

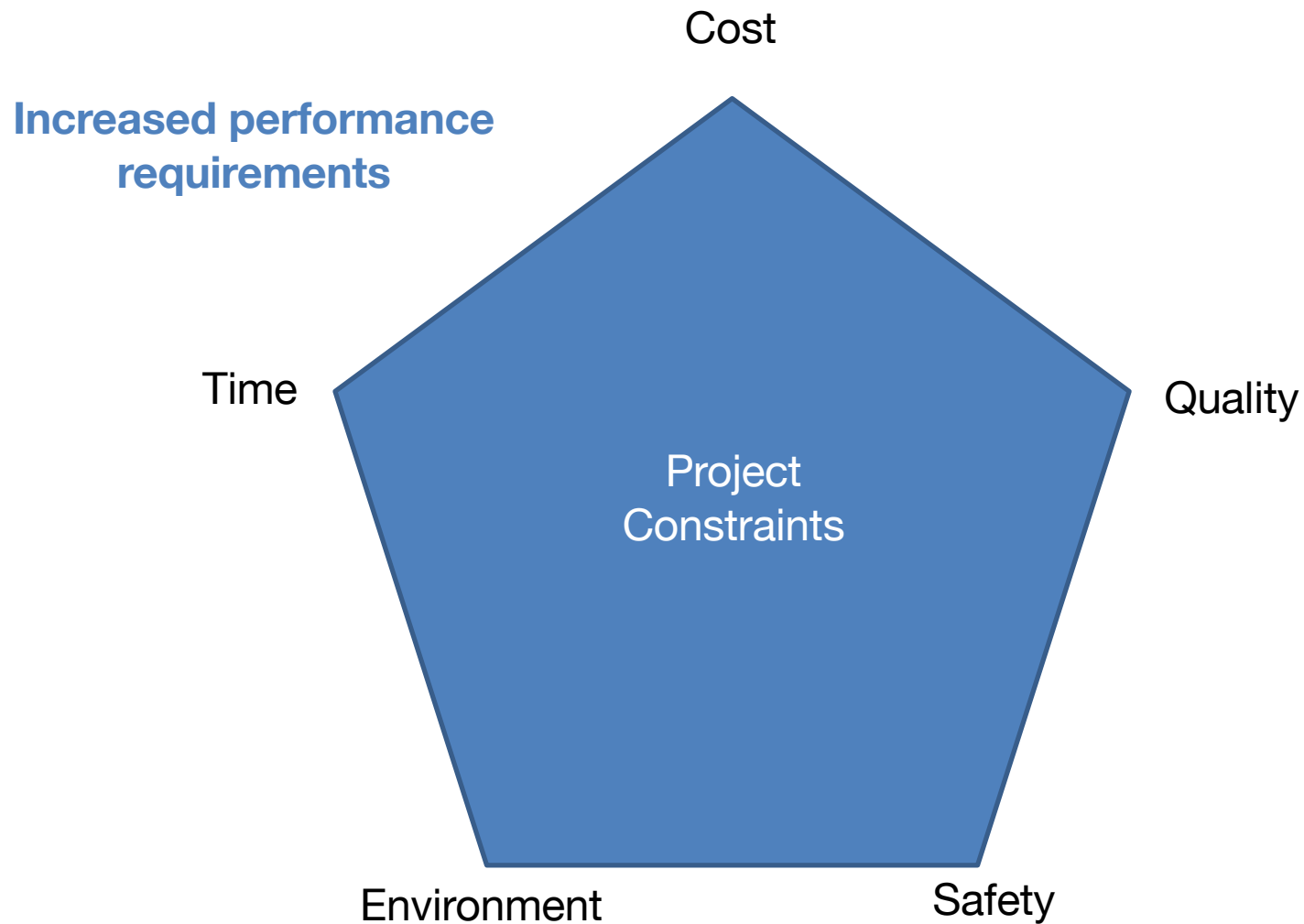
CENG 6101 Project Management

Introduction to Building Information Modeling (BIM)

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March, 2017

Why BIM?



Why BIM?

