Building Information Modelling (BIM) Training

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

1.2 Basic concepts of BIM

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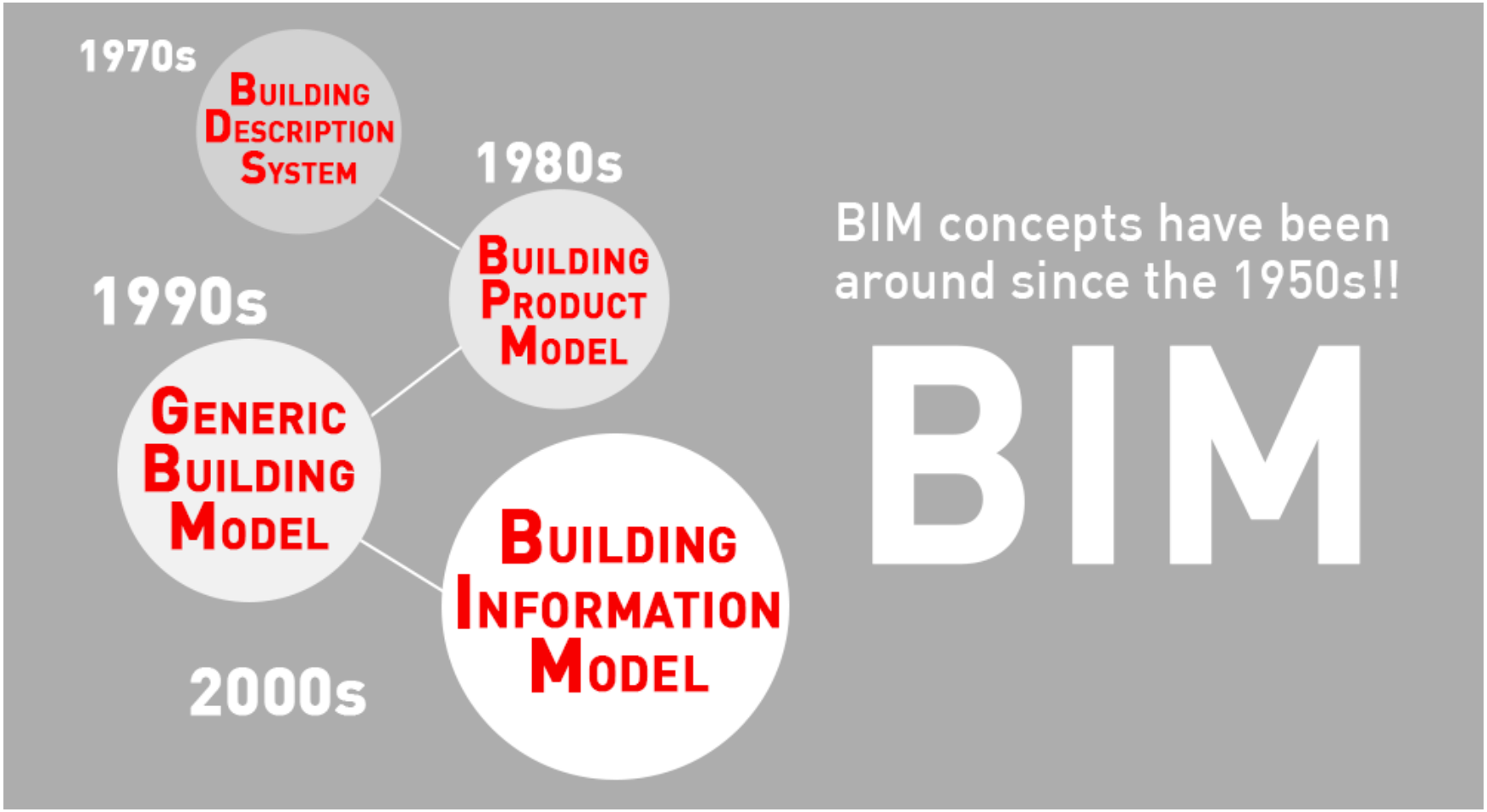
- History: From 2D to BIM
- BIM elements and standards
- BIM dimensions
- BIM maturity levels
- Level of development (LOD)

History: From 2D to BIM

- BIM concept has existed since the late-50s



(Source: If BIM's a Mystery, Here's the History! https://www.exactal.com/en/company/blog/if-bims-a-mystery-heres-the-history/)

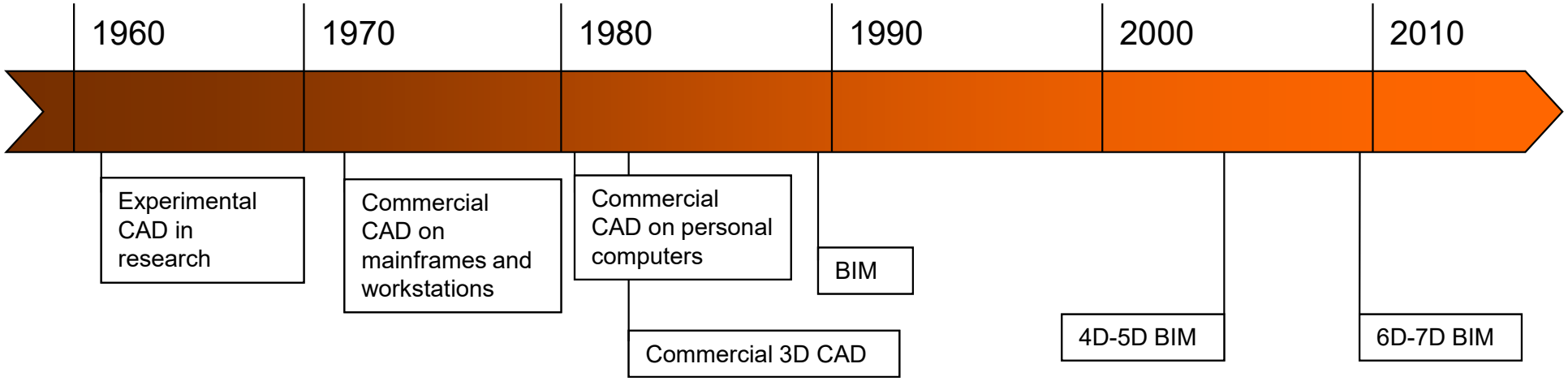
Evolution of AEC CAD

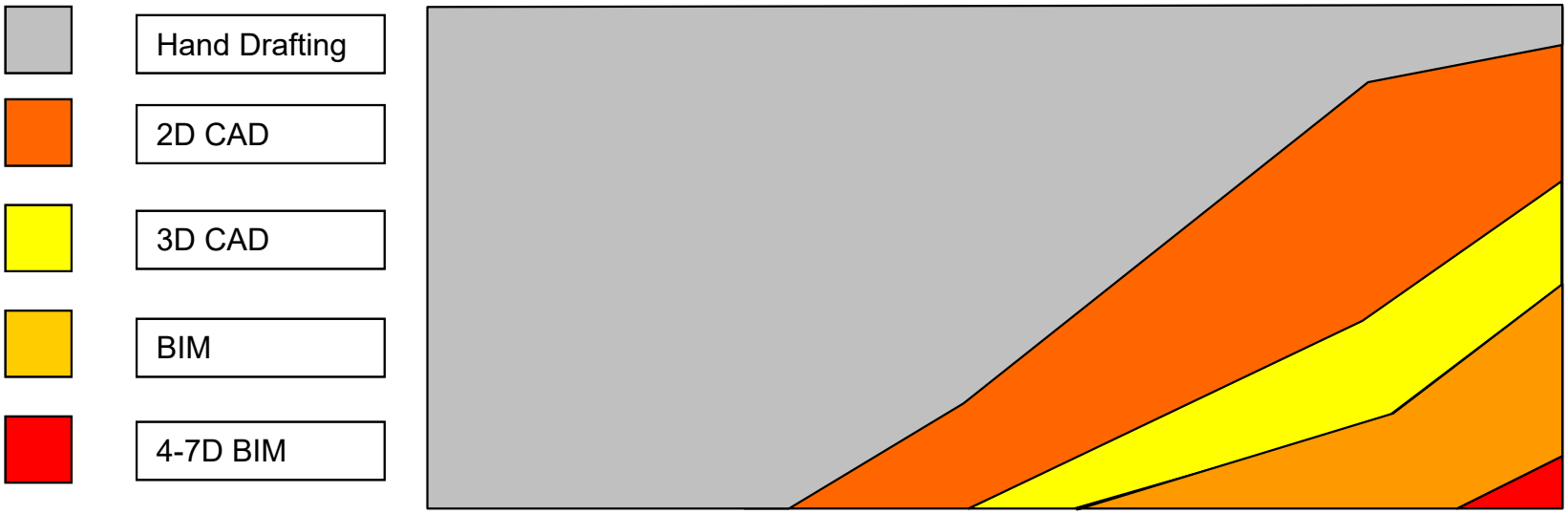
- 2D solutions
  - Electronic drafting board
- 3D solutions
  - Modeling for pure visualization purposes
- BIM solutions
  - Models with integrated architectural information
- 4D-5D BIM - Construction Coordination
  - Timing/scheduling and Cost estimation
- 6D-7D BIM
  - Facility Management and Life Cycle Management

(*AEC = Architecture, Engineering and Construction; CAD = Computer-aided Design)

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

AEC CAD Timeline





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

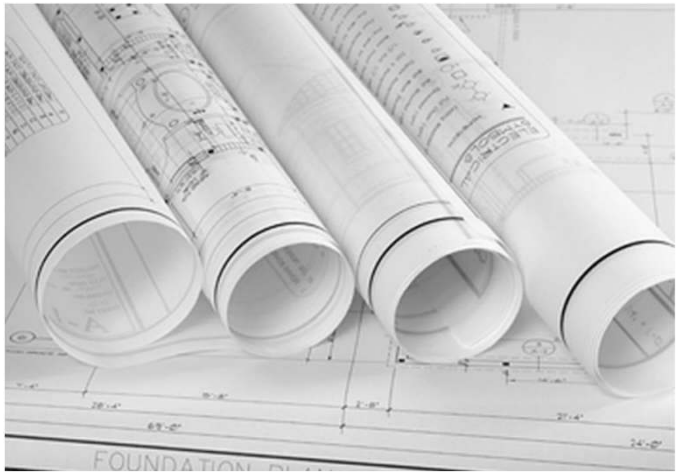
2D CAD - Workflow

- Design and document all in 2D
- No 3D model
- Drawings in separate files
- Manual coordination of drawings
- No visualization and calculation tools

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

2D CAD - Evaluation

Benefits



Compared to hand drafting

- Fast modifications
- Accuracy
- Intelligent drafting tools (fills, dimensions)
- Repetitive element handling (blocks, xrefs)

Compared to 3D CAD and BIM

- Simple working concept (electronic drafting)
- Relatively small file size (only 2D data)
- Workflow is applicable for all building types

Drawbacks

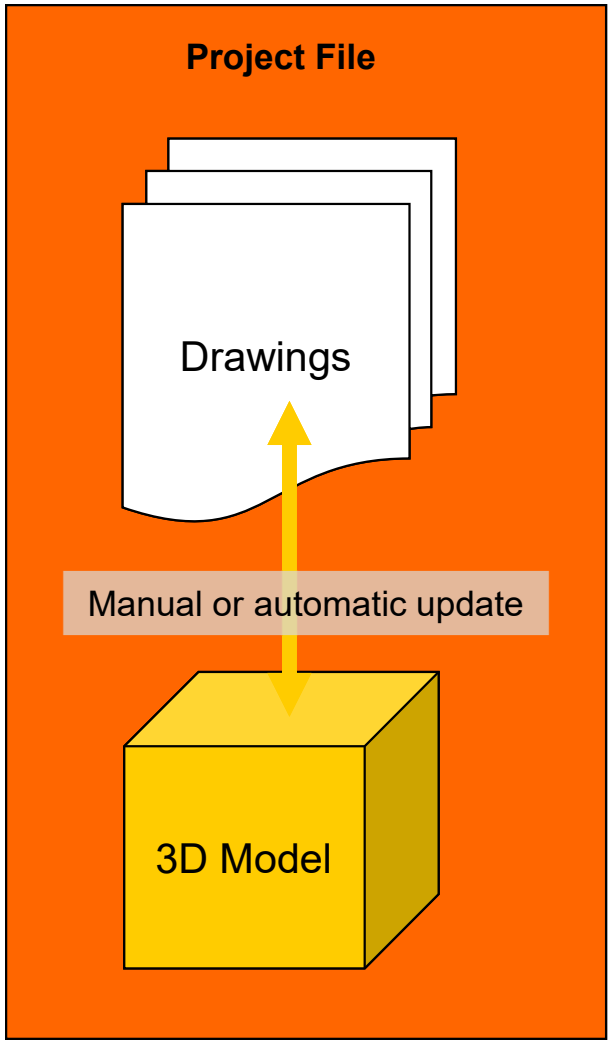
Compared to 3D CAD and BIM

- Drawings are not coordinated automatically
- No 3D visualization
- No automatic calculations, quantity take-offs or schedules
- No collision detection

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

3D CAD - Workflow

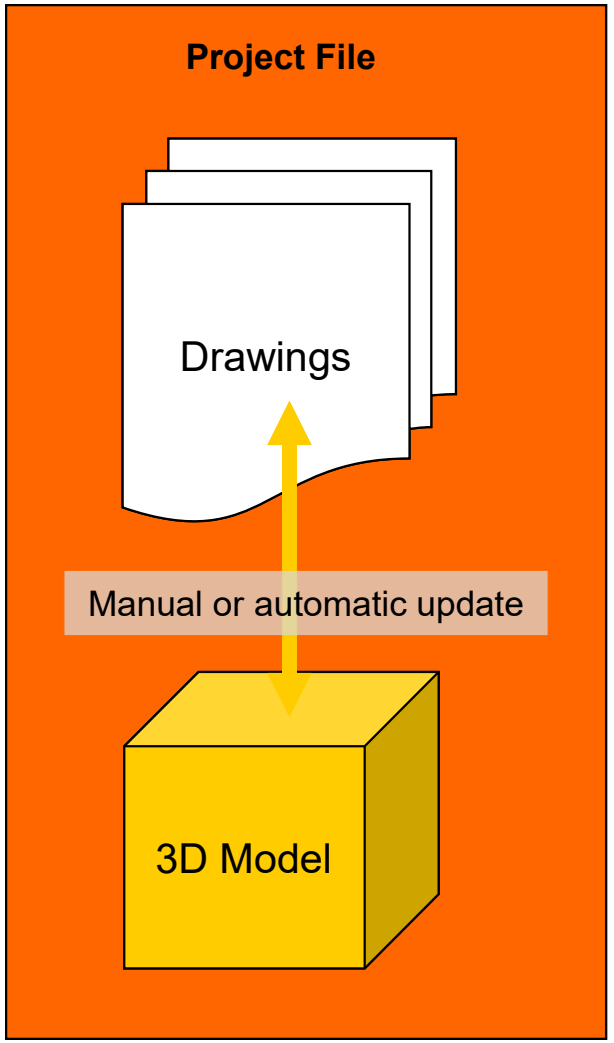
- CAD application has 2D & 3D capabilities
- Buildings can be modeled in 3D
- 3D and 2D information can be included in one file
- Drawings are (partially) derived from the model
- No automatic documentation
- Applications mostly works with 2D and 3D tools instead of real architectural elements
- Basic visualization and calculation tools



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

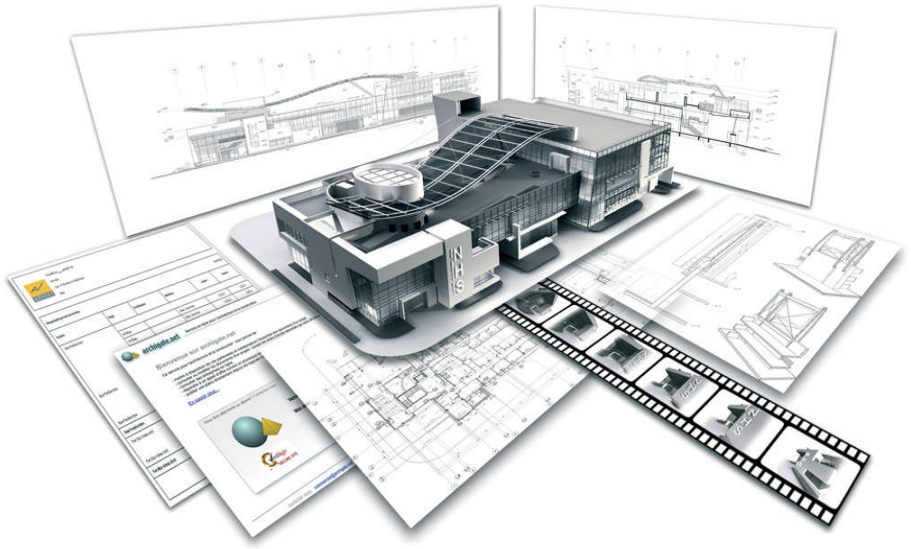
3D CAD - Evaluation

- **Benefits**
  - Compared to 2D CAD
    - Easier identification of design problems
    - Faster change management
    - Visualization and calculation capabilities
  - Compared to BIM
    - 3D modeling is optional
    - Smaller file size
- **Drawbacks**
  - Concept doesn't follow the architectural design process
  - No automatic documentation
  - No real architectural elements



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

The BIM Concept



NHS Office, www.paastudio.com

BIM = **B**uilding **I**nformation **M**odeling

Also known as „Virtual Building" or „Building Simulation"

Drawings, model views, visualizations, calculations and quantity take-offs are automatically derived from the 3D model.

