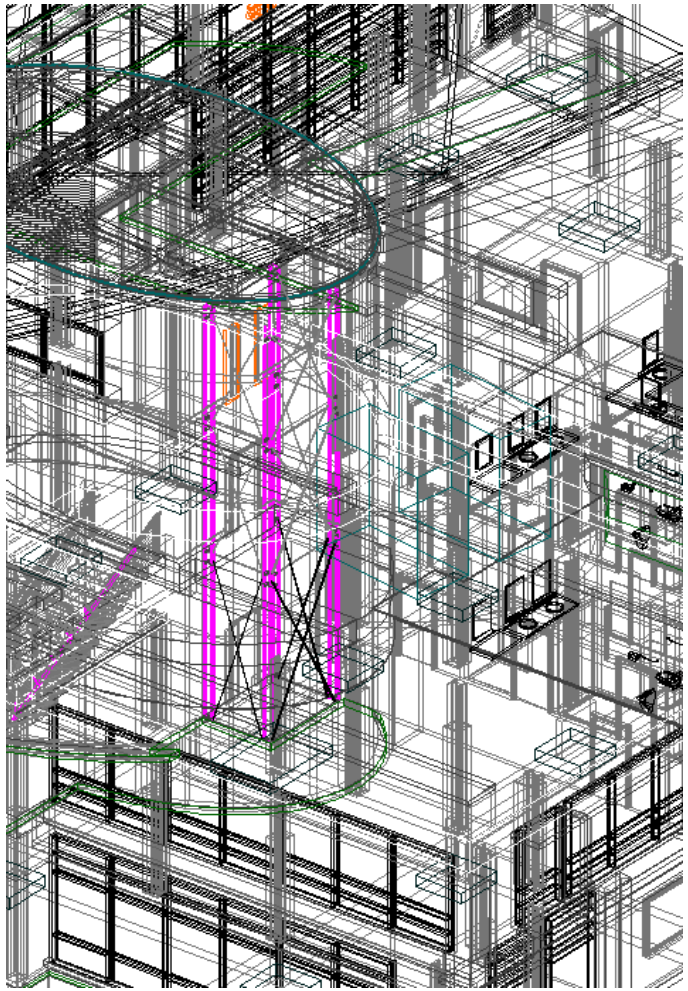
Santiago Calatrava

- **Use the appropriate tools**
  - Combine several applications for the best result

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

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



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

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

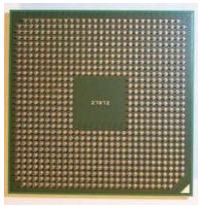
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Hardware Requirements

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

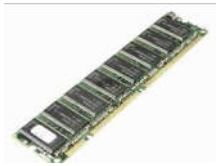
- CPU
  - Speed: General latency

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.

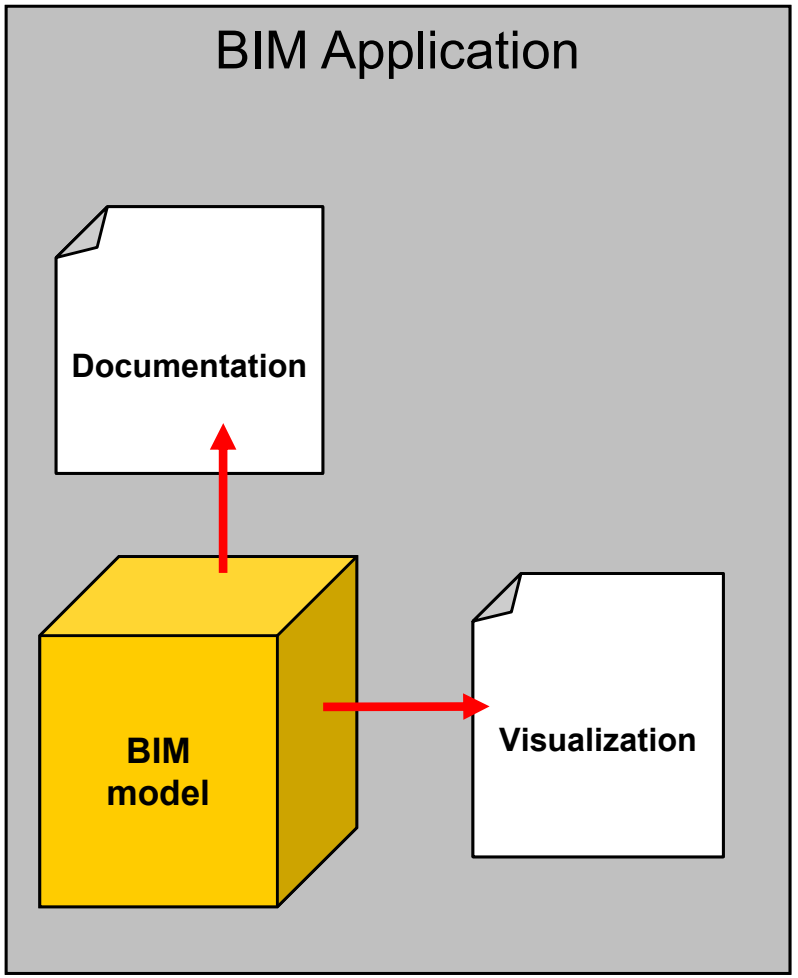
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Software Solutions