Change Orders

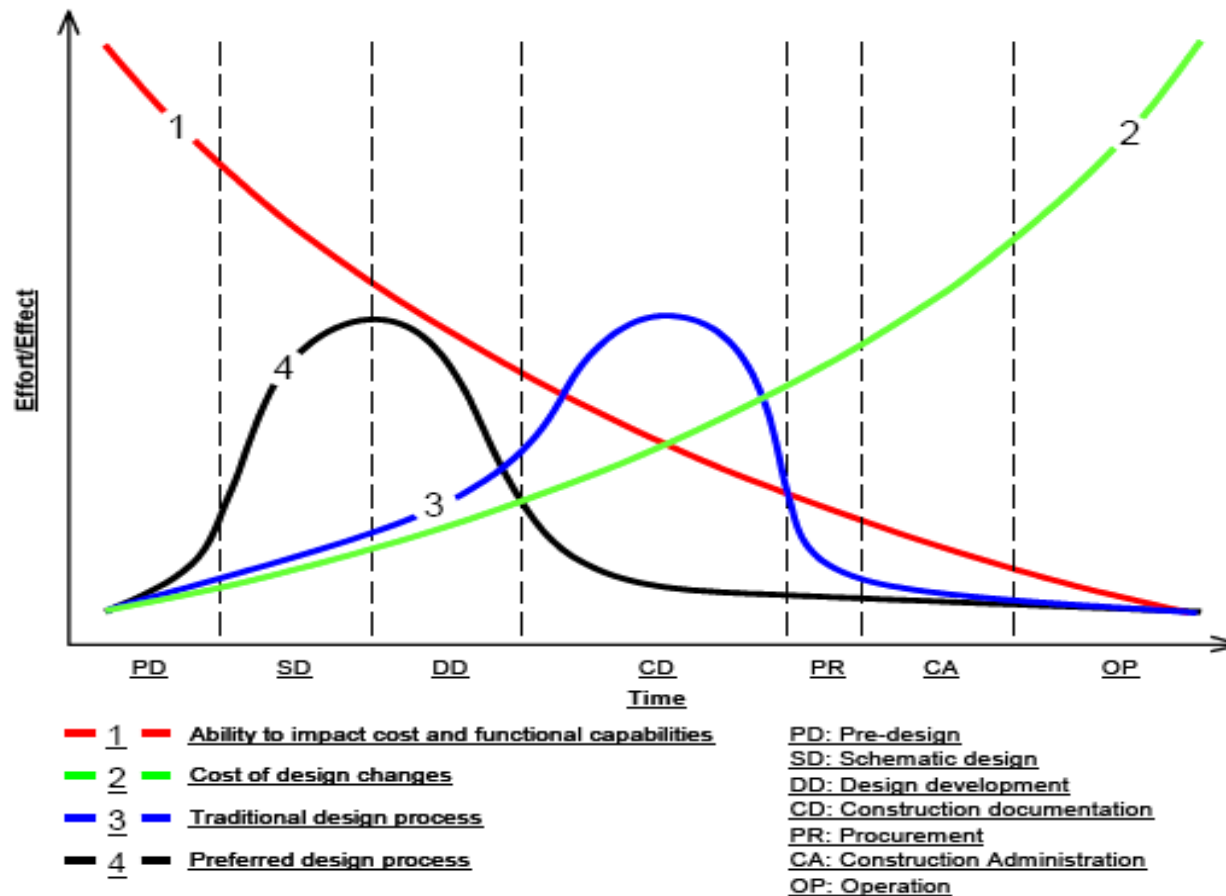