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

BIM - Workflow

- Single file concept:
- The complete building model and all of it's representations are included in the virtual building file

- Real architectural elements used for modeling

- Changes of the model affects all drawings, and vice versa

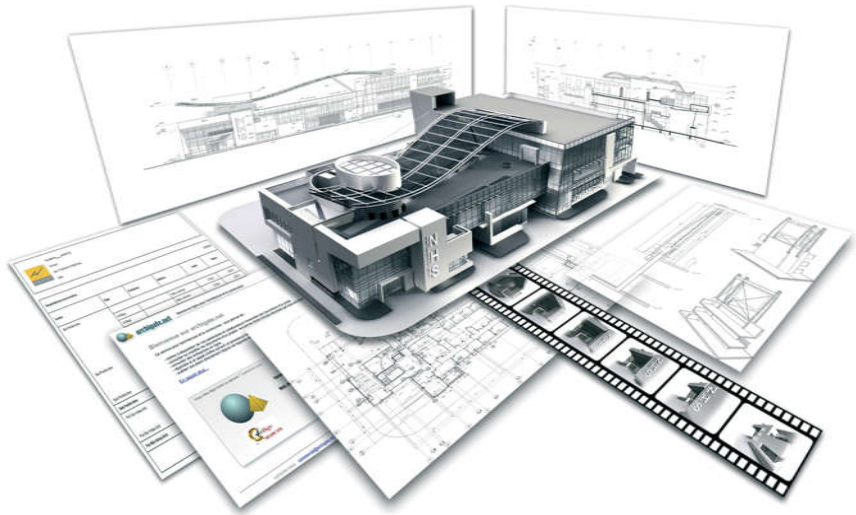
- Automatic documentation workflow

- Rich architectural content (libraries)

- Building information data attached to
- the elements

- Internal visualization tools

- Calculations, schedules



NHS Office, www.paastudio.com

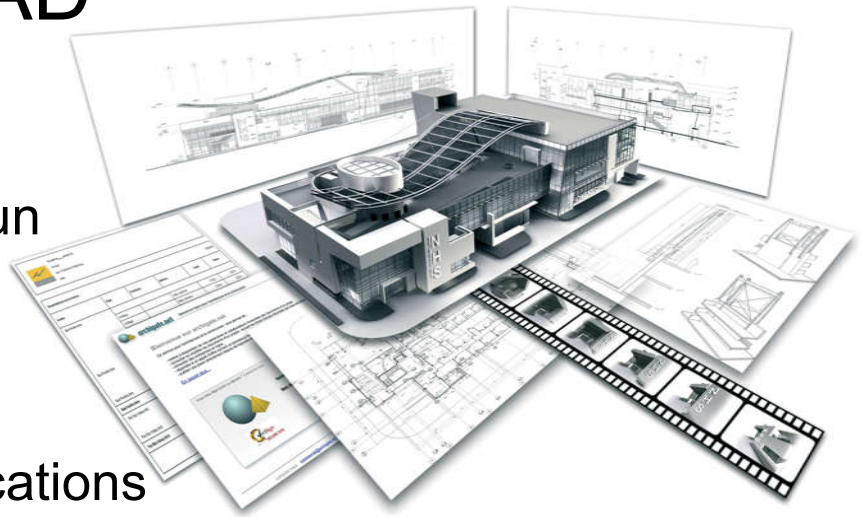
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

BIM - Evaluation

Benefits

Compared to 2D and 3D CAD

- Real architectural elements
- Automatic drawing coordination
- Rich visualization content (animation, sun studies, renderings etc.)
- Automatic quantity take-offs, schedules
- Connection to structural, MEP, energy calculation and collision detection applications



NHS Office, www.paastudio.com

Drawbacks

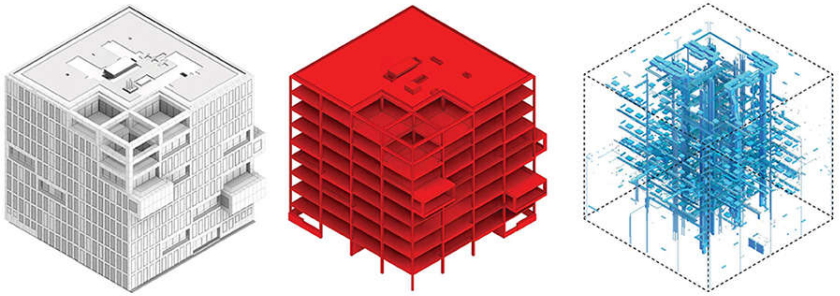
Compared to 2D and 3D CAD

- Might be difficult to learn the BIM approach for 2D cross-graders
- Training requirements

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

BIM elements and standards

- Typical elements:
  - Architecture, MEP (Building Services), Structure
- Information:
  - Model based documentation
  - Calculations and analyses

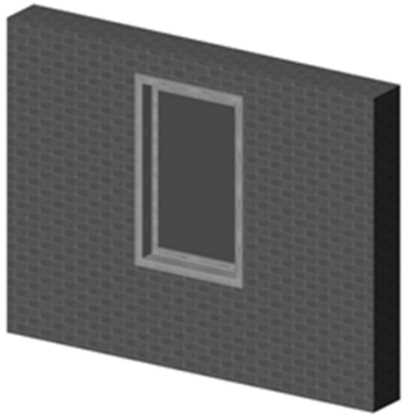


- Collaboration:
  - External, internal, teamwork
- BIM Standards, e.g. in UK, USA and HK

BIM - Real Architectural Elements

Drawing representation

- Floor plan, section and elevation views
- Adjustable contours, fills, backgrounds
- Scale sensitivity

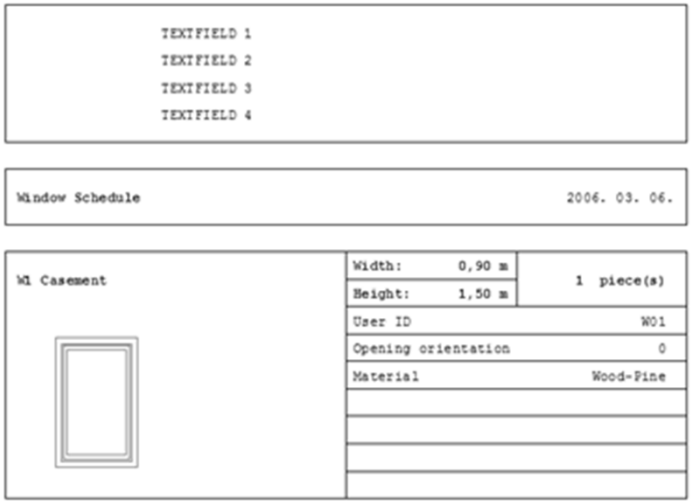


Model representation

- 3D shapes connected to drawing element
- Surface color and texture

Non-graphical information

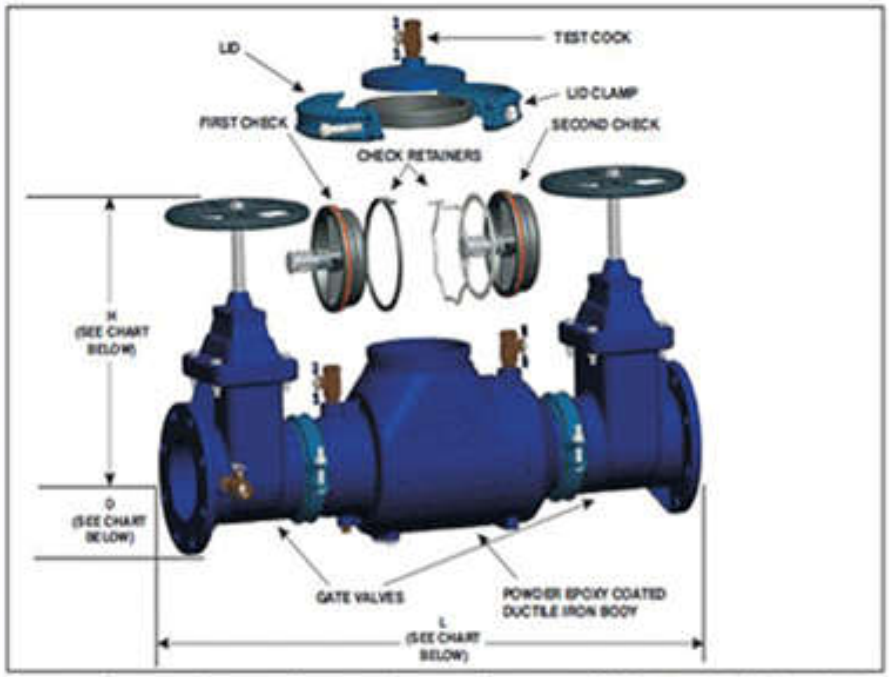
- Material descriptions
- Quantities, volumes
- Cost



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

Example of MEP (Building Services) elements: A control valve

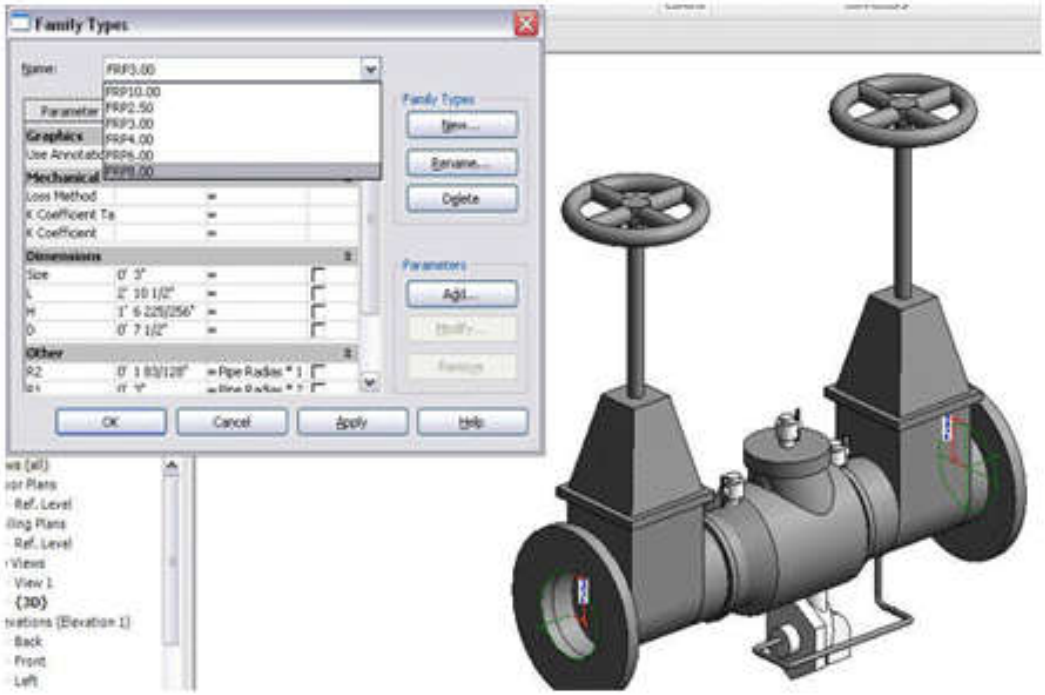
INPUT



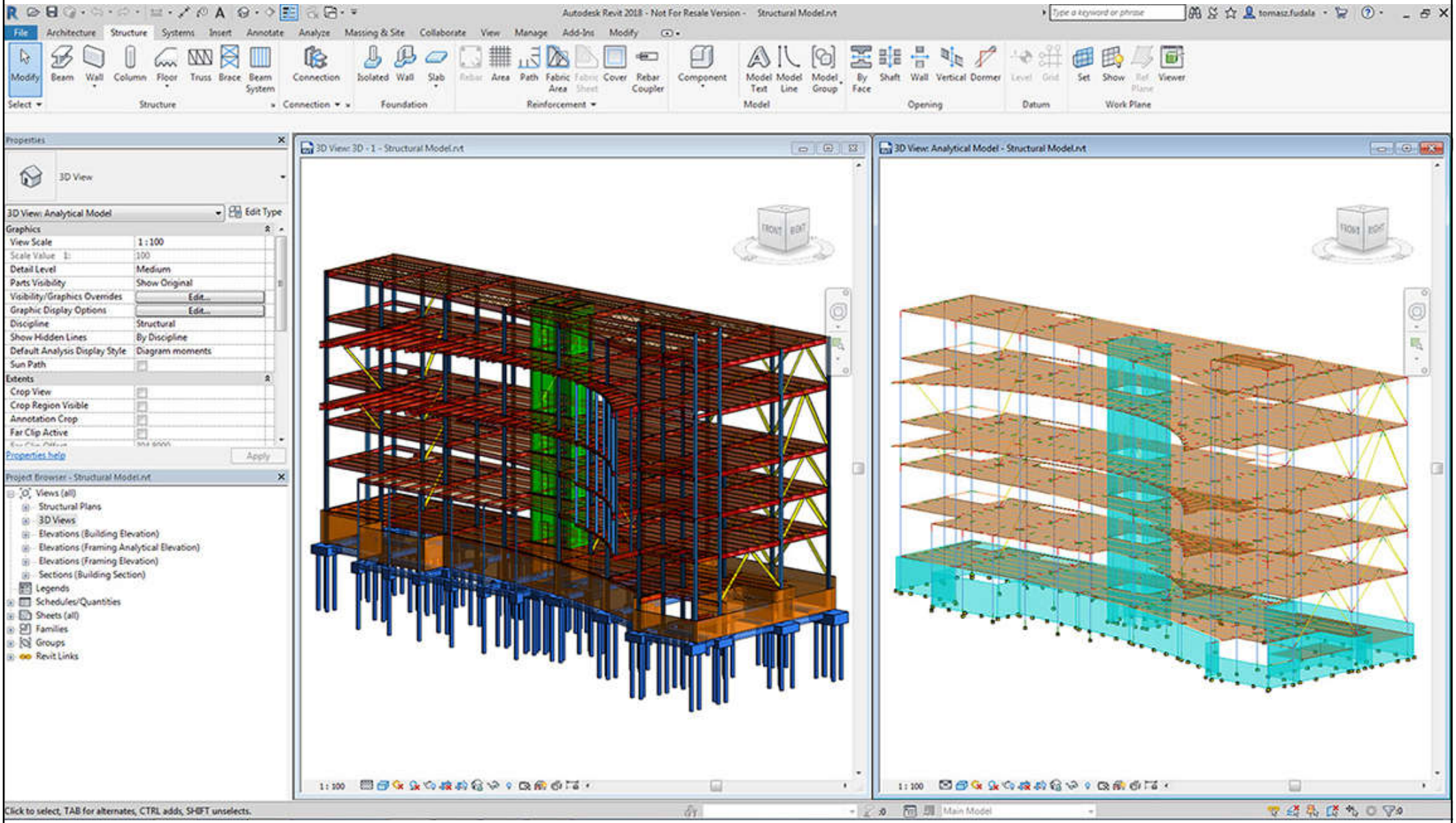
Model No.	Size	L	H OSY OPEN	H NRS	D
FDC2.50	2 1/2"	33.5	18.88	16.38	7
FDC3.00	3"	34.5	21.88	18.88	7.5
FDC4.00	4"	40.8	25.63	21.63	9
FDC6.00	6"	43.8	35.13	29.13	11
FDC8.00	8"	56.5	44.63	36.63	13.5
FDC10.00	10"	59.5	54.5	44.5	16

OPTIONAL VARIATIONS:	SUFFIX
☐ Non Rising Stem Gate Valve	-NRS
☐ Outside Stem and Yoke Gate Valve	-OSY
☐ Meets Buy America and Pennsylvania Steel Act	-BA
☐ Strainer attached	-S
☐ Double Check Detector Assembly	-DCDA
☐ Grooved Flange Connection	-G
☐ No Gate Valves	-LF