Classic BIM modeling approach for small to medium scale projects:

All in one application:

- modeling
- documentation
- visualization



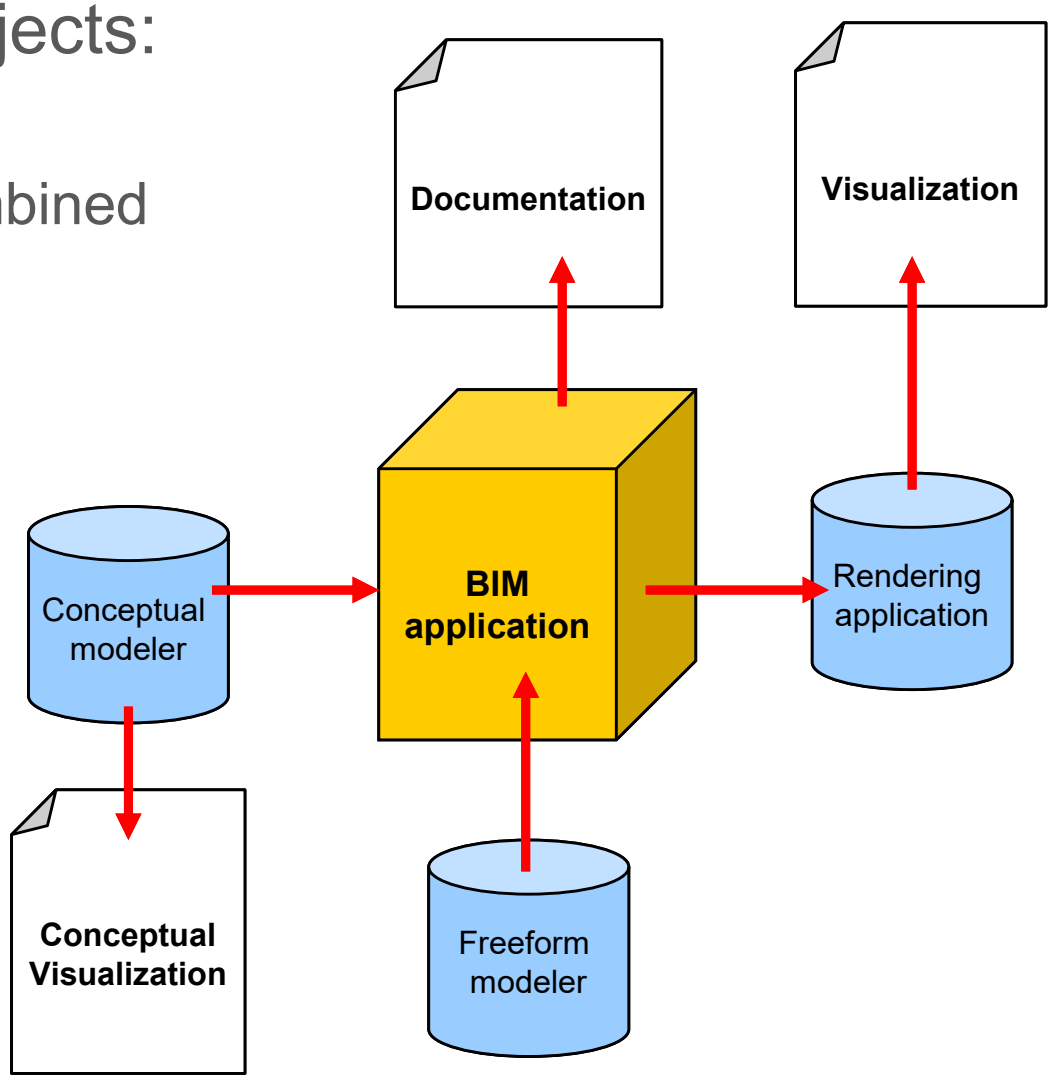
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

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



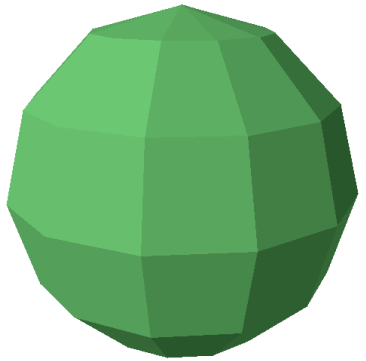
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Computer Modelling Techniques

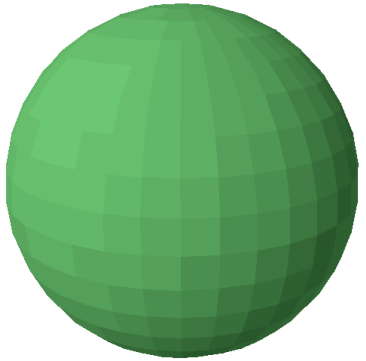
- **Polygonal modeling** is an approach for modeling objects by representing or approximating their surfaces using polygons.