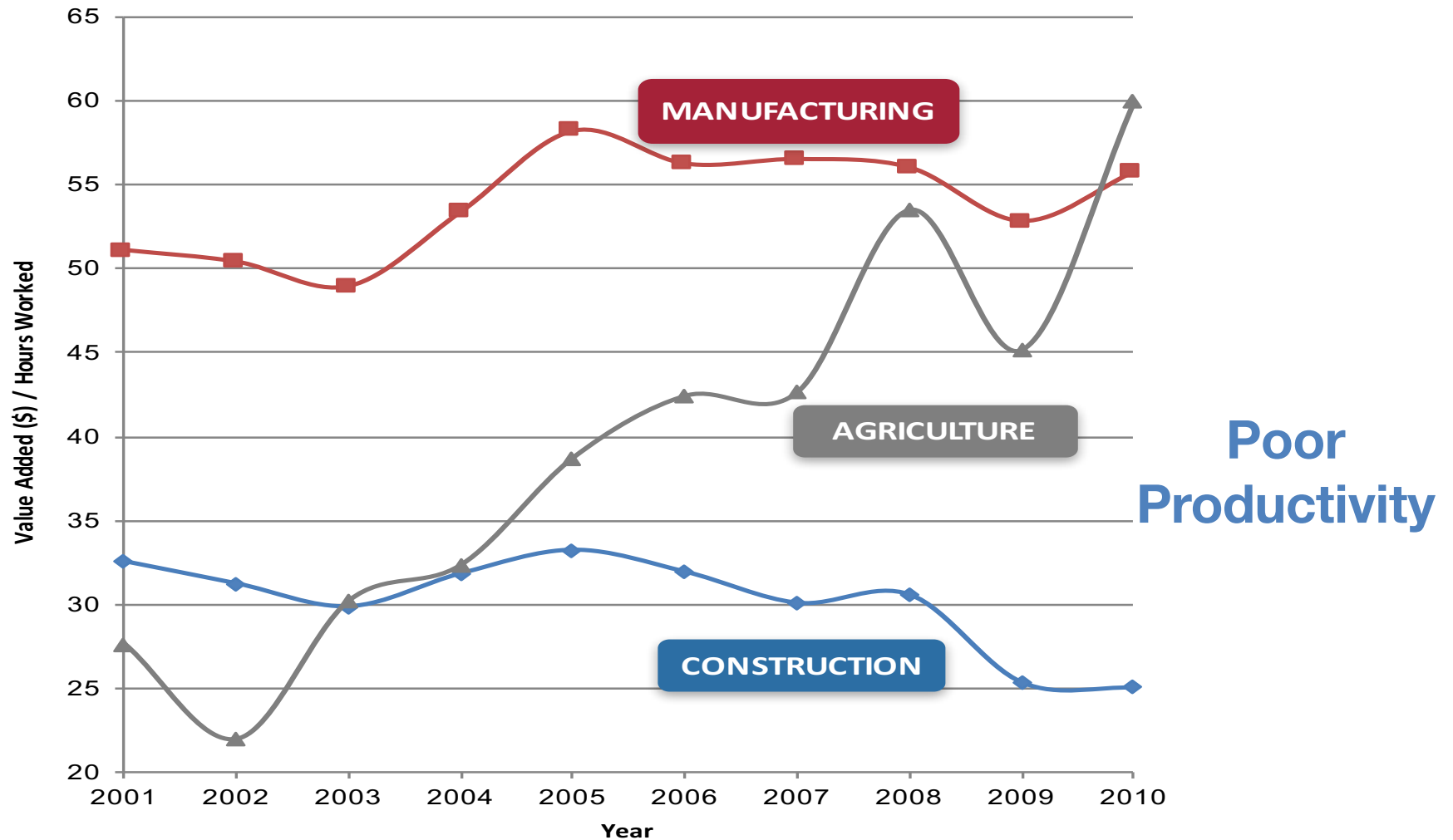