OUTPUT



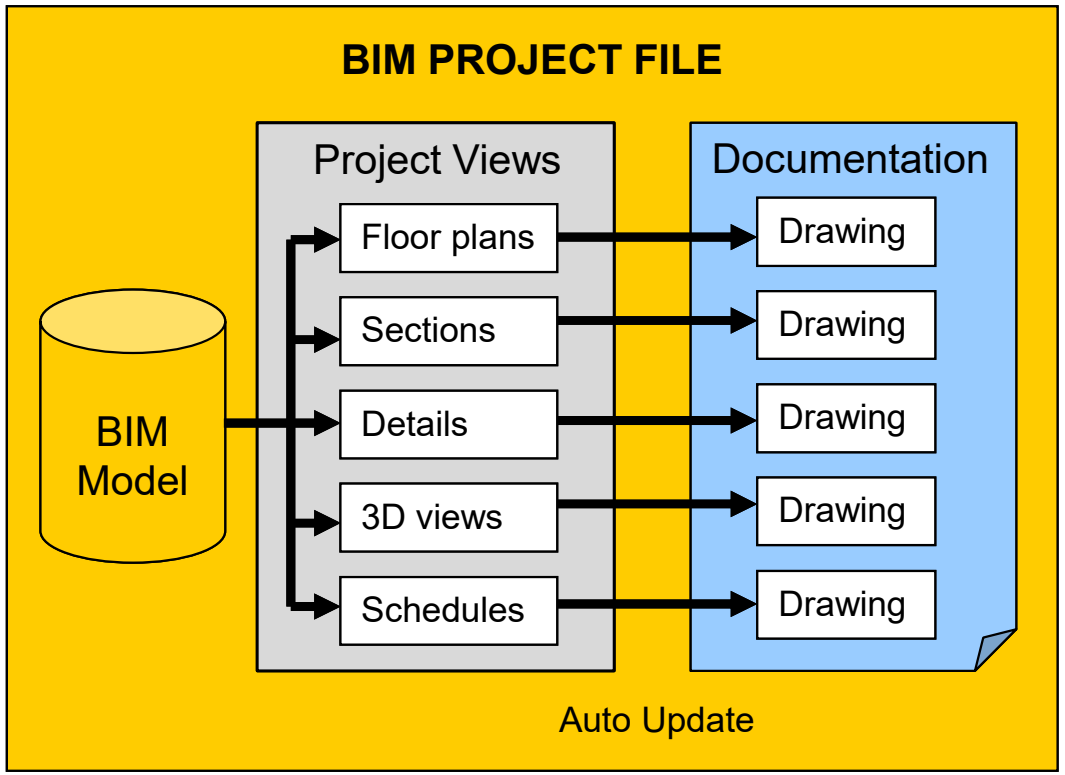
BIM structure elements and structural analysis



(Source: Autodesk Revit Structure)

BIM - Model Based Documentation

- Coherence between model and drawing
- All drawings derived from the model
- Model coordinates drawings
- Scale sensitive elements
- The complete project lifecycle can be controlled from a single file
- Rich 3D visualization content



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

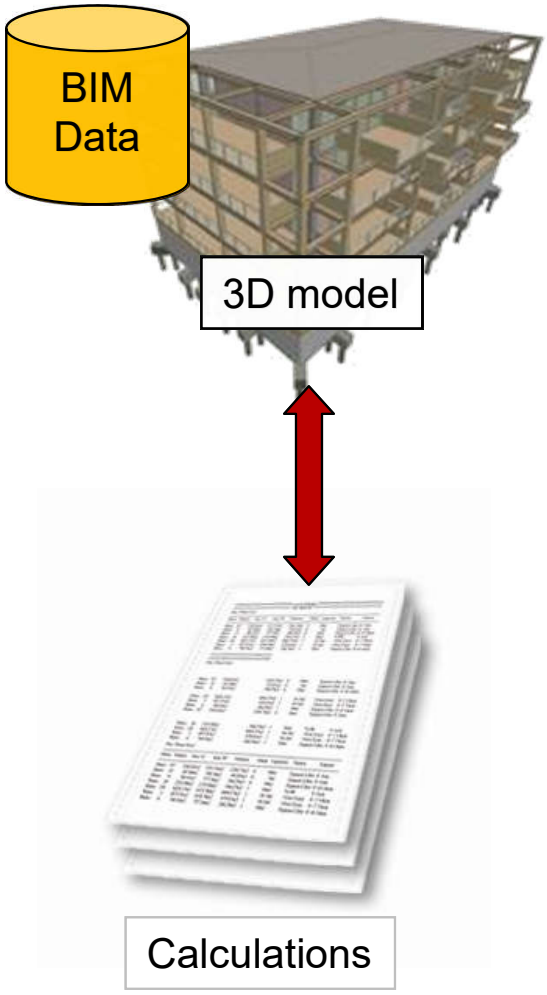
BIM - Calculation

Additional information attached to a model

- Quantity
- Materials
- Descriptions
  - Product details
  - Construction details
  - Safety details
- Cost

Instant Calculation

- Quantity takeoffs
- Room Inventories
- Door & Window schedules



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

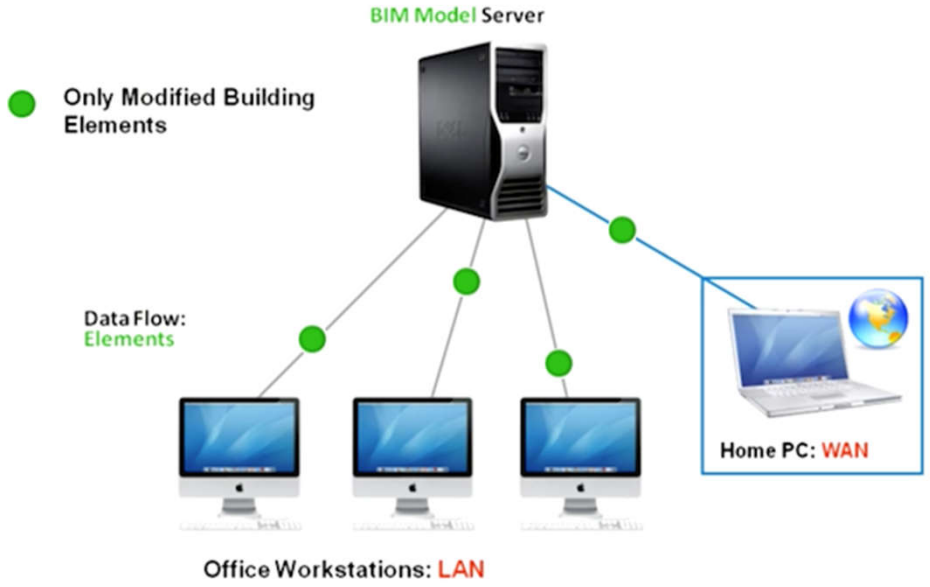
BIM - Collaboration

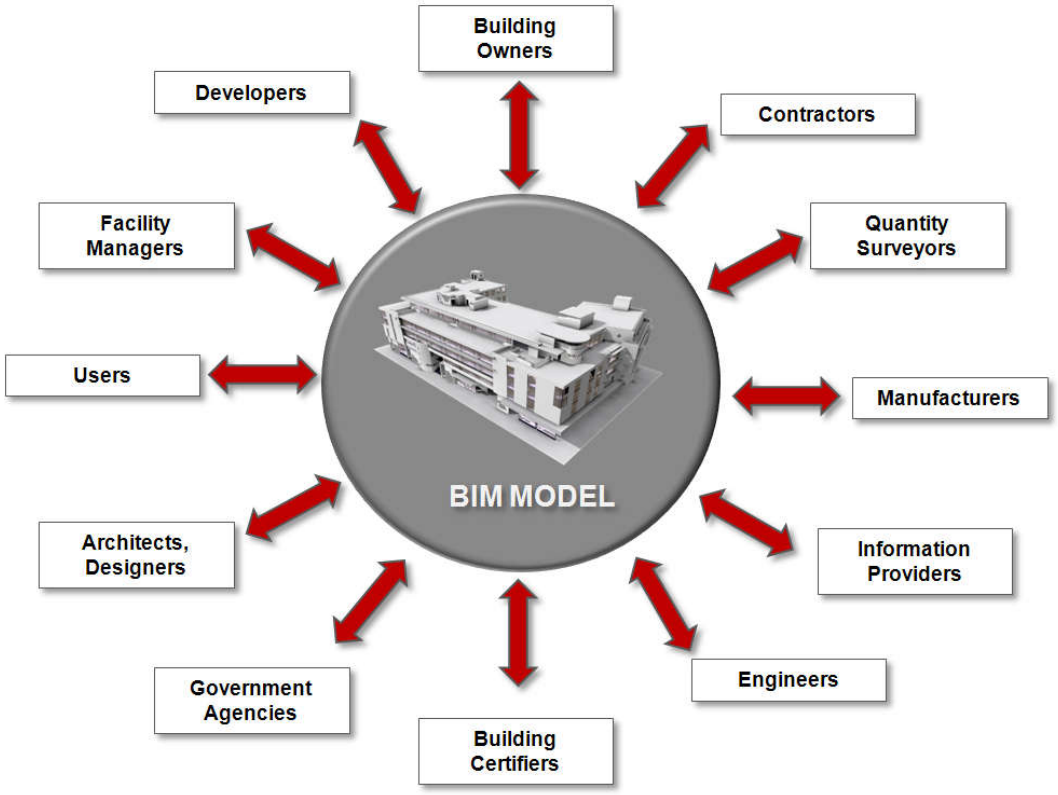
The AEC industry is moving toward integration of disciplines.

The collaborative mode will become a standard approach.

Collaboration solutions in BIM:

- Internal Collaboration
- External Collaboration



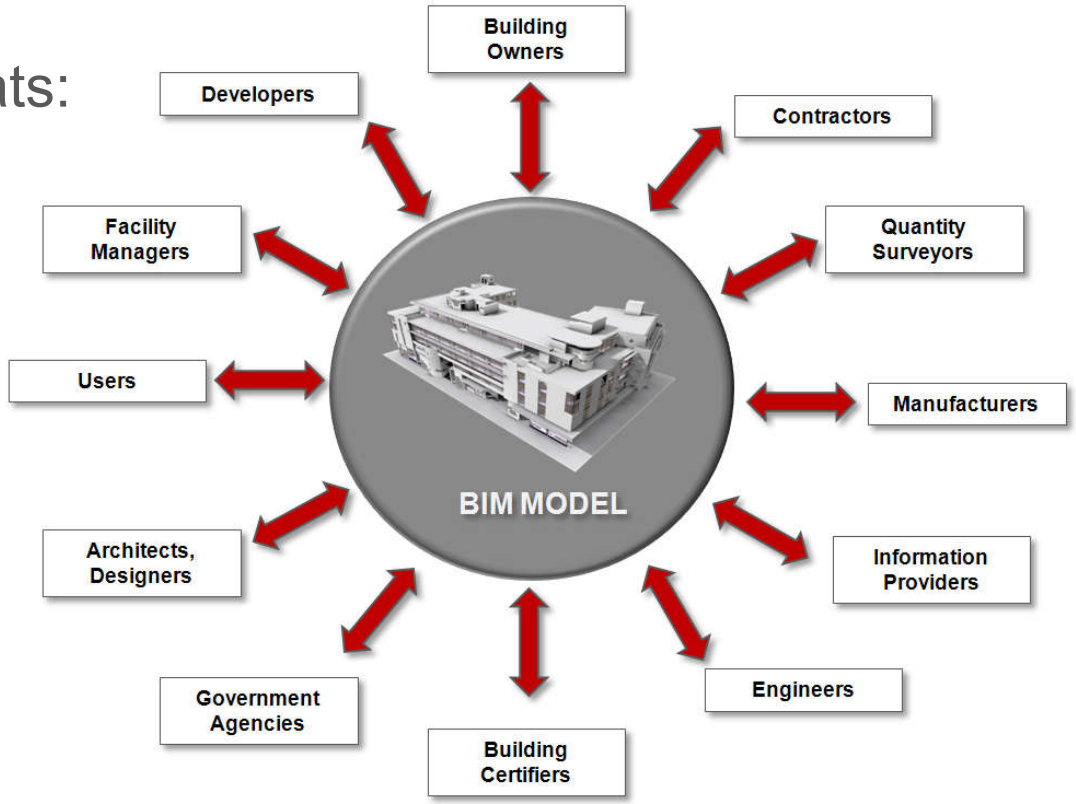


(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

BIM - External Collaboration

BIM applications allow the sharing of building data with the project stakeholders via many file formats:

- IFC
- DXF-DWG
- PDF
- XML
- Native file formats
- ……



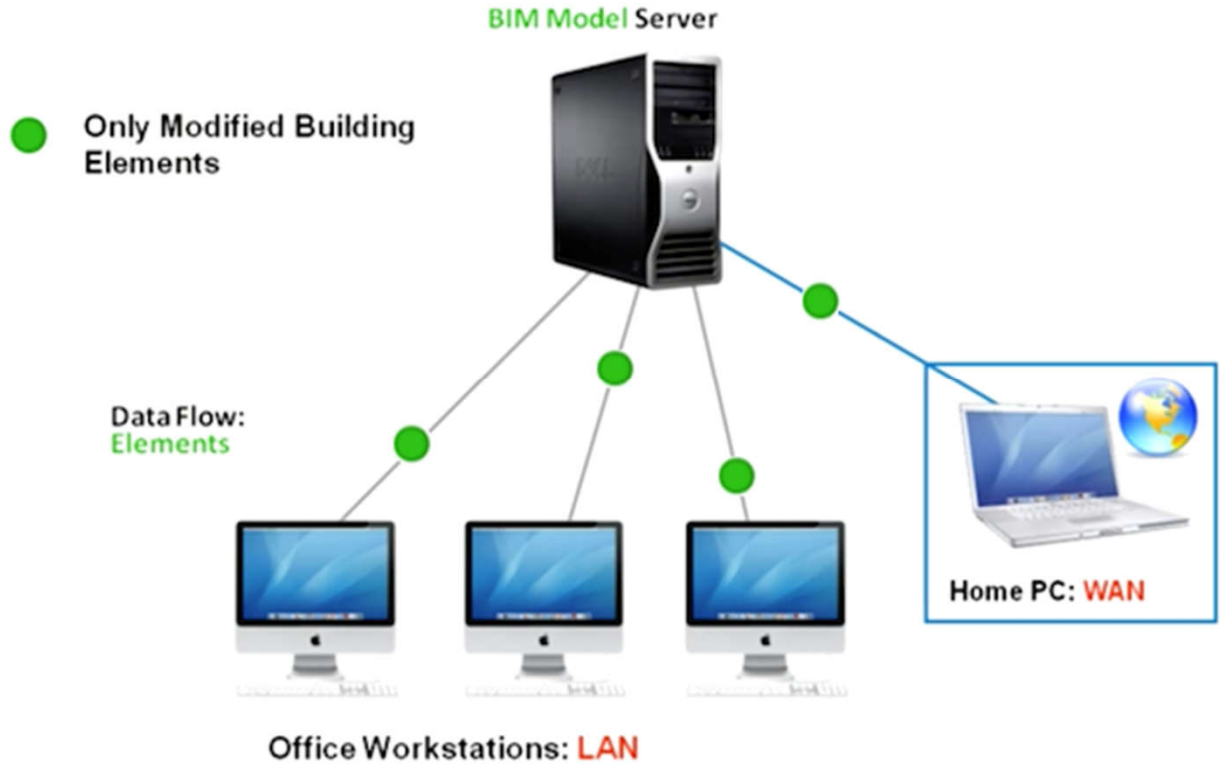
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

BIM - Internal Collaboration

Advanced BIM applications allow the seamless sharing of the virtual building data between the project team members

The most common project sharing methods are:

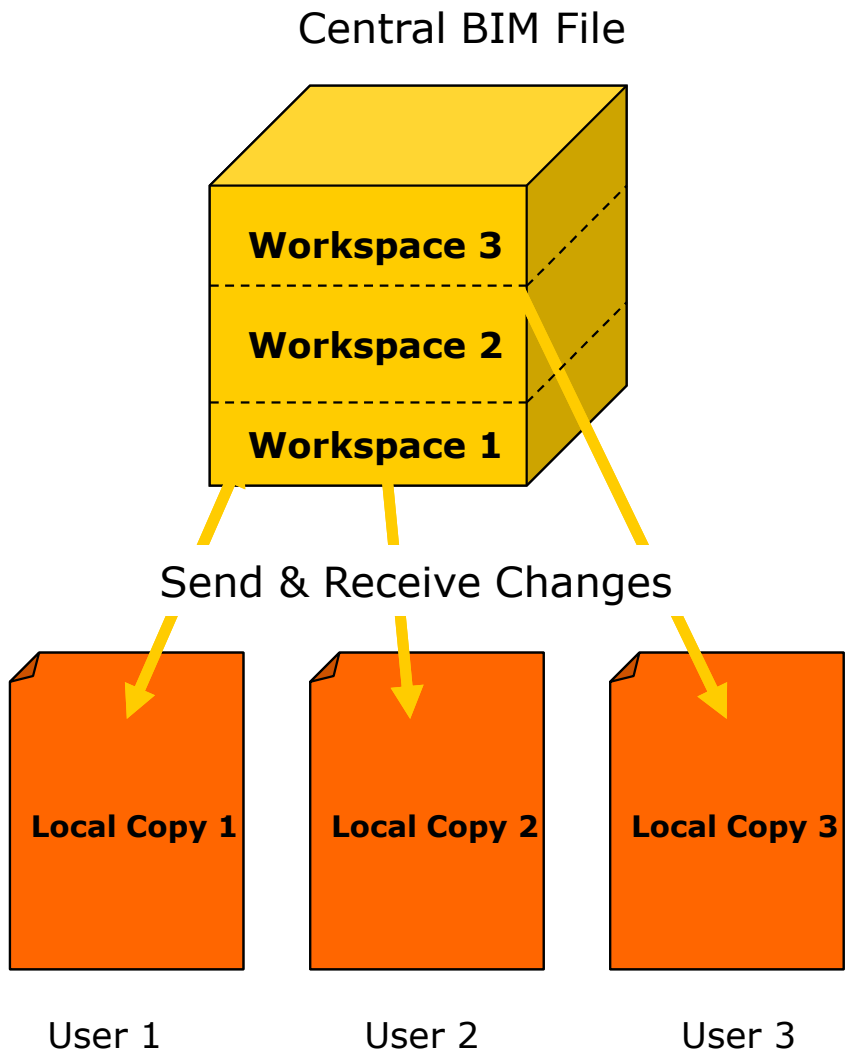
- Hotlinked file methods
- File-server based teamwork solutions
- Client-server based teamwork solutions