- 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

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

Computer Modelling Techniques

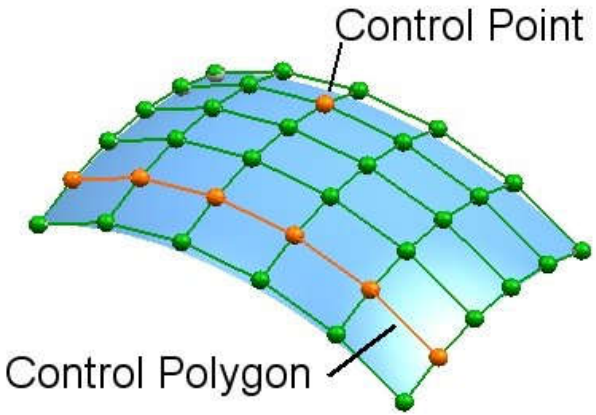
- **NURBS**, short for non-uniform, rational B-spline, is a mathematical model commonly used for generating and representing curves and surfaces. A NURBS curve is defined by its **order**, a set of weighted **control points**, and a **knot vector**.

- 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).

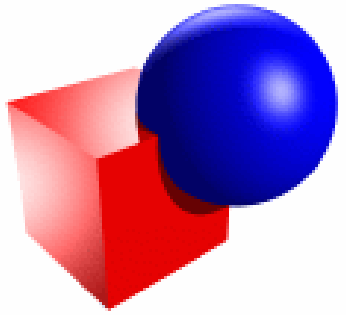


(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

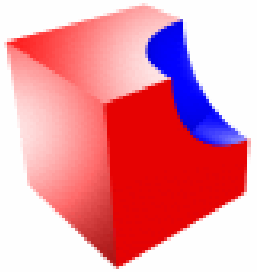
Computer Modelling Techniques

- **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

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

BIM software

- Three common BIM software packages
  - ArchiCAD by Graphisoft
  - Microstation by Bentley System
  - Revit by Autodesk

BENTLEY

GRAPHISOFT ARCHICAD

AUTODESK REVIT

- 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

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?

(Source: Building information modelling BIM https://www.designingbuildings.co.uk/wiki/Building_information_modelling_BIM)

BIM software

(Source: BIM Software guide https://www.buildingincloud.net/en/bim-software-guide/)