Figure 4: “McLeany Curve” illustrating that effort and decision-making is shifted earlier in the design process in an Integrated Project Delivery (Construction Users Roundtable 2004).

Why BIM?



[Adapted from "Labour productivity (\$2002 per hour worked), Alberta, by two-digit NAICS industry, 1997-2010," by Center for the Study of Living Standard (CSLS), 2012]

Why BIM?

- In 2004 the Construction Industry Institute estimated that **57% of money spent on construction is non-value-added – which is WASTE.**² With the U.S. construction market estimated at US\$1.288 trillion for 2008, at 57% waste, over \$600 billion per year is being wasted.

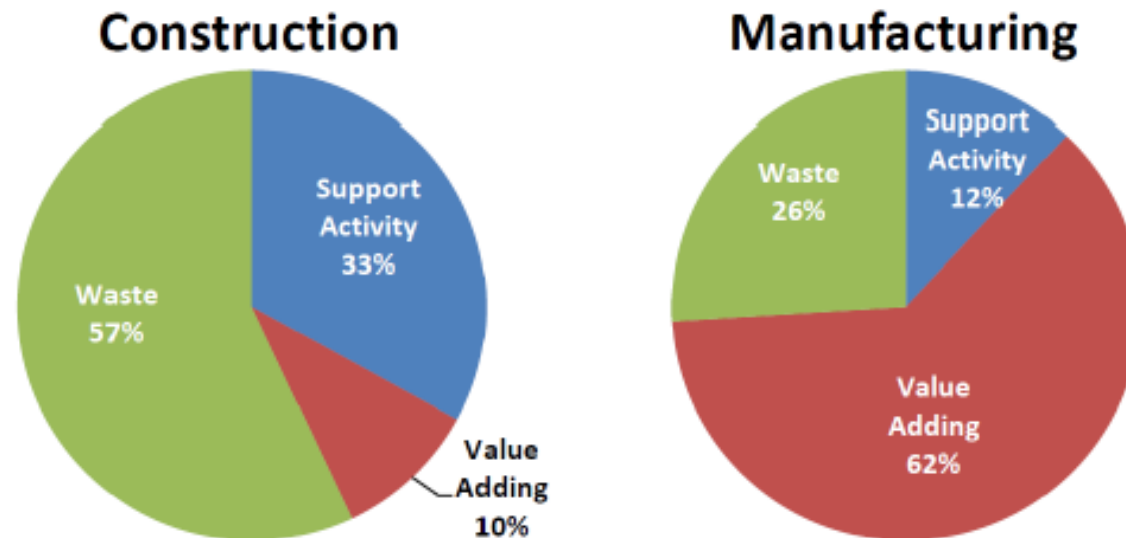


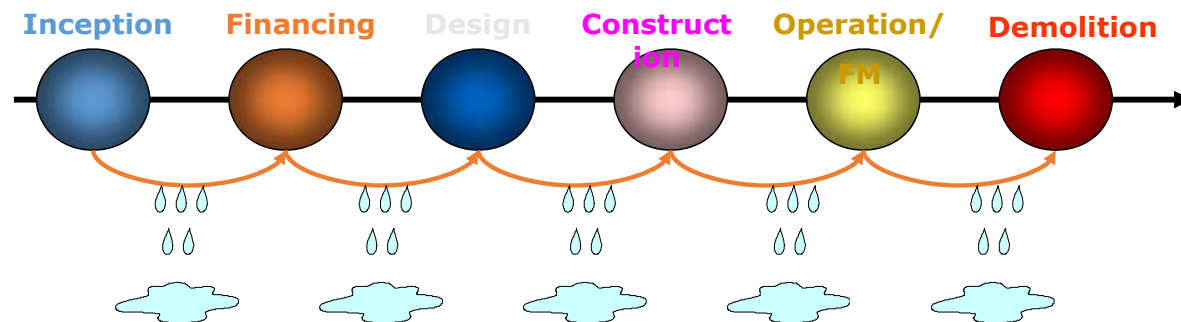
Figure 1: A large portion of the money spent in the construction industry is wasted, especially when compared to the manufacturing industry.

Wastage

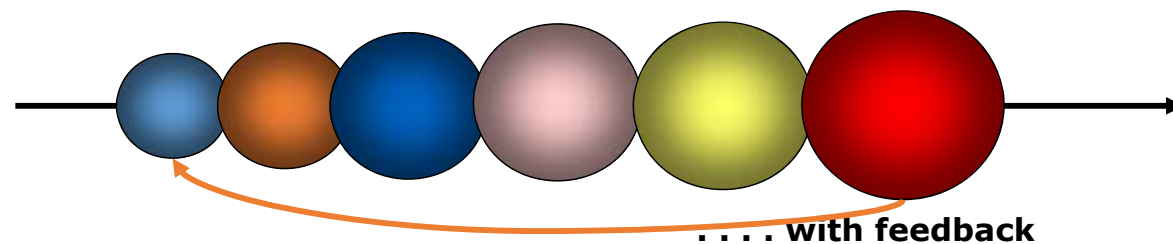
Why BIM?