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

BIM - Teamwork

- Teamwork solutions in BIM applications are usually based on the following concept:
  - Central file contains the complete virtual building database
  - Team members work on local copies of the project
  - Team members have dedicated workspaces
  - Team members send and receive changes between the server and their local project copies

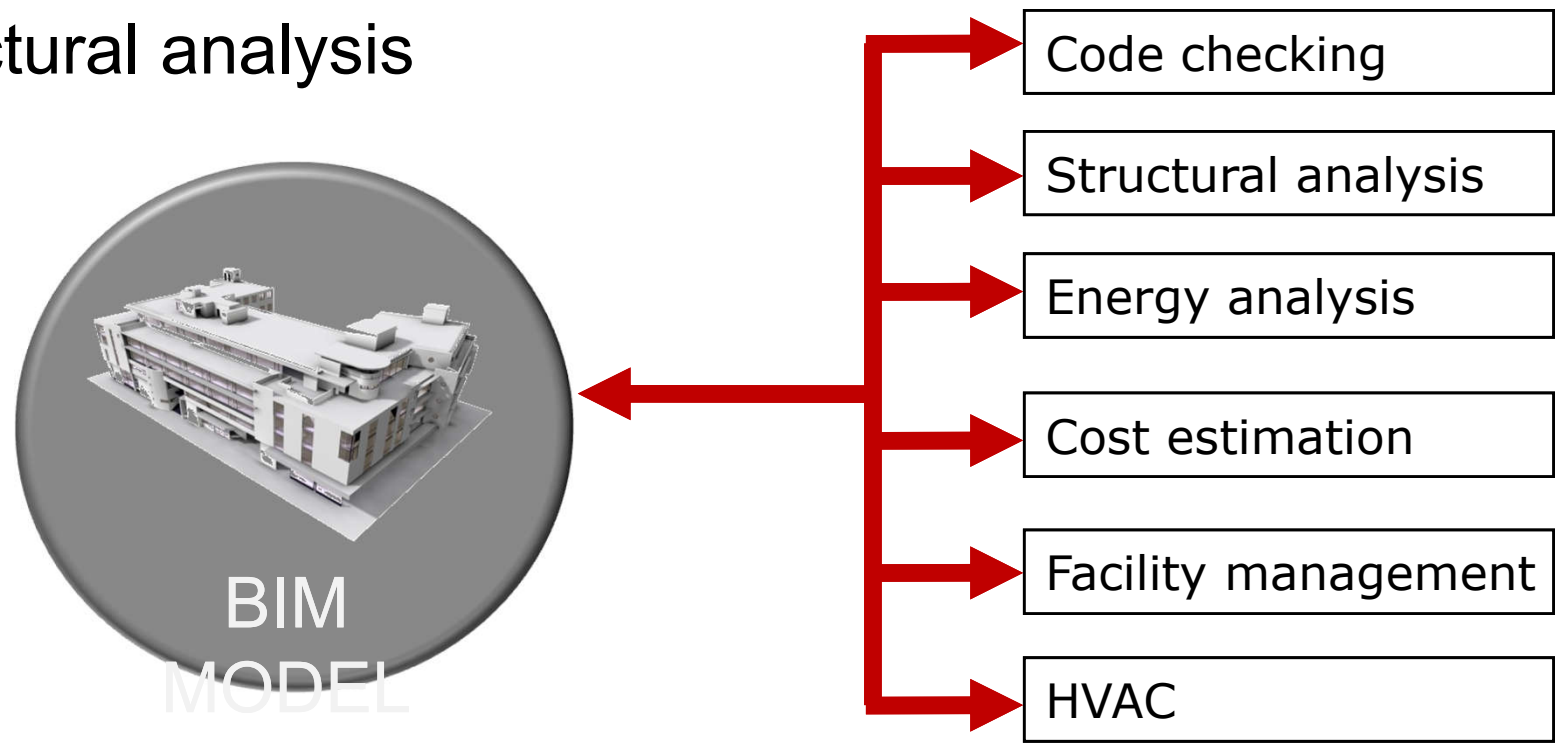


(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

BIM - Analysis, Coordination

Further processing the BIM data in third party applications allows a wide range of analytical activities:

- Code checking (collision detection)
- Energy efficiency analysis
- Structural analysis



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

BIM - AEC CAD standards

- *BS 1192* (British Standards) widely used in the UK
- *AIA CAD Layer Guidelines* is widespread in the U.S.
- *Uniformat* is a U.S. standard for the organization of building elements
- *ISO 13567* International standard, common in Northern Europe

U.S. National CAD Standard (NCS) - layer name format

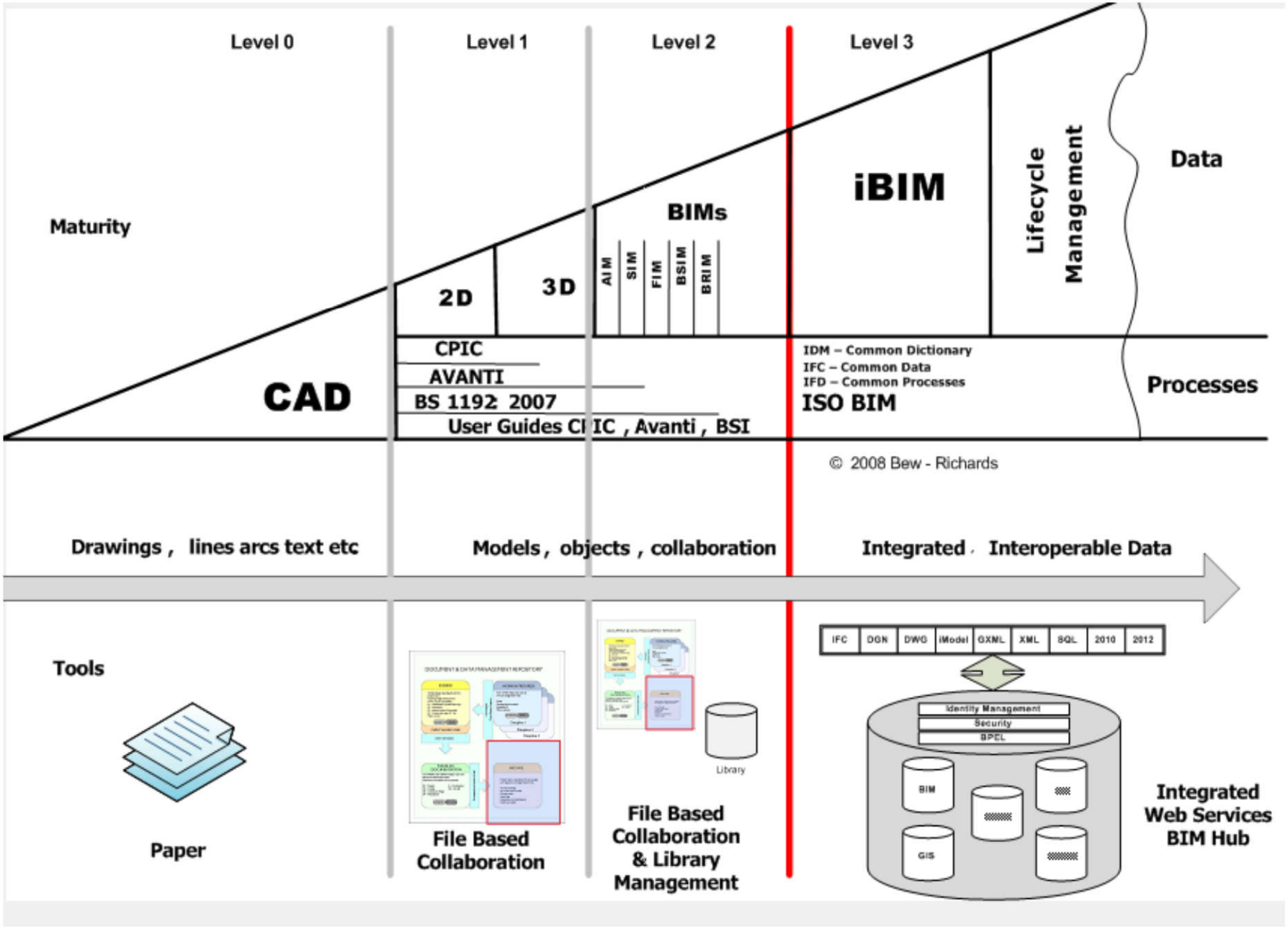
Discipline			Major Group					Minor Group					Minor Group					Status
A	I	-	W	A	L	L	-	F	U	L	L	-	D	I	M	S	-	N

AEC (UK) CAD Standard - layer name format

Role		Classification				Presentation		Description						View
A	-	G	2	2	-	M	-	F	l	o	o	r	-	Fwd

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

BIM - AEC (UK) BIM standards



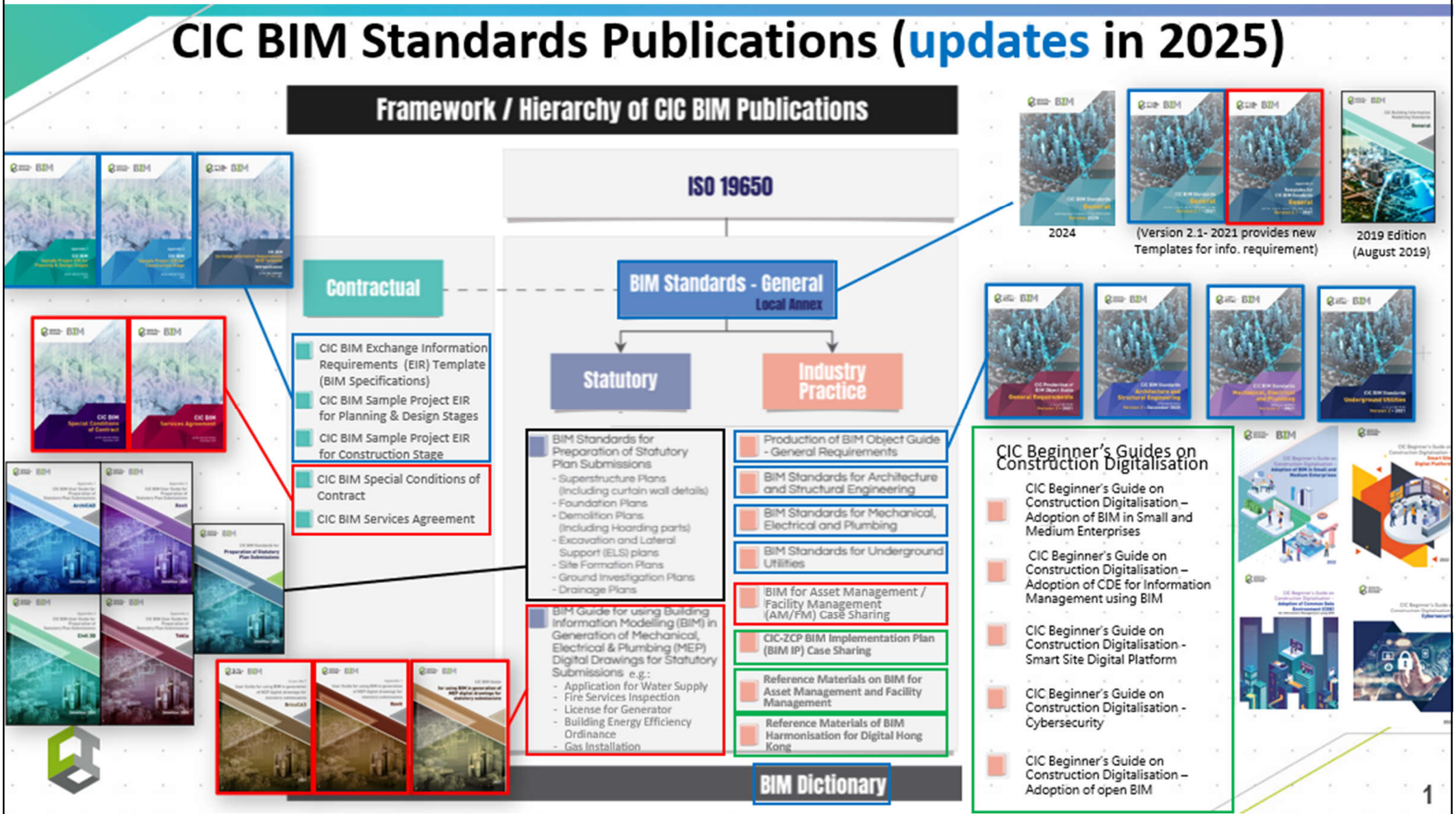
[Source – M.Bew and M.Richards 2008]

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

BIM elements and standards

- Common protocols and standards:
  - PAS 1192-2 Specification for information management for the capital/delivery phase of construction projects using Building Information Modelling
  - PAS 1192-3 Specification for information management for the operational phase of construction projects using building information modelling
  - Industry Foundation Classes (IFC)
  - COBie (Construction Operations Building Information Exchange)

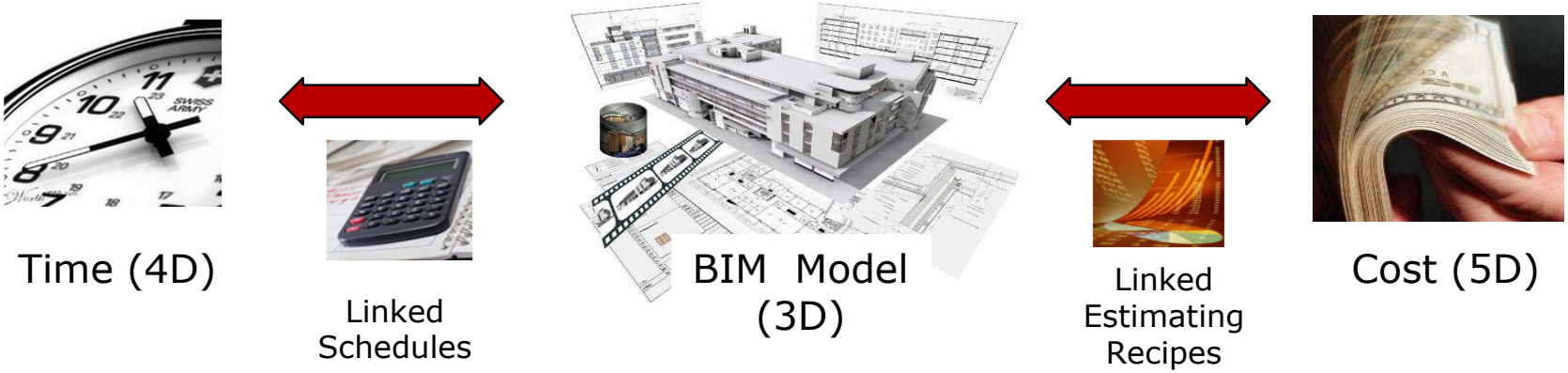
BIM standards in Hong Kong (from Construction Industry Council)

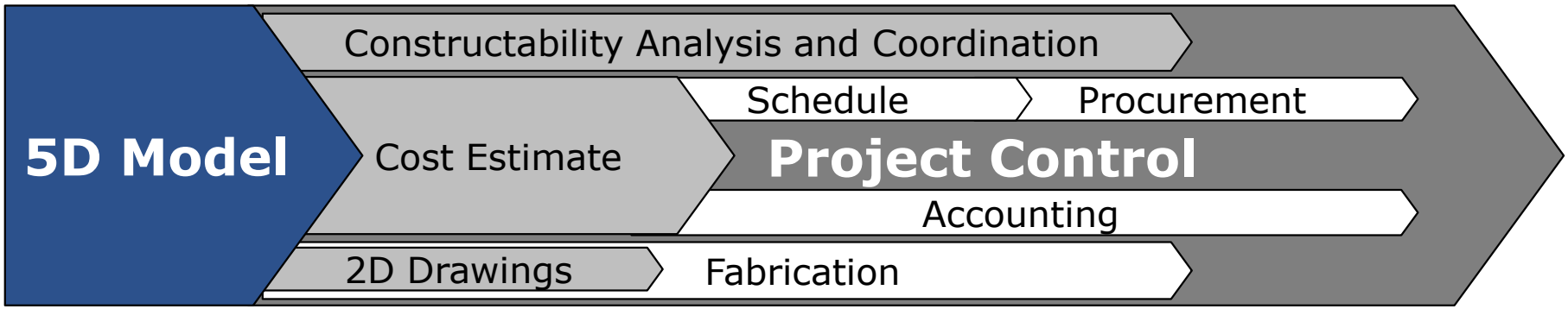


(Source: https://www.bim.cic.hk/en/resources/publications_detail/117)

Virtual Construction

- Construction industry is moving towards automated solutions. Adding time and cost information to the 3D model results the virtual construction model.