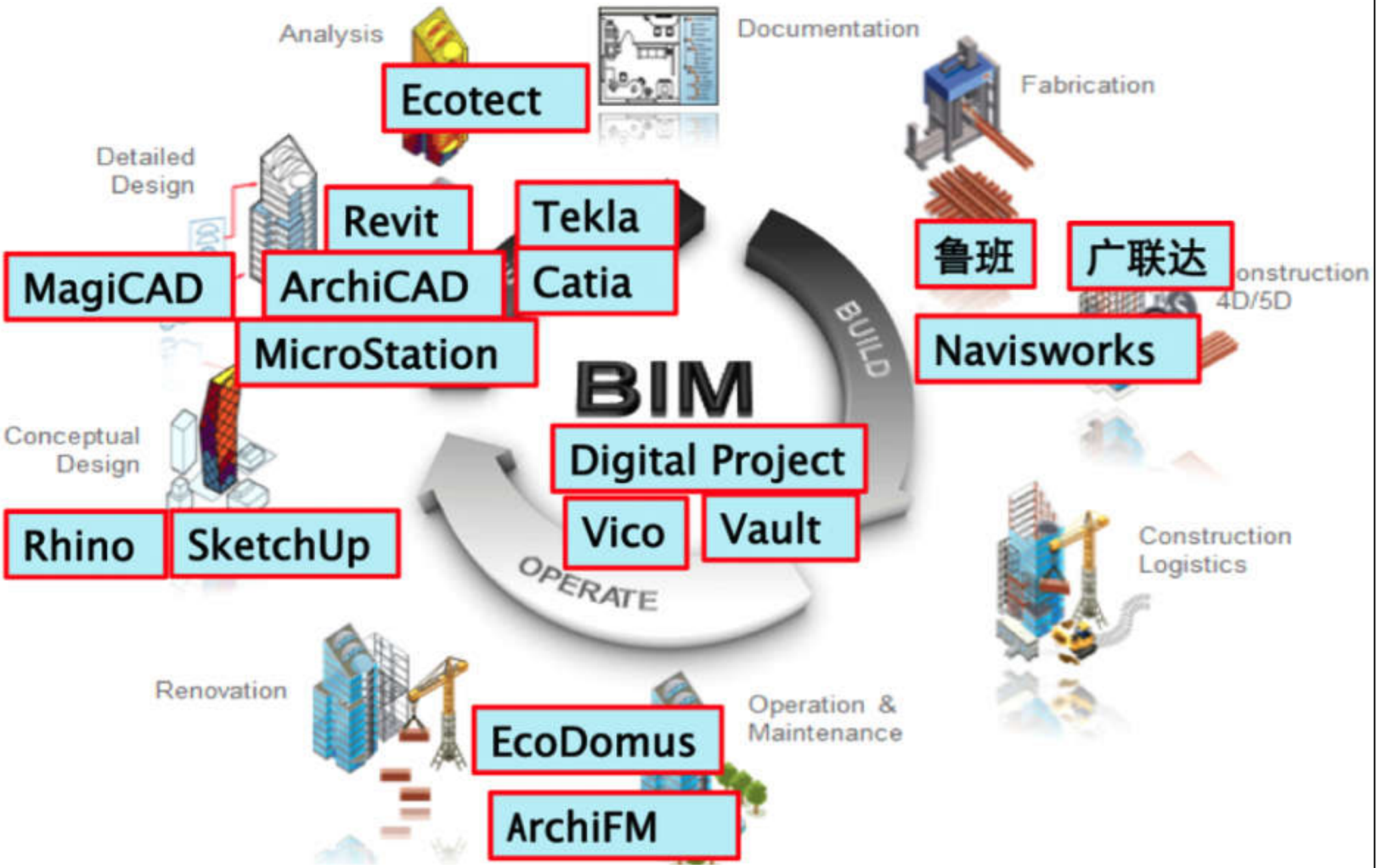
Overview of software for BIM design

(Source: Overview of software for BIM design https://www.linkedin.com/pulse/overview-software-bim-design-eugen-arkaniuk/)

BIM software

- Types of software based on BIM dimensions:
  - 3D Modelling
  - 4D Scheduling
  - 5D Cost
  - 6D Sustainability
  - 7D Maintenance & Operation
- 15 Best BIM Software [2025 Updated BIM Software List]
  - https://www.constructionplacements.com/bim-software/

Choice of BIM software for different phases



(Source: List of BIM Software & Providers https://thebimhub.com/2015/08/17/list-of-bim-software-providers)