Fragmentation

- Current model



- Model with interoperable solutions



Flanagan (2007)

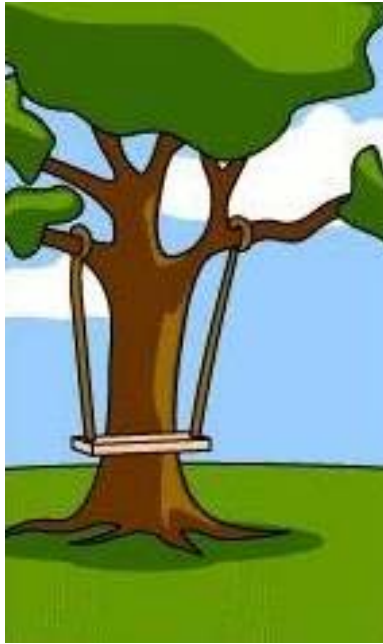
Why BIM?

Fragmentation



Why BIM?

Communication



What the client wanted



As the design team understood it



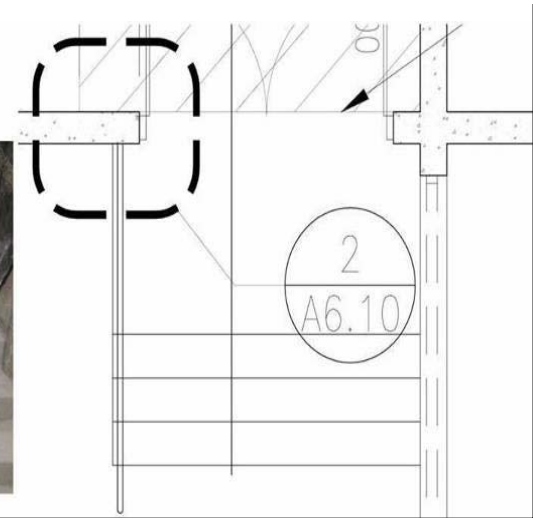
As the contractor build it

Why BIM?



Communication

Two different worlds of Designers
and Builders



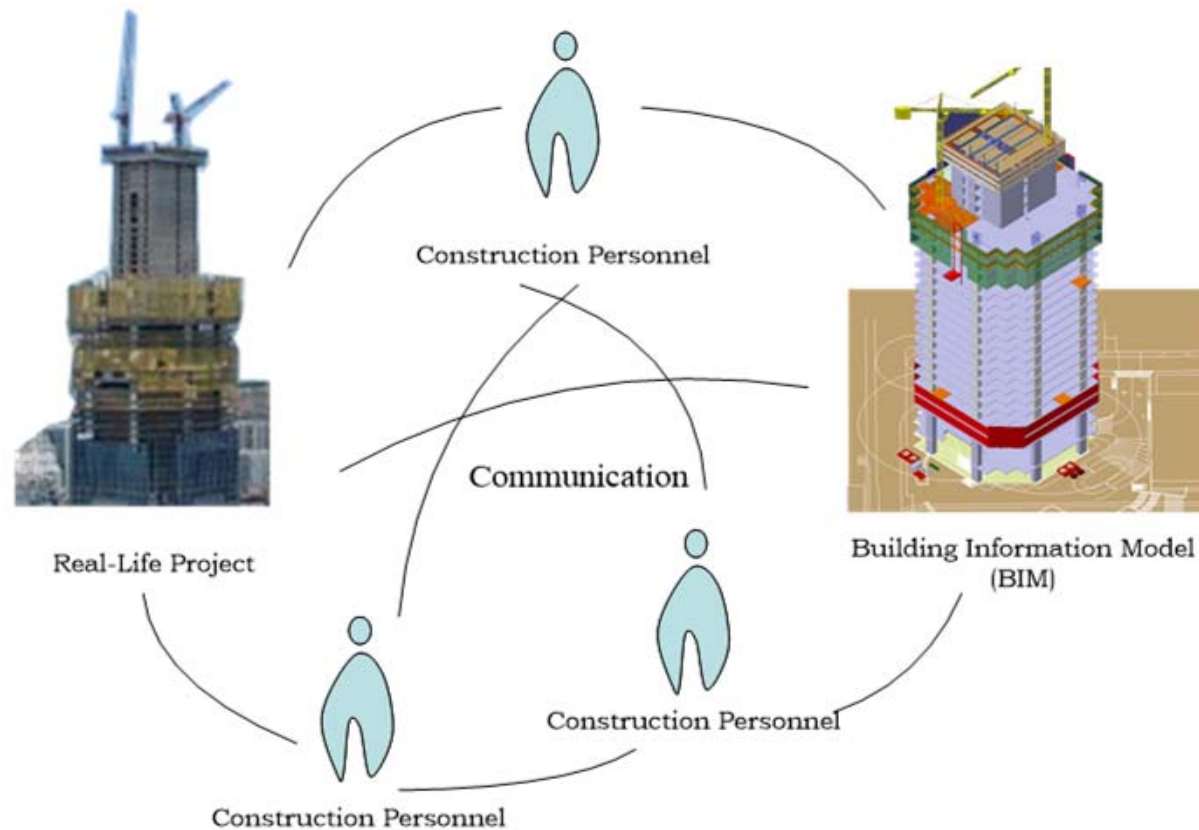
Why BIM?