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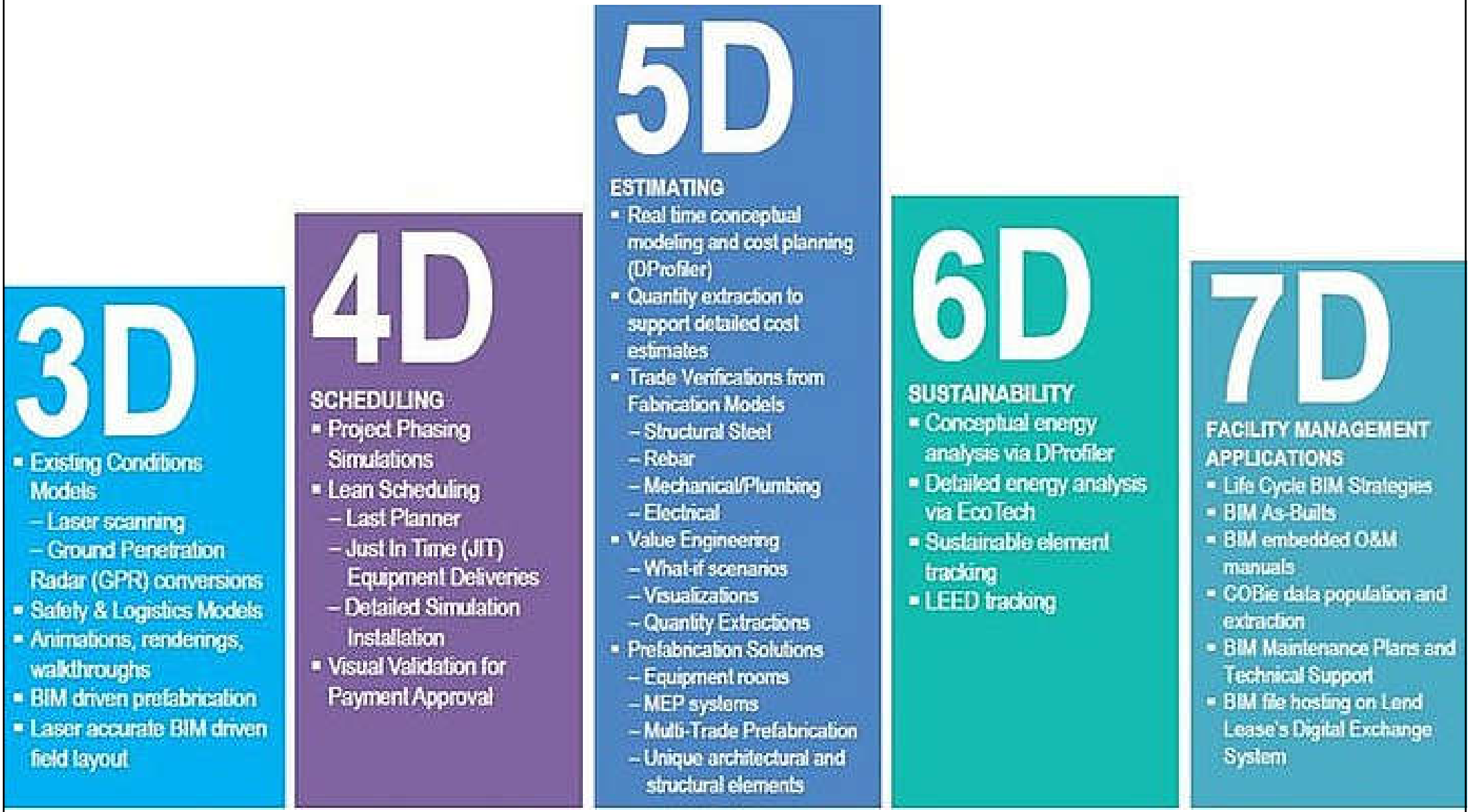
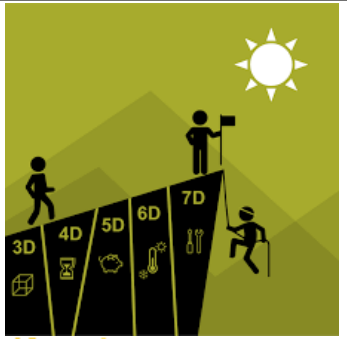
BIM dimensions



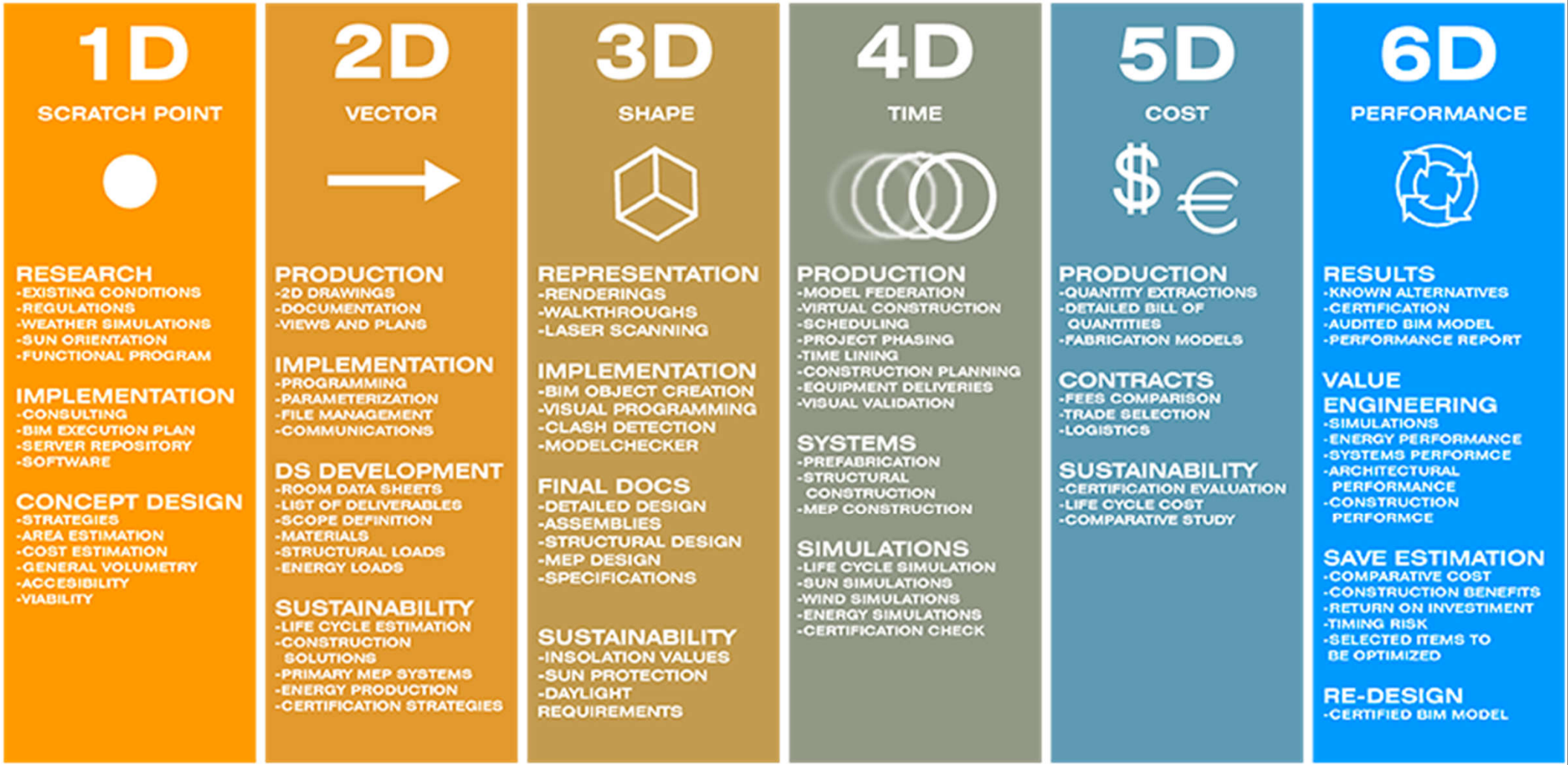
BIM dimensions



- Very broadly, building information includes:
  - 2D
  - 3D
  - 4D (including time / programme information)
  - 5D (including cost information)
  - 6D (including facilities management information)
- Parametric software modelling is used
- The common data environment (CDE) is the single source of information for the project

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

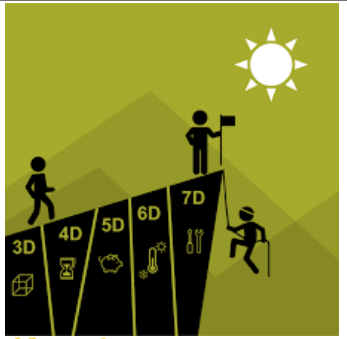
BIM dimensions: 1D to 6D



Note: the 6D is sometimes associated with Facility Management activity or Sustainability.

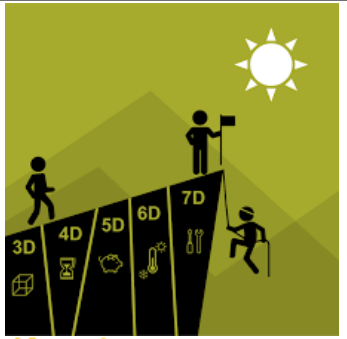
(See also: BIM Dimensions http://data.bim6d.es/bim-dimensions)

BIM dimensions

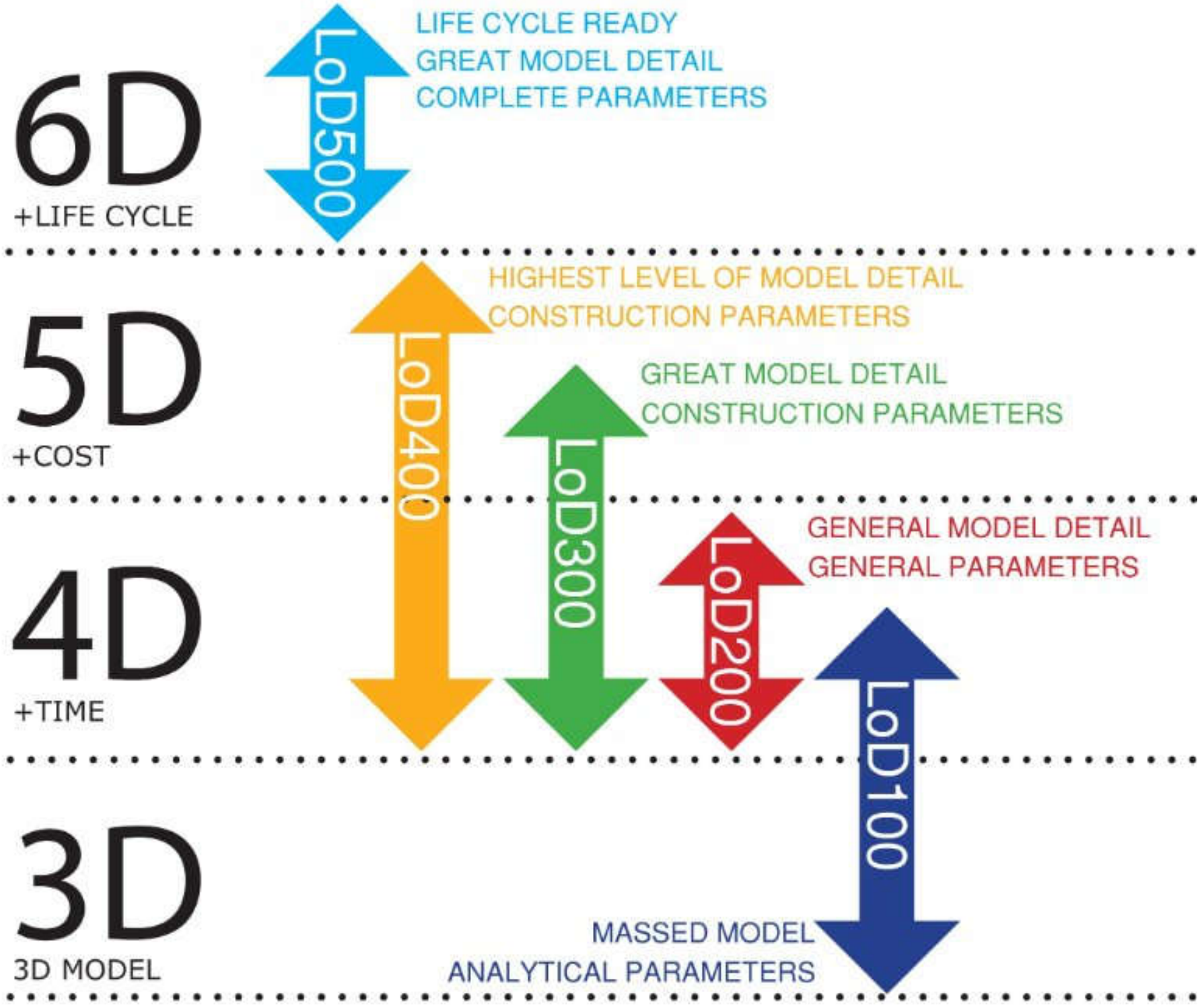


- 3D + Time = 4D Schedule
  - Better communication for construction sequencing
  - Better site planning & logistics
  - Better analysis for project management
  - Uncovers flawed logic in the schedule from visual
- 4D + Quantity + Cost = 5D
  - QTO – Quantity Take Off (in minutes), estimation
  - Spot the difference – track changing variables
  - Auto search & dynamic document of record