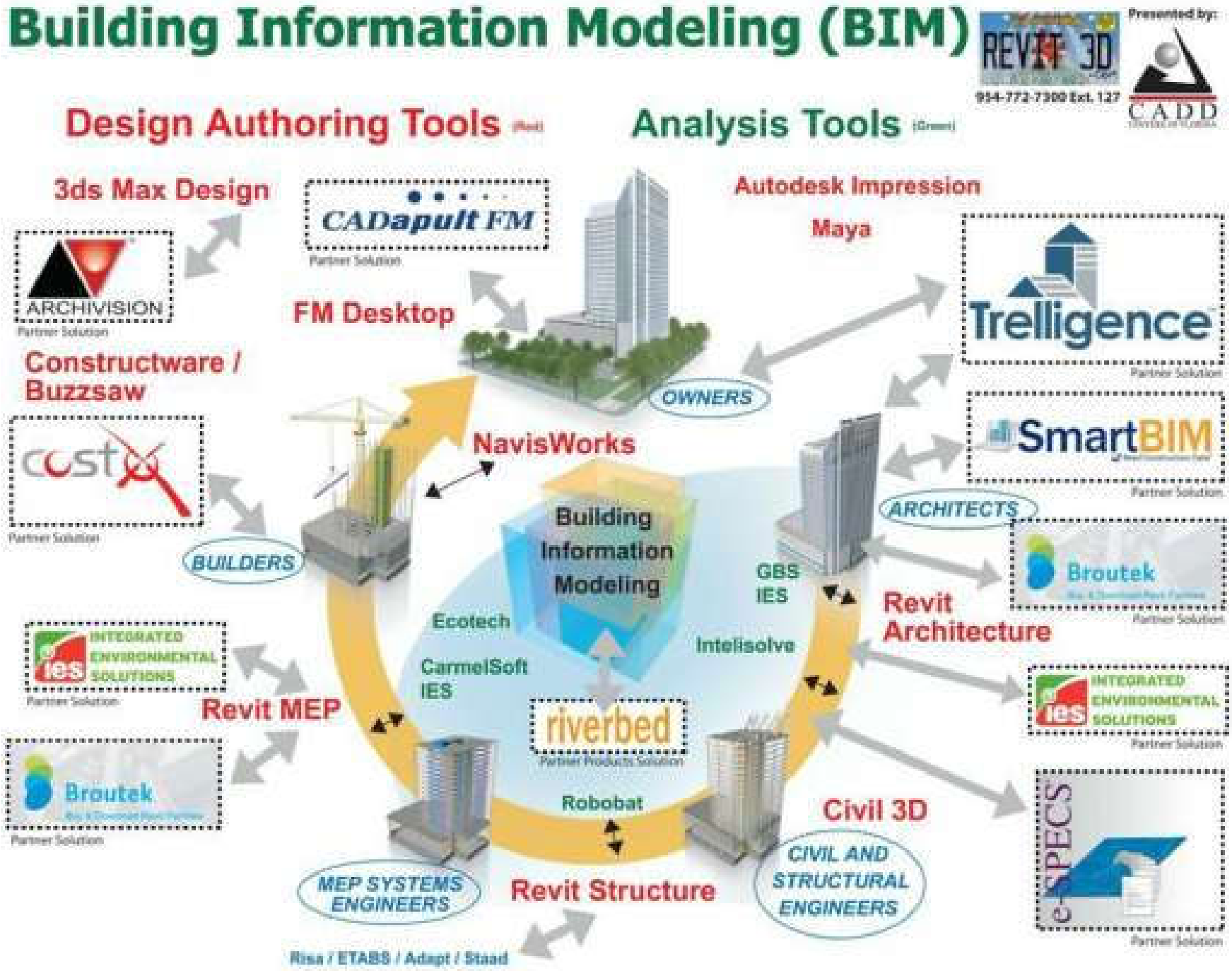
BIM software

- 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

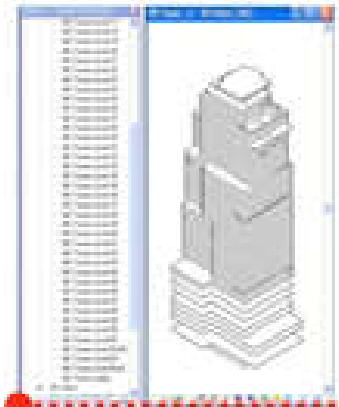
BIM software classification

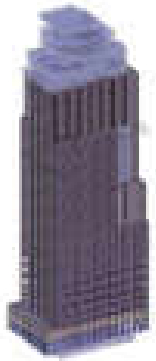
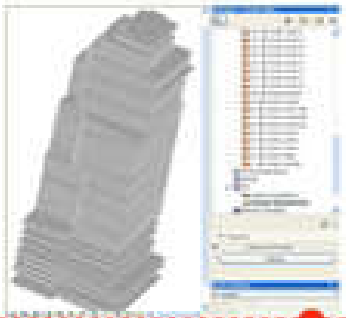
(Source: BIM Software guide https://www.buildingincloud.net/en/bim-software-guide/)

Design authoring and analysis tools for BIM

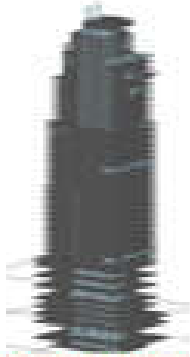


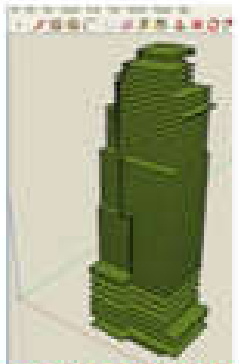
Examples of software tools for supporting the BIM process