No prototyping



Why BIM?

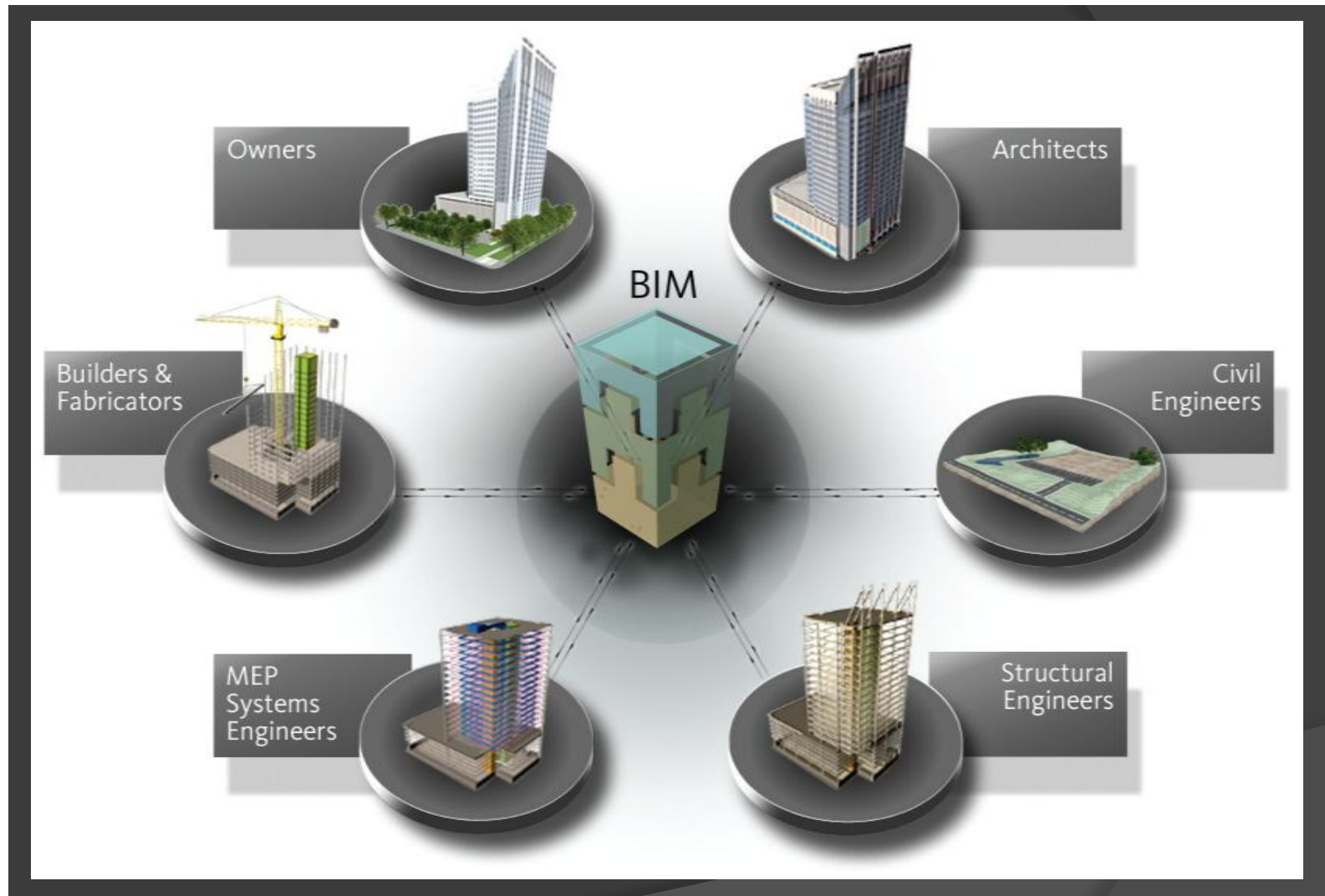
Building Information Modeling (BIM) or Building Information Model (BIM)