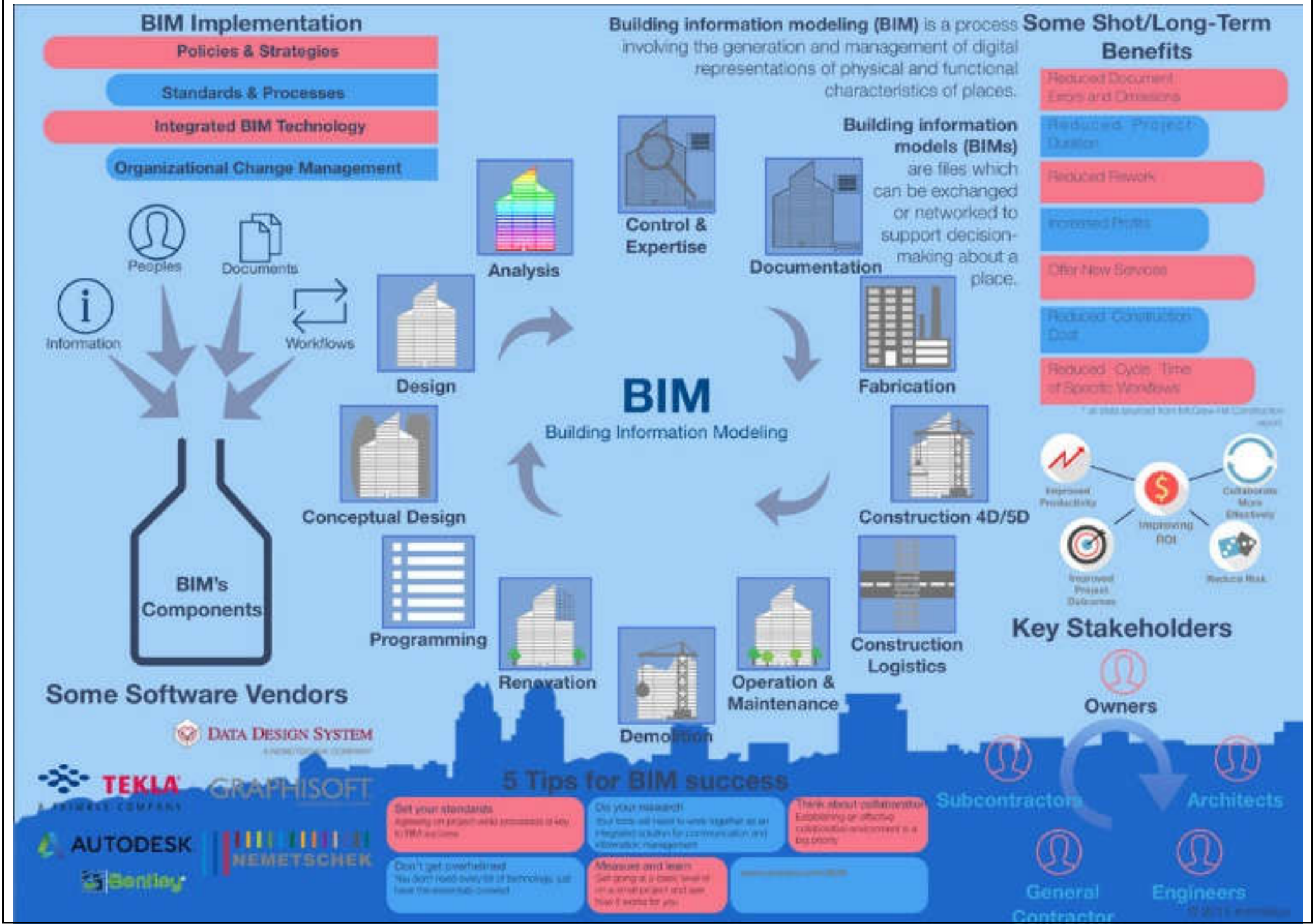
BIM dimensions



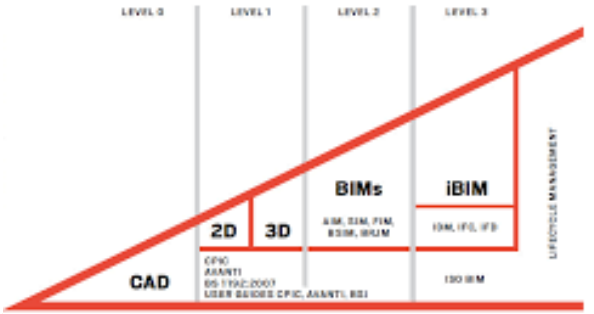
- 5D +Facility Information = 6D
  - As-builts are delivered as a Model
  - O&M data – Technical product info – Warranty info – Maintenance schedule/history – All exist in the Model
  - Space utilization tool – Simplify remodels – lease and rental analysis tools
- 7D? or nD? = Sustainability, Safety


6D
+LIFE CYCLE
LoD500
LIFE CYCLE READY
GREAT MODEL DETAIL
COMPLETE PARAMETERS
5D
+COST
LoD400
HIGHEST LEVEL OF MODEL DETAIL
CONSTRUCTION PARAMETERS
LoD300
GREAT MODEL DETAIL
CONSTRUCTION PARAMETERS
4D
+TIME
LoD200
GENERAL MODEL DETAIL
GENERAL PARAMETERS
LoD100
3D
3D MODEL
MASSED MODEL
ANALYTICAL PARAMETERS

The big picture of BIM



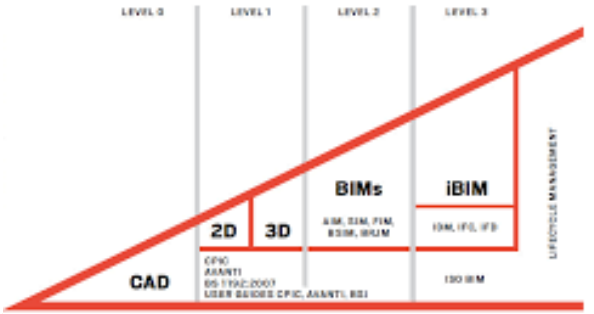
BIM maturity levels



- The range of BIM maturity levels:
  - Level 0: Unmanaged CAD (Computer Aided Design)
  - Level 1: Managed CAD in 2D or 3D
  - Level 2: Managed 3D environment with data attached, but created in separate discipline models
  - Level 3: Single, online, project model with construction sequencing, cost and life-cycle management information

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

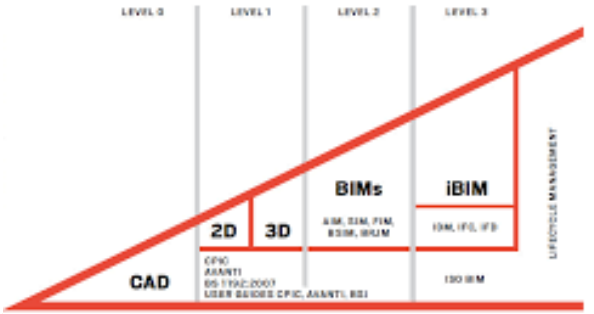
BIM maturity levels



- BIM Levels explained
  - Level 0:
    - No collaboration; 2D CAD drafting only
    - Output and distribution is via paper or electronic prints, or a mixture of both
  - Level 1:
    - A mixture of 3D CAD for concept work, and 2D for drafting of statutory approval documentation and production information
    - Models are not shared between project team members

(Source: BIM Levels explained https://www.thenbs.com/knowledge/bim-levels-explained)

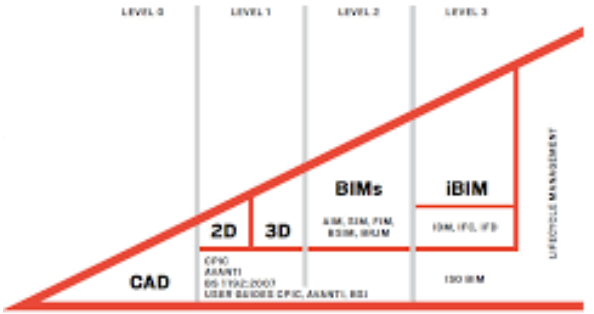
BIM maturity levels



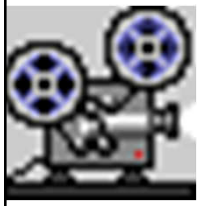
- BIM Levels explained (cont'd)
  - Level 2:
    - Collaborative working – all parties use their own 3D CAD models, but not necessarily working on a single, shared model
    - Design information is shared and exchanged through a common file format
  - Level 3: OPEN BIM™
    - Full collaboration between all disciplines by means of using a single, shared project model which is held in a centralized repository (also known as "Open BIM")

(Source: BIM Levels explained https://www.thenbs.com/knowledge/bim-levels-explained)

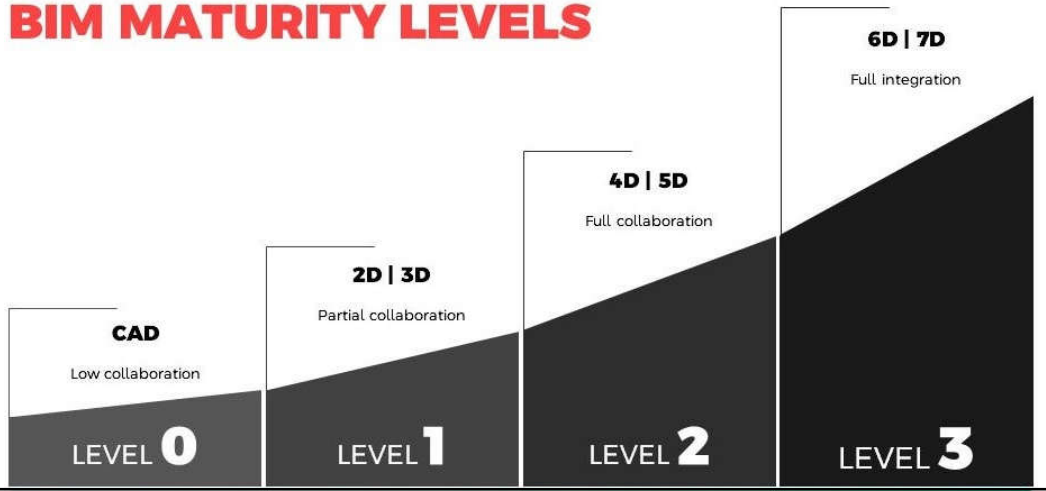
BIM maturity levels



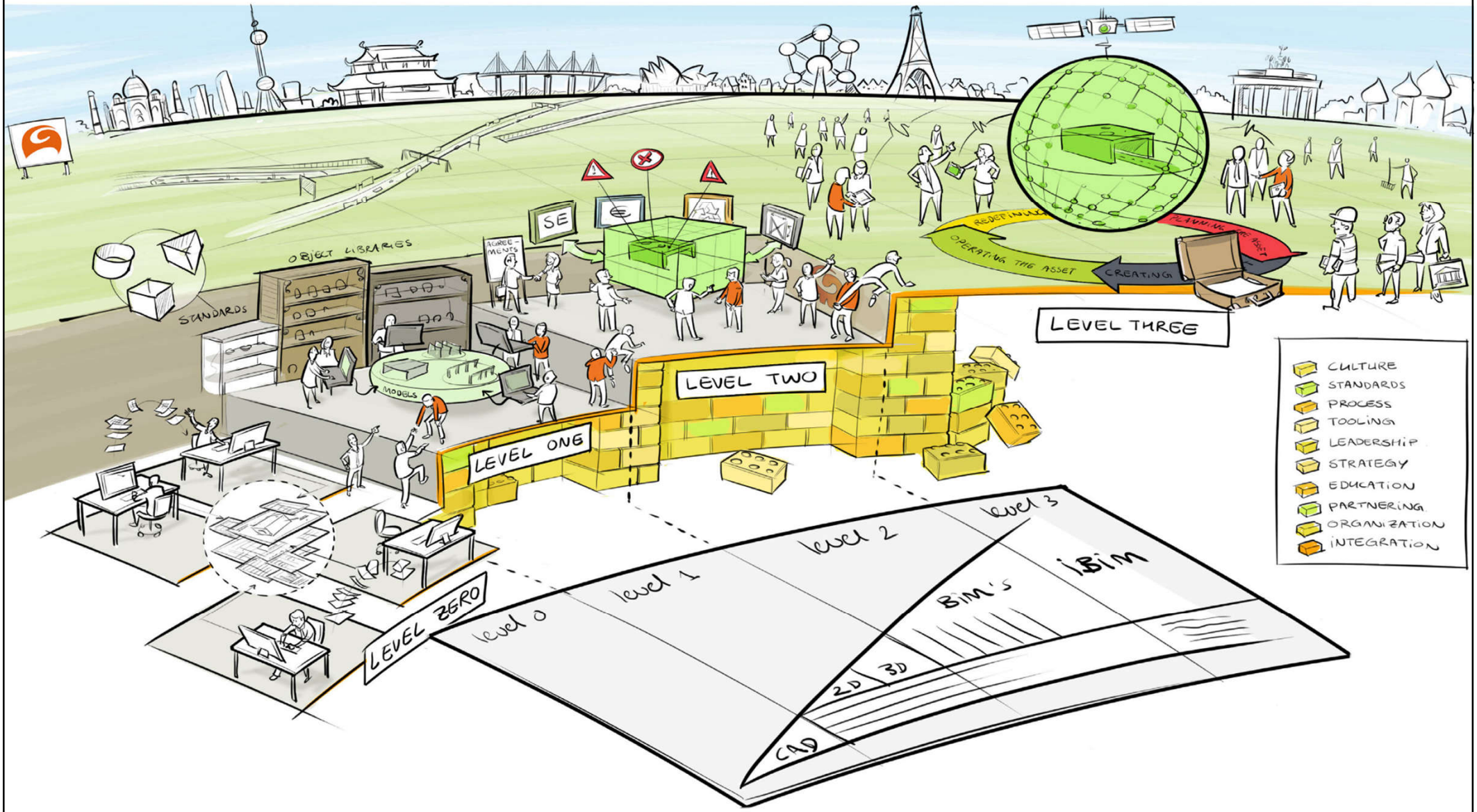
- Video: Wienerberger - What is BIM? (5:23)



  - https://youtu.be/ZYvQk78WlTc
  - An brief introduction to BIM and Geo-BIM, through a short animation. The video highlights what BIM Level 2 and Level 3 entail and how these are directly influencing construction in the UK.



BIM maturity levels



BIM maturity levels

LEVEL 0

Low collaboration

Information is produced with 2D drawings using Computer Aided Design (CAD)

Files are being shared digitally as separated sources of information.

LEVEL 1

Partial collaboration

Project teams are using a CDM (Common Data Environment) to collect, manage and share all project data

The development of the project and the production of information is a combination of 3D and 2D CAD drawings.

LEVEL 2

Full collaboration

Project teams are using 3D modeling to develop their projects and produce information

3D models with project data are shared using a common file type (like IFC). In this way, they are able to put together a unified BIM model.

Dimensions related to time management (4D) and cost of the project are (5D) available in Level 2 BIM.

LEVEL 3

Full integration (iBIM)

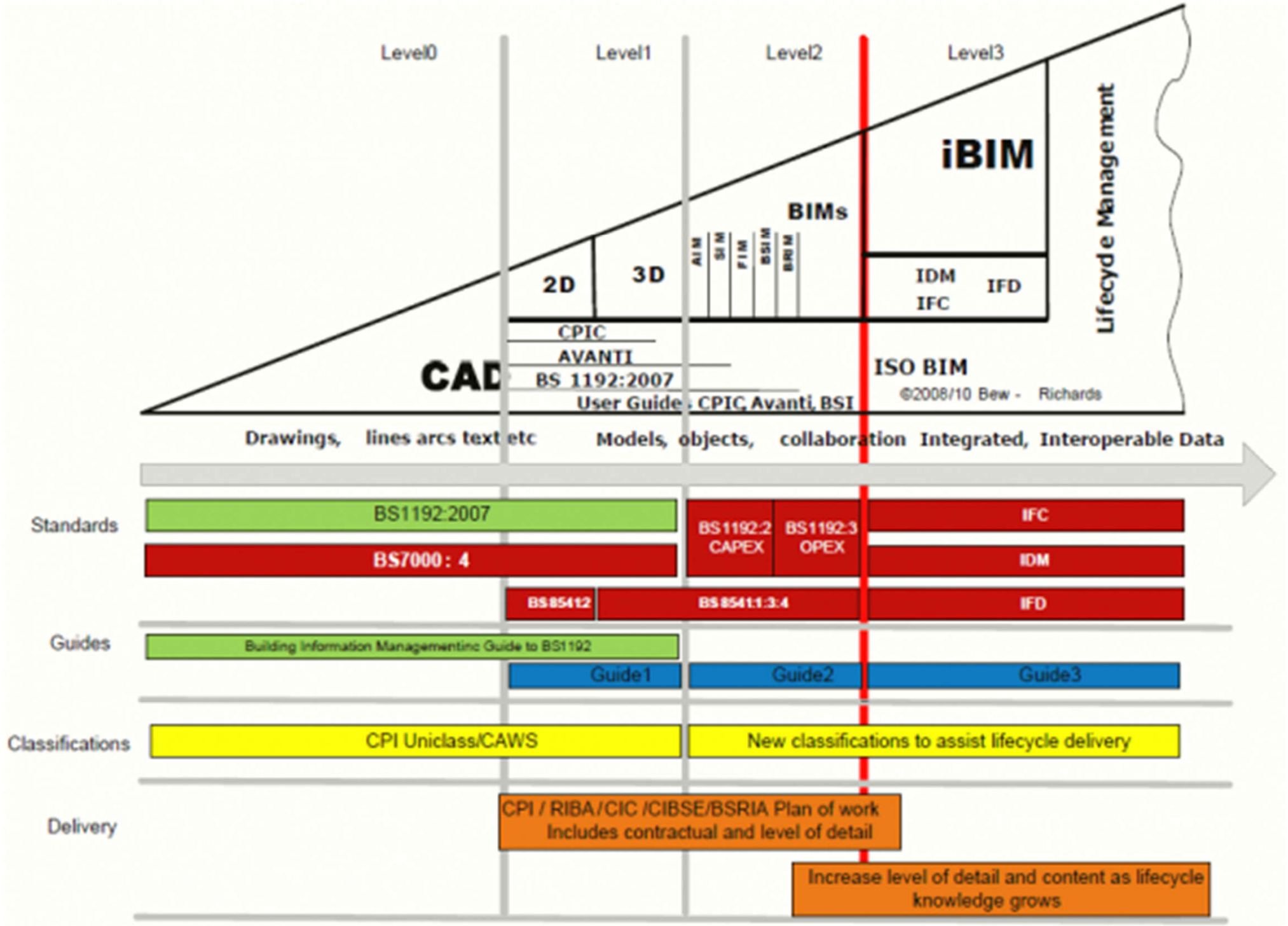
A common shared model (or a unified BIM model) is used via a cloud-based environment.