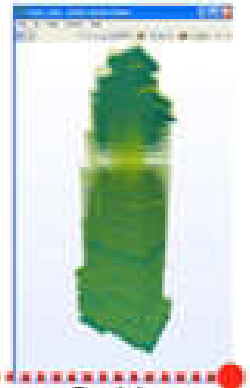

Revit Architecture & Structure
IFC



Archicad
IFC

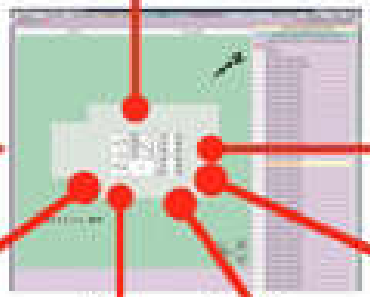

VectorWorks
IFC

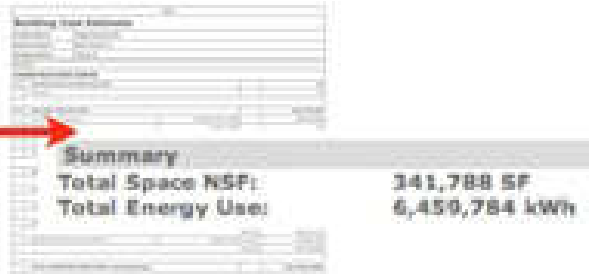

Nemetshek
IFC Viewer


SketchUP
IFC

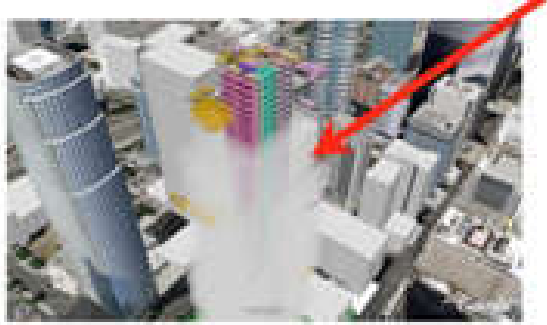

Solibri
IFC

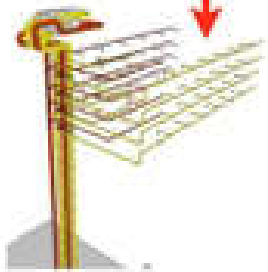

Excel