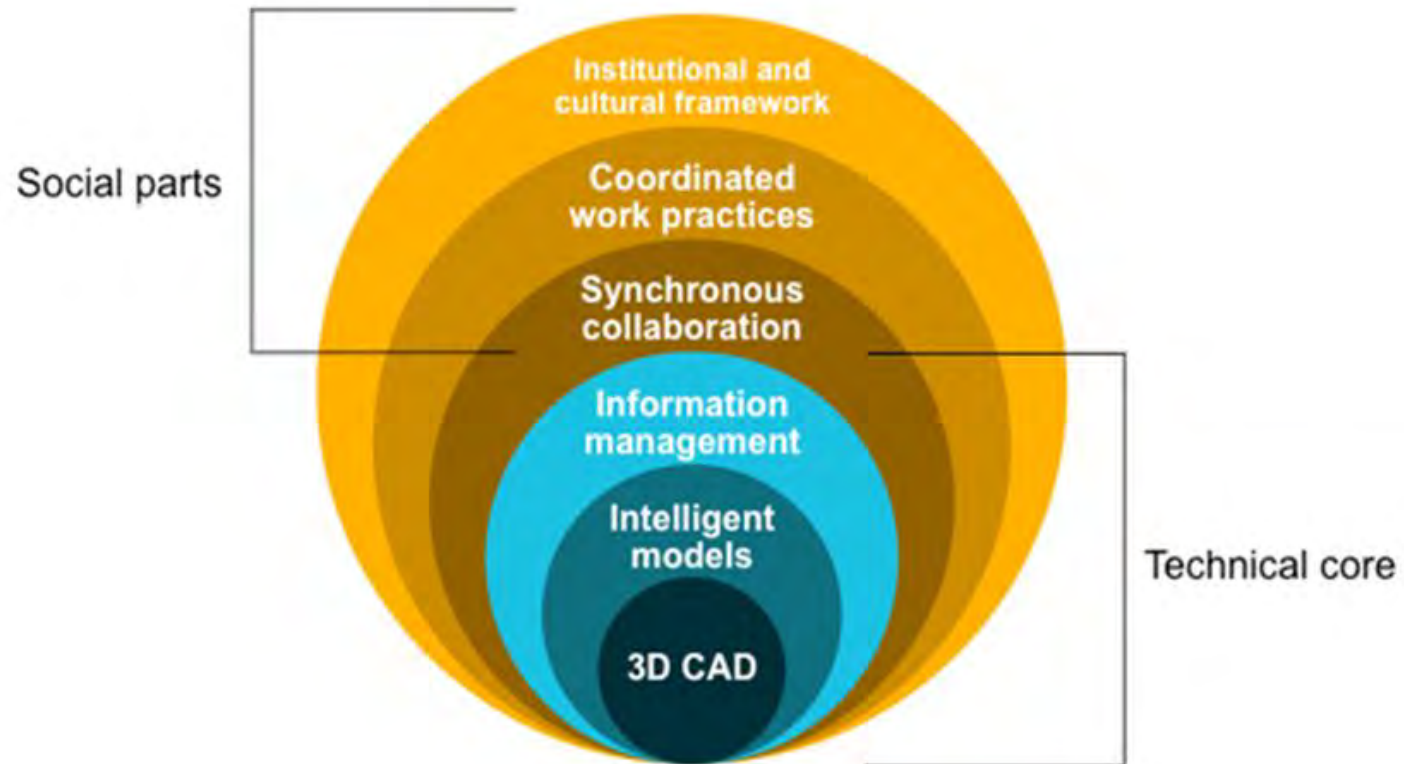
BIM Definition

- BIM is defined as a digital representation of the building process to facilitate exchange and interoperability of information in digital format (Eastman, 1999).
- According to the U.S. National BIM Standard (2007), BIM is “a digital representation of physical and functional characteristics of a facility and a shared knowledge resource for information about a facility a reliable basis for decisions during its life-cycle.”

BIM Basics