Anyone who is involved in the project has access to it and is able to add information, according to his role in the project.

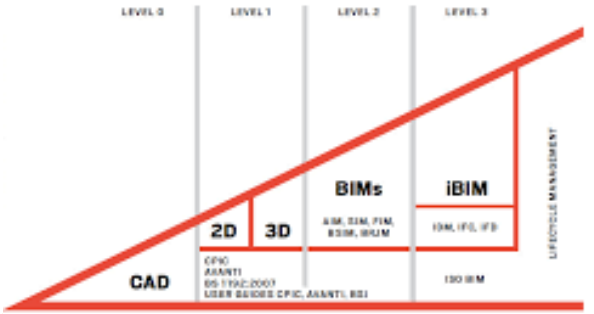
Along with 4D & 5D, a new dimension is available. The 6D, which is focused on the management of the building's lifecycle.

(Source: https://medium.com/specter-automation-insights/bim-maturity-levels-explained-922060c163ef)

BIM maturity levels and development path in UK



BIM maturity levels



- Maturity of organisations regarding BIM:
  - Company level: object-based modelling
  - Project level: information exchange processes based on models (for collaboration)
  - Sectorial level: a global view, linked to public (procurement) policies, e.g. mandatory BIM
- Integrated Project Delivery (IPD): the long-term goal of BIM implementation

Integrated Project Delivery

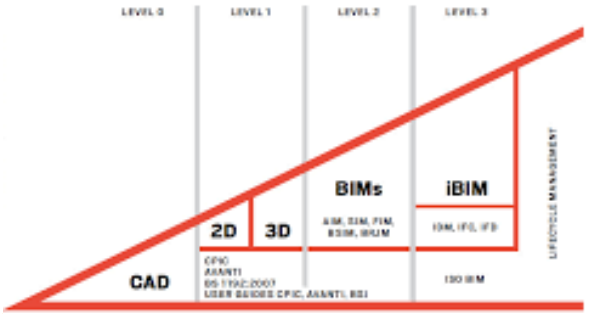
*"Integrated Project Delivery (IPD) is a project delivery approach that **integrates people, systems, business structures and practices** into a process that collaboratively harnesses the talents and insights of all participants to **reduce waste** and **optimize efficiency** through all phases of design, fabrication and construction."*

AIA CALIFORNIA COUNCIL
The American Institute of Architects

Traditional		IPD
Segmented	**Teams**	Integrated, collaborative
Linear, distinct, segregated	**Process**	Concurrent, multi-level, integrated
Individually managed	**Risk**	Collectively managed
Individual success, minimum effort for maximum return	**Reward**	Value-based, team success
Paper based, 2D, analog	**Technology**	Digitally based, BIM, 4D
Minimize or transfer risk, don't share	**Agreements**	Open sharing, collaboration, full integration
Individually focused	**Education**	Team-based , integrated, collaborative

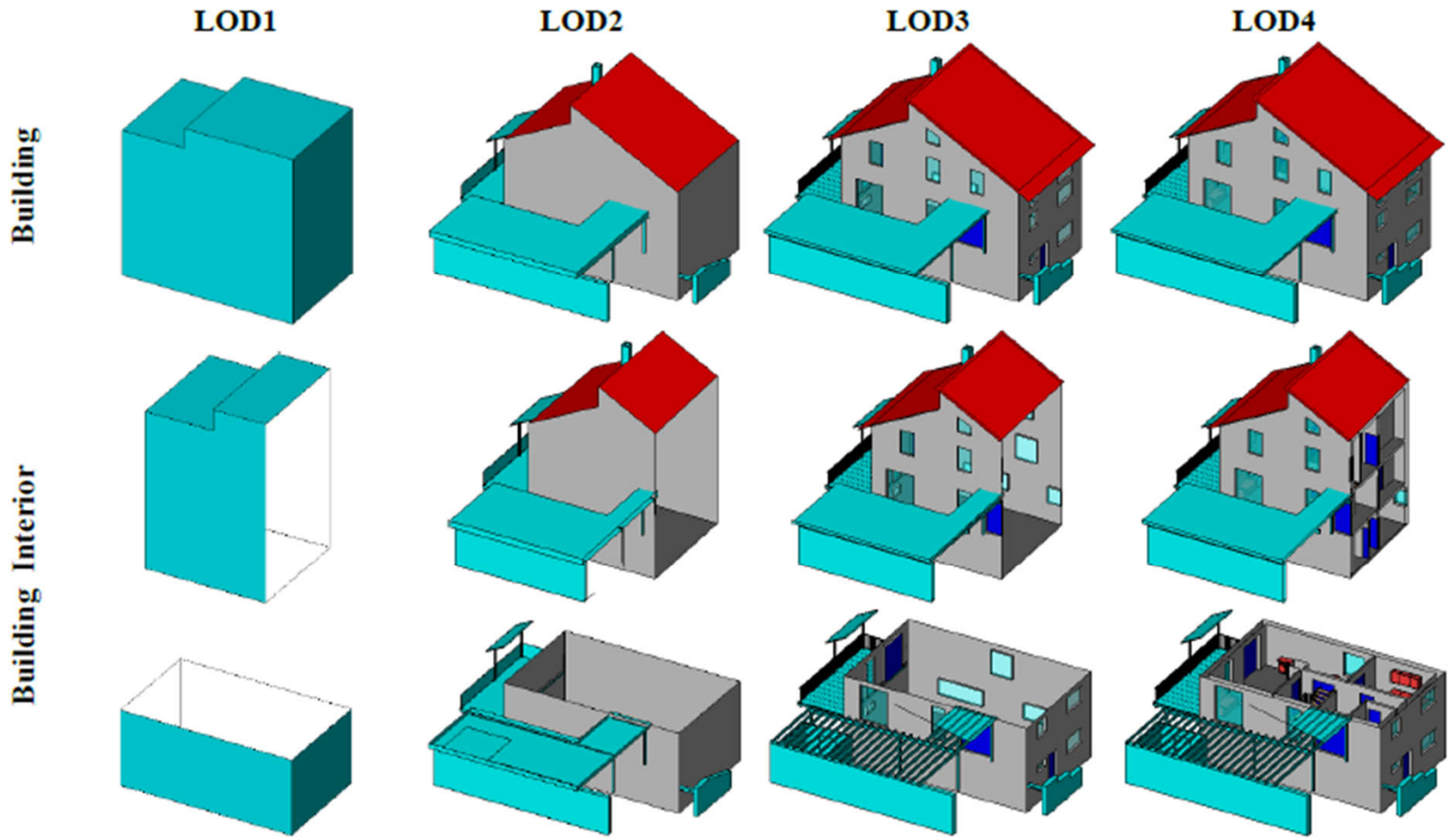
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

BIM maturity levels

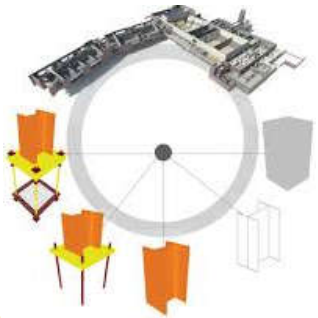


- Integrated Project Delivery (IPD) 集成項目交付
  - Involve all team members in design meetings
  - Identify key objectives up front
  - Open collaboration at all stages of a project
  - BIM is utilized
  - Minimize paper based processes and collaborate digitally
  - Check for & manage interferences with 3D clash detection
  - Set up contract mechanisms that enable and reward achievement of key objectives
  - Create a culture of trust and information sharing (win-win-win)

Level of development (LOD)



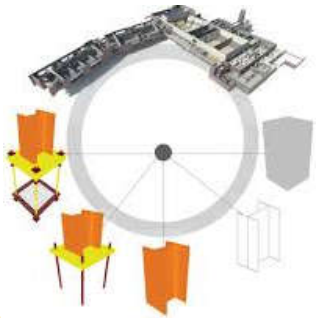
Level of development (LOD)



- LOD is commonly used to represent the level of precision of model content
  - This is the degree to which an element's geometry and its attached information have been thought through – the degree to which project team members may rely on the information when using the model
  - The expected LOD by element/category/building system at each stage of the project has to be determined and documented

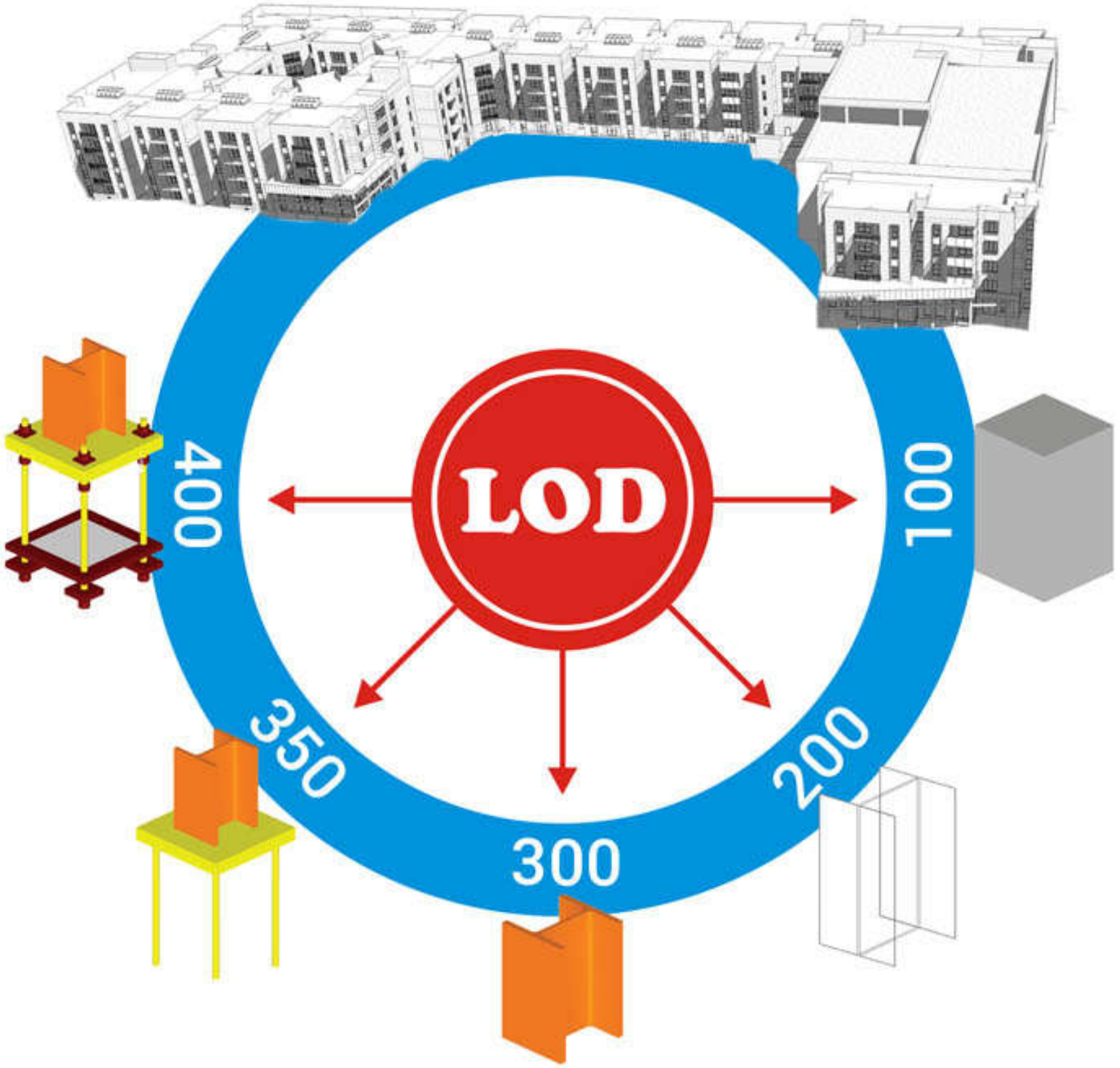
(Source: Denis, F., 2015. *Building Information Modelling – Belgian Guide for the Construction Industry*, ADEB-VBA, Brussel.)

Level of development (LOD)

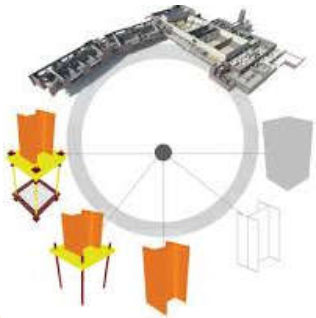


- Level of Development (LOD) specifications:
  - LOD 100: Conceptual design
  - LOD 200: Design Development
  - LOD 300: General Construction documents
  - LOD 350: The compromise
  - LOD 400: Fabrication information
  - LOD 500: As-built model

(Source: LOD | BIMForum http://bimforum.org/lod/)


LOD
100
200
300
350
400

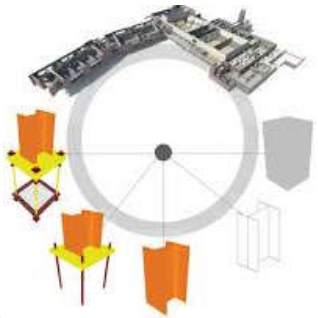
Level of development (LOD)



- LOD 100 elements:
  - Are not geometric presentations (may be symbols or other generic representations)
  - Any information derived from them must be considered approximate
- LOD 200 elements:
  - Are represented graphically but are generic placeholders, e.g., volume, quantity, location, or orientation (they must be considered approximate)

(Source: LOD | BIMForum http://bimforum.org/lod/)

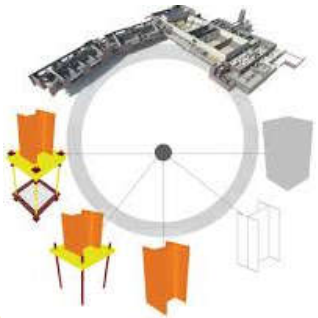
Level of development (LOD)



- LOD 300 elements:
  - Are graphically represented as specific systems, objects, or assemblies from which quantity, shape, size, location, and orientation can be measured directly, without having to refer to non-modeled information such as notes or dimension call-outs
- LOD 350 elements:
  - Are enhanced beyond LOD 300 by the addition of information regarding interfaces with other building systems

(Source: LOD | BIMForum http://bimforum.org/lod/)

Level of development (LOD)



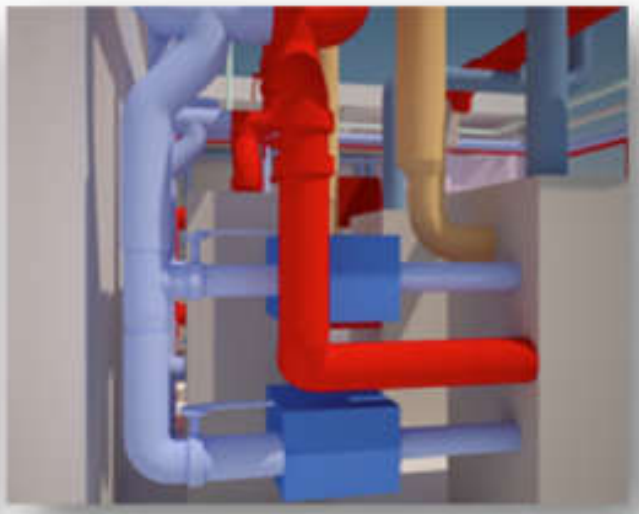
- LOD 400 elements:
  - Are modeled at sufficient detail and accuracy for fabrication of the represented component

- LOD 500 element:*
  - It is a field verified representation in terms of size, shape, location, quantity, and orientation
  - Non-graphic information may also be attached
  - * The Specification does not define or illustrate it

(Source: LOD | BIMForum http://bimforum.org/lod/)