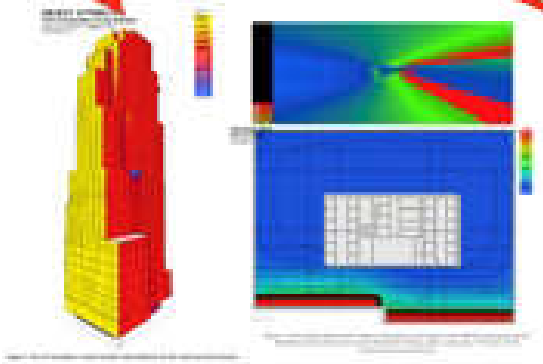

Onuma Planning System
IFC, KML, GBXML, CSV

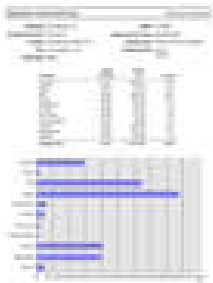


OPS Reports

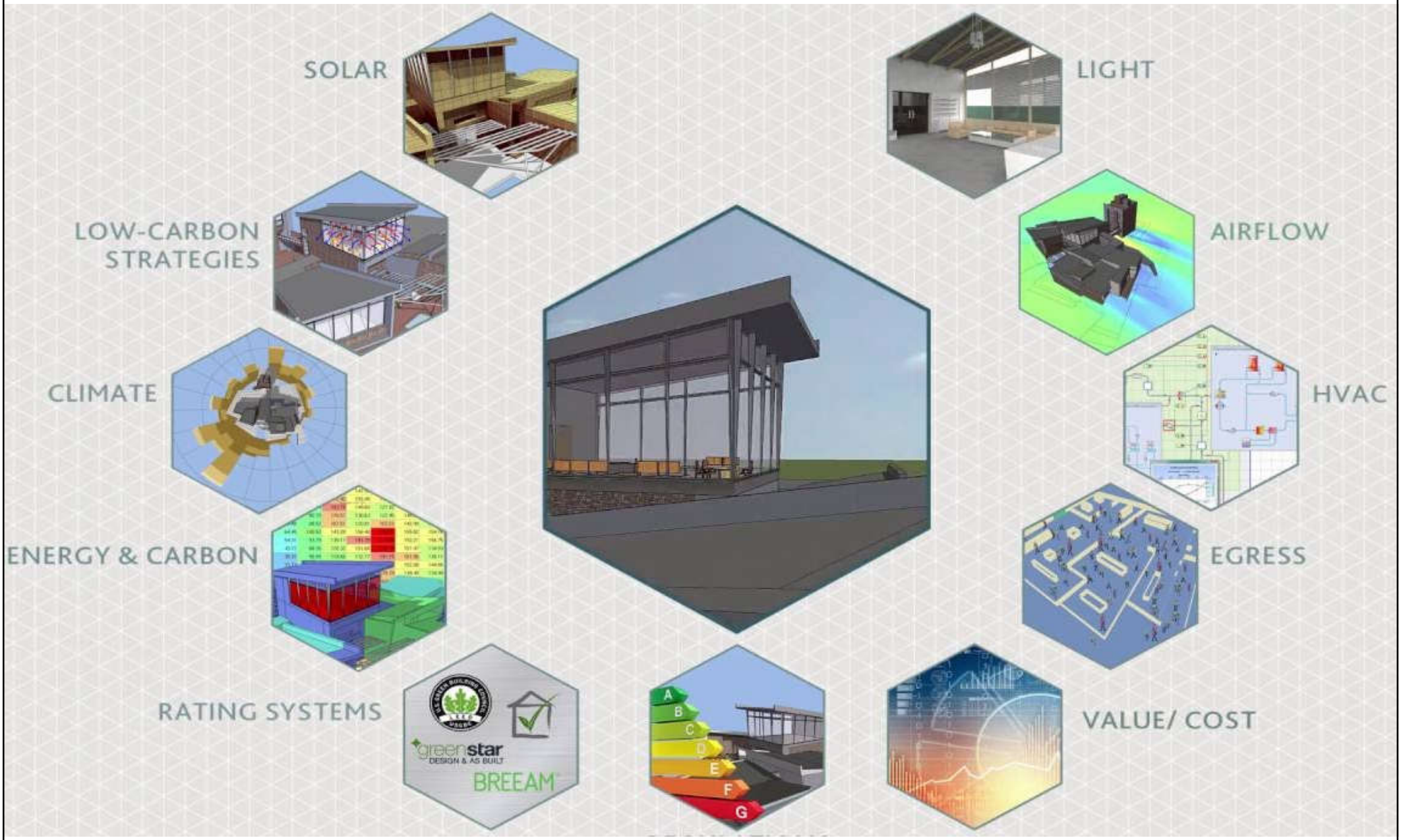

Google Earth - KML


Elite CAD
IFC


Ecotect
GBXML & IFC


Whitestone
O&M
PDF and Excel

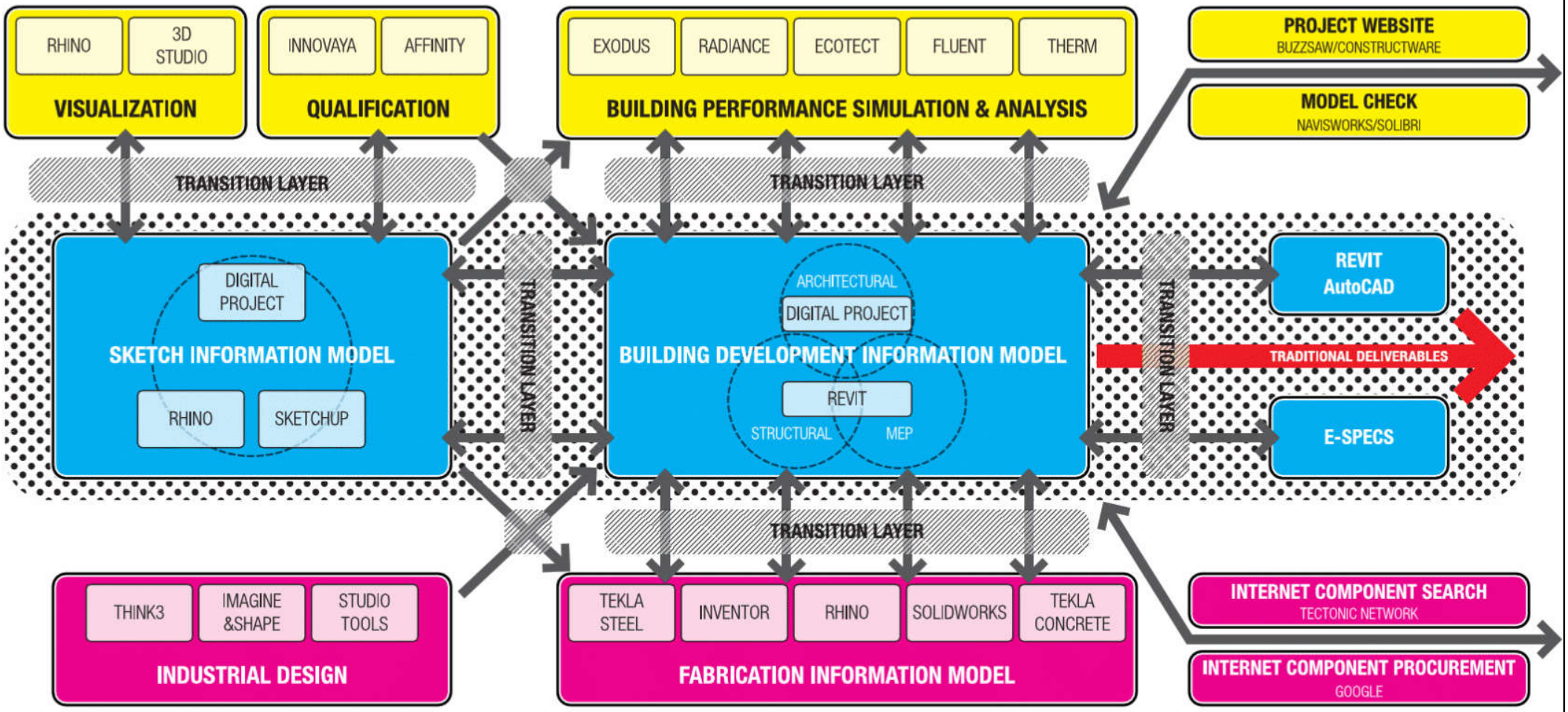
Analyses using software in the BIM process