A piping project at various LOD levels

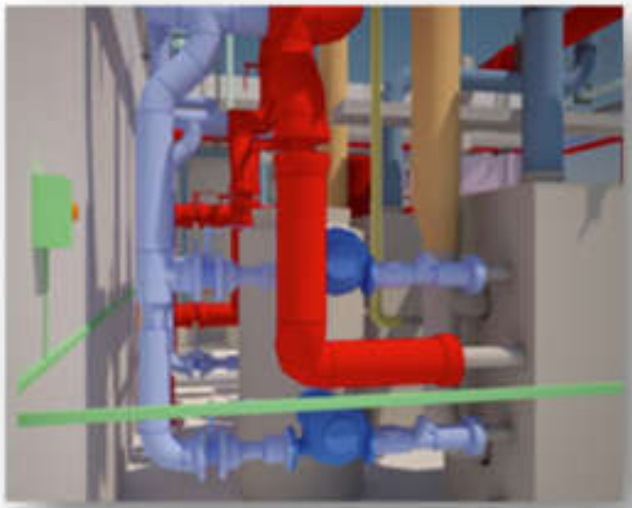
LOD 200



LOD 300

LOD 350

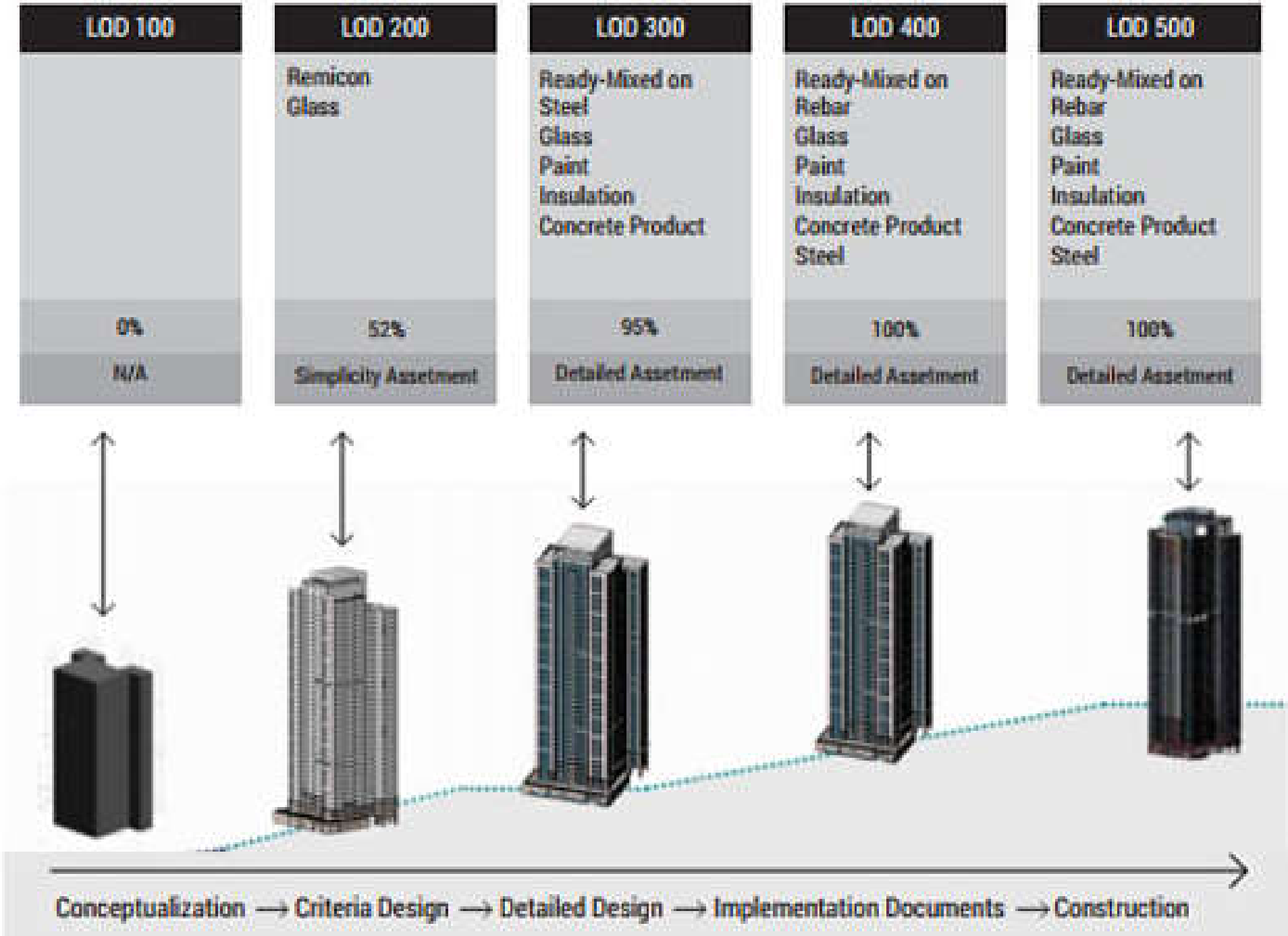
LOD 400



LOD 500

(Source: LOD – Development or Detail & Why it Matters http://lanmarservices.com/2014/05/14/lod-in-scan-to-bim/)

Level of Development (LOD): examples



(*BIM Level of Development(LOD) 100, 200, 300, 400 & 500 http://www.srinsofttech.com/bim-level-of-development-lod-300-400-500.html)

LEVEL of DEVELOPMENT

LOD 100

Concept (Presentation)

DESCRIPTION:
Office Chair
Arms, Wheels
WIDTH:

DEPTH:

HEIGHT:

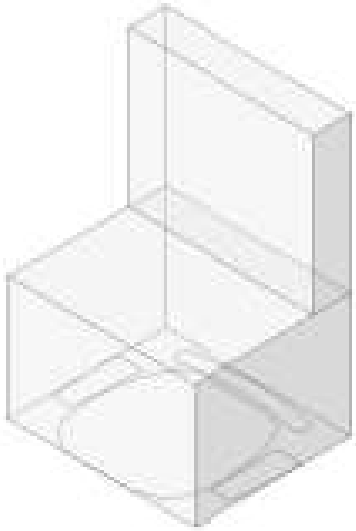
MANUFACTURER:
Herman Miller, Inc.
MODEL:
Mirra
LOD:
100

LOD 200

Design Development

DESCRIPTION:
Office Chair
Arms, Wheels
WIDTH:
700
DEPTH:
450
HEIGHT:
1100
MANUFACTURER:
Herman Miller, Inc.
MODEL:
Mirra
LOD:
200

LOD 300



Documentation

DESCRIPTION:
Office Chair
Arms, Wheels
WIDTH:
700
DEPTH:
450
HEIGHT:
1100
MANUFACTURER:
Herman Miller, Inc.
MODEL:
Mirra
LOD:
300

LOD 400

Construction

DESCRIPTION:
Office Chair
Arms, Wheels
WIDTH:
685
DEPTH:
430
HEIGHT:
1085
MANUFACTURER:
Herman Miller, Inc
MODEL:
Mirra
LOD:
400

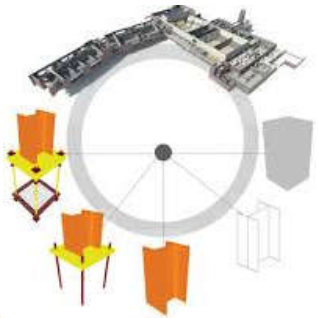
LOD 500

Facilities Management

DESCRIPTION:
Office Chair
Arms, Wheels
WIDTH:
685
DEPTH:
430
HEIGHT:
1085
MANUFACTURER:
Herman Miller, Inc
MODEL:
Mirra
PURCHASE DATE:
01/02/2013

(Only data in **red** is useable)

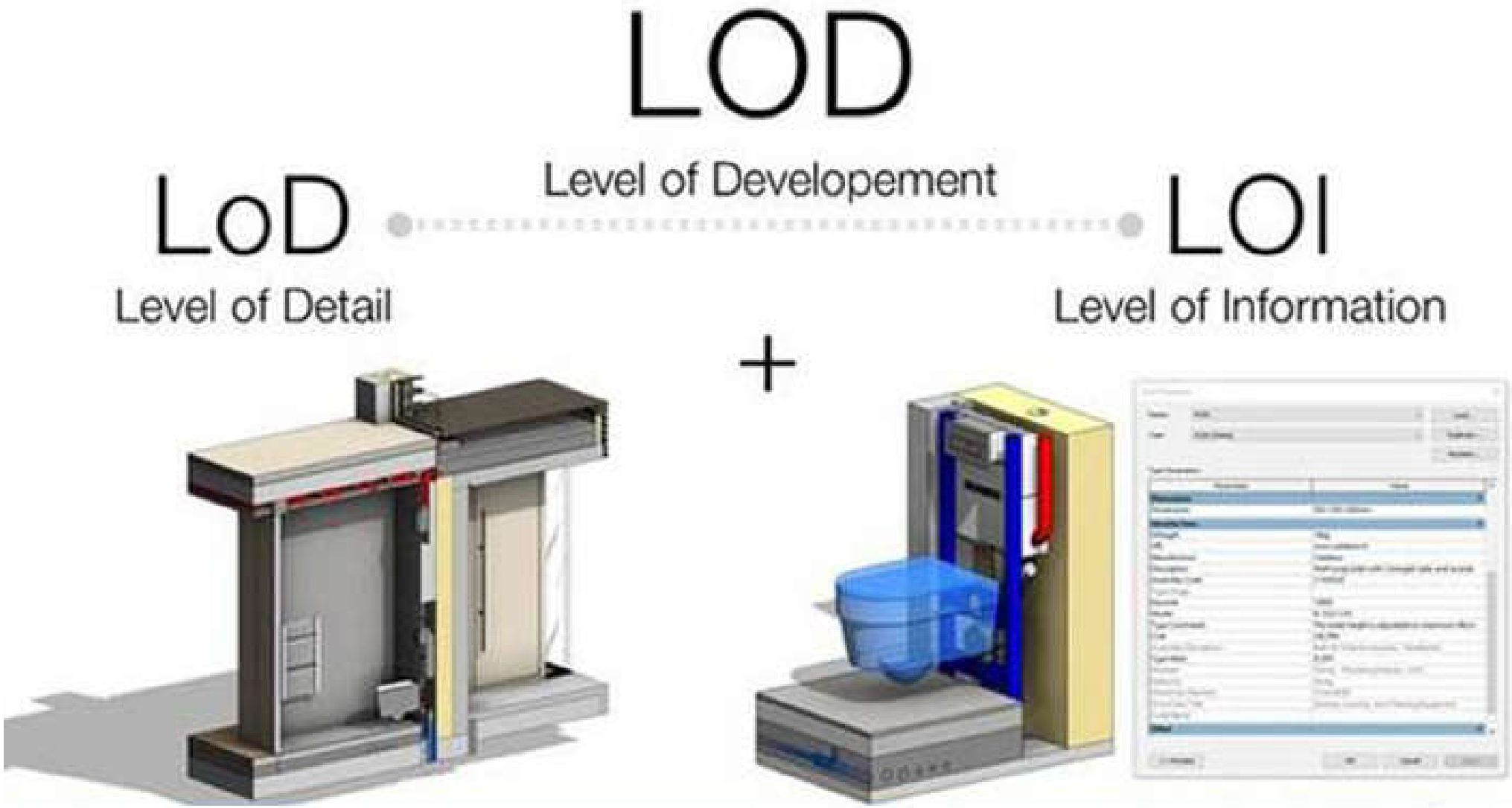
Level of development (LOD)



- Level of Development vs. Level of Detail
  - Level of Detail (LoD) is essentially how much detail is included in the model element
  - Level of Development (LOD) is the degree to which the element's geometry and attached information has been thought through
    - Level of Detail can be thought of as input to the element, while Level of Development is reliable output
  - Levels of (model) information (LOI), which relates to the non-graphical content of models

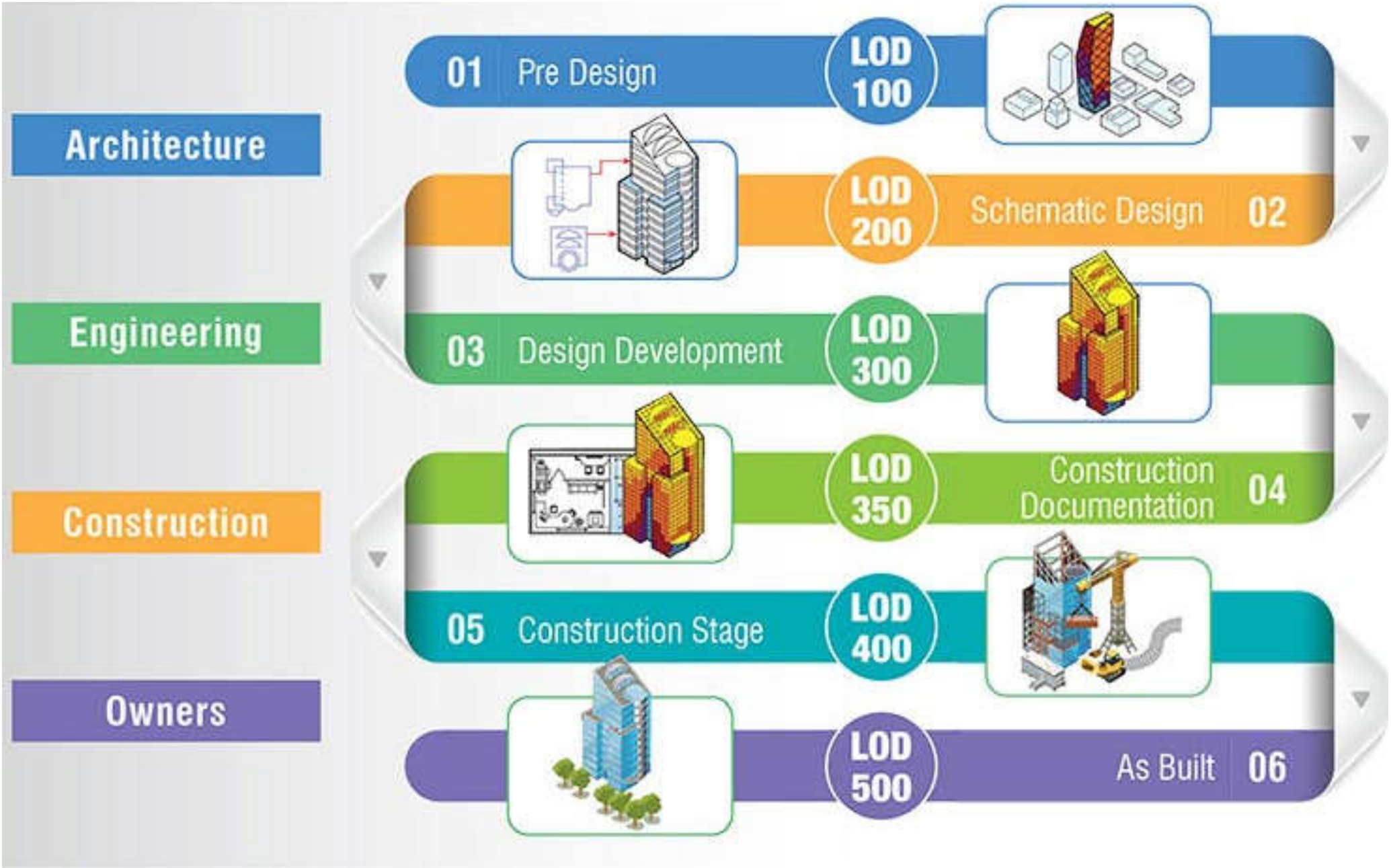
(Source: LOD | BIMForum http://bimforum.org/lod/)

Level of Development (LOD) vs. Level of Detail (LoD)

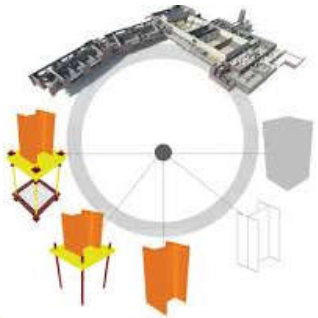


(*BIM Level of Development(LOD) 100, 200, 300, 400 & 500 http://www.srinsofttech.com/bim-level-of-development-lod-300-400-500.html)

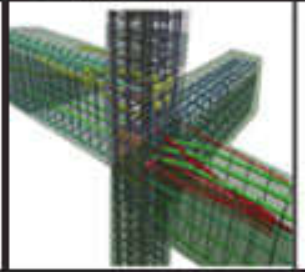
Level of Development (LOD) and building development process



Level of development (LOD)



- LOD in the design and construction process:
  - 1. Element-oriented modelling
    - As-Built (LOD 500)
    - Fabrication and assembly (LOD 400)
  - 2. System/Component oriented modelling
    - Detailed design (LOD 300)
    - Basic design (LOD 200)
  - 3. Conceptual information model
    - Conceptual design (LOD 100)
    - Client requirements (Pre-modelling)

Element-Oriented Modeling	As-Built	LOD 500		Operation; Budget; Occupancy; Capacity; Location; LEED Class
	Fabrication and Asembly	LOD 400		Shape; Areas; Volumes; Number of Levels; Structural System; Mechanical Systems; Electrical Systems
System \ Component Oriented Modeling	Detailed Design	LOD 300		Component 1 Basement Space: Geometry G1 G2 ..., Position P1 P2 ..., Specification S1 S2 ... → Component Attributes
	Basic Design	LOD 200		Comp. 1.1 Basement Wall; Comp. 1.2 Basement Floor Slab; Geo. G1; Pos. P1; Spc. S1; Inter-model Dependency
Conceptual Information Model	Conceptual Design	LOD 100		C. 1.1.1 Wall Formwork; C. 1.1.2 Wall Rein. Bar; G. P. S.
	Client Requirements	Pre-Modeling		C. 1.2.2 Floor Slab Reinf. Bar; C. 1.2.1 Floor Slab Formwork; G. P. S.

(*BIM Level of Development(LOD) 100, 200, 300, 400 & 500 http://www.srinsofttech.com/bim-level-of-development-lod-300-400-500.html)