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

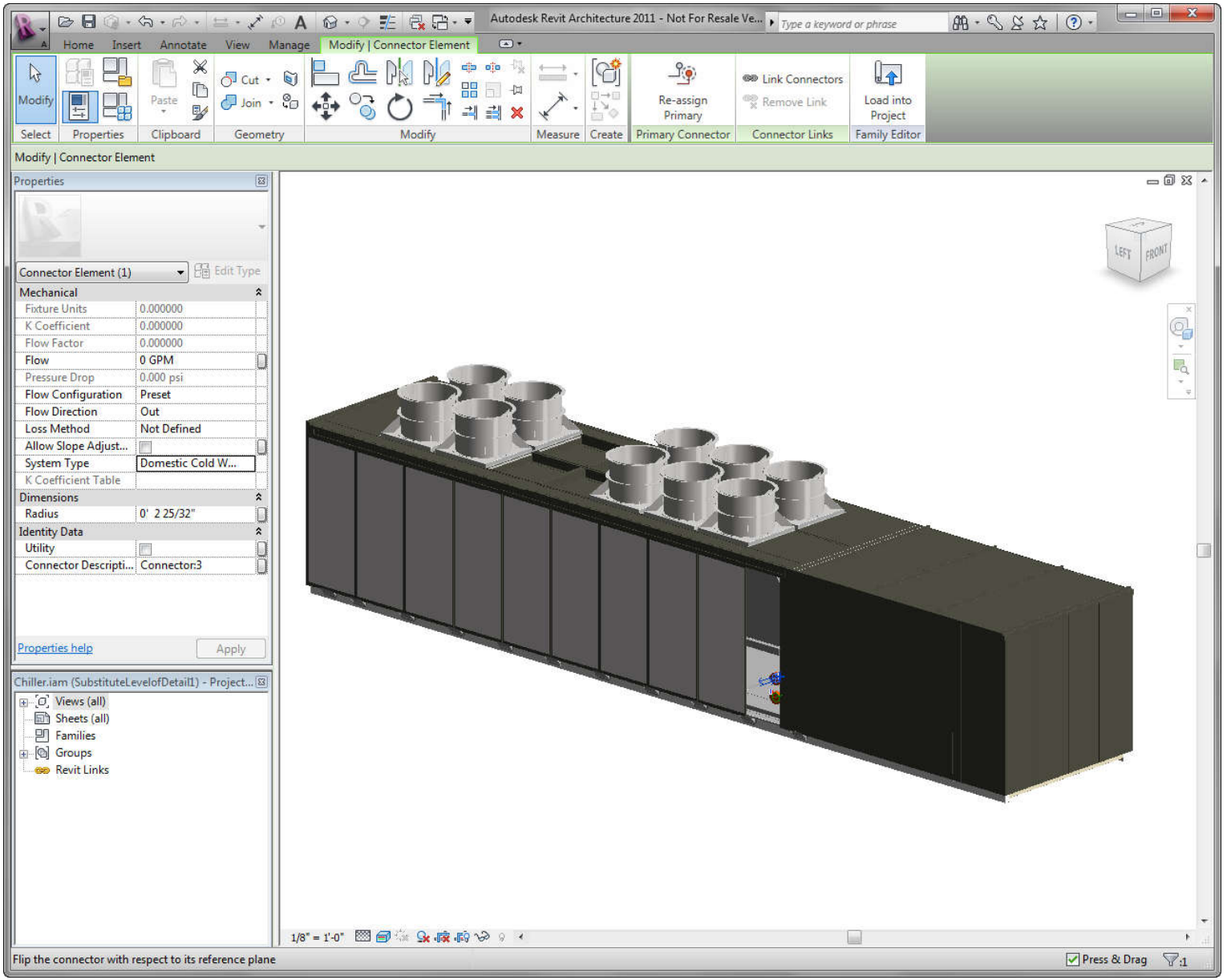
Typical BIM process and software tools



(Source: Garber, R., 2014. *BIM Design: Realising the Creative Potential of Building Information Modelling*)

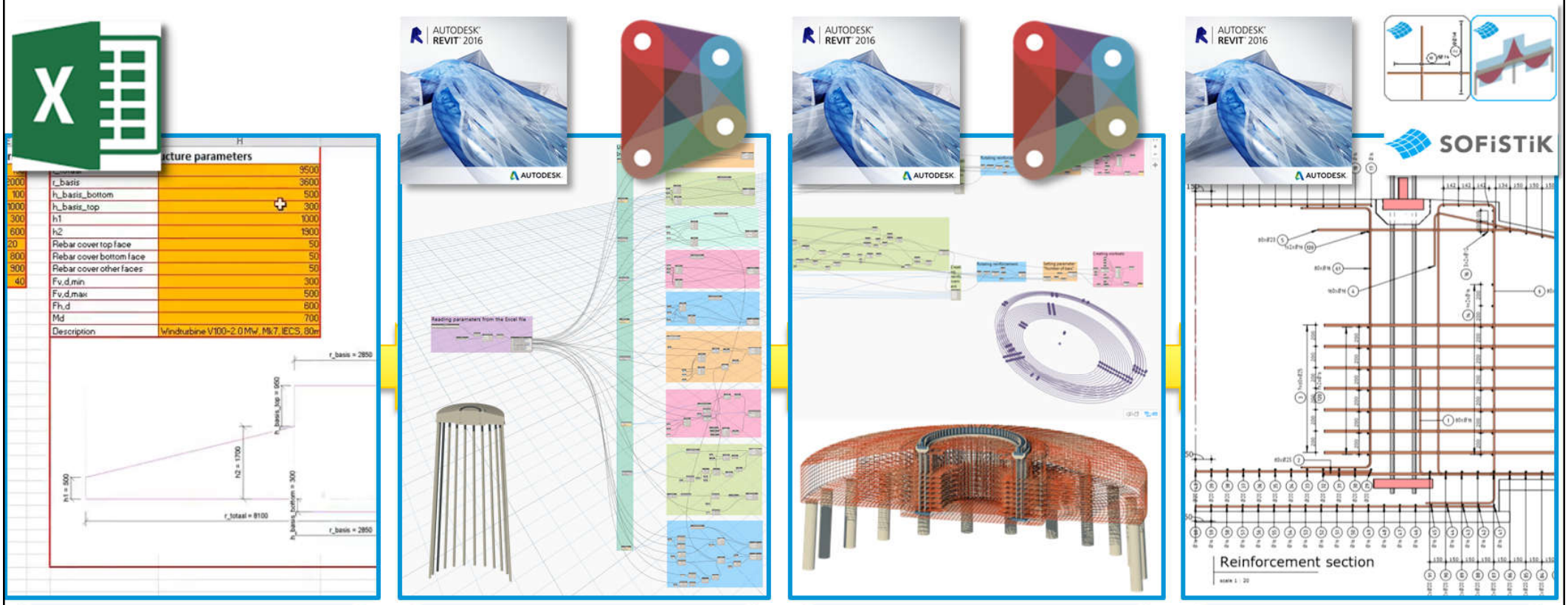
Part 6: Digital Prototyping and BIM - Inventor to BIM Demo

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)

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/

(Source: Autodesk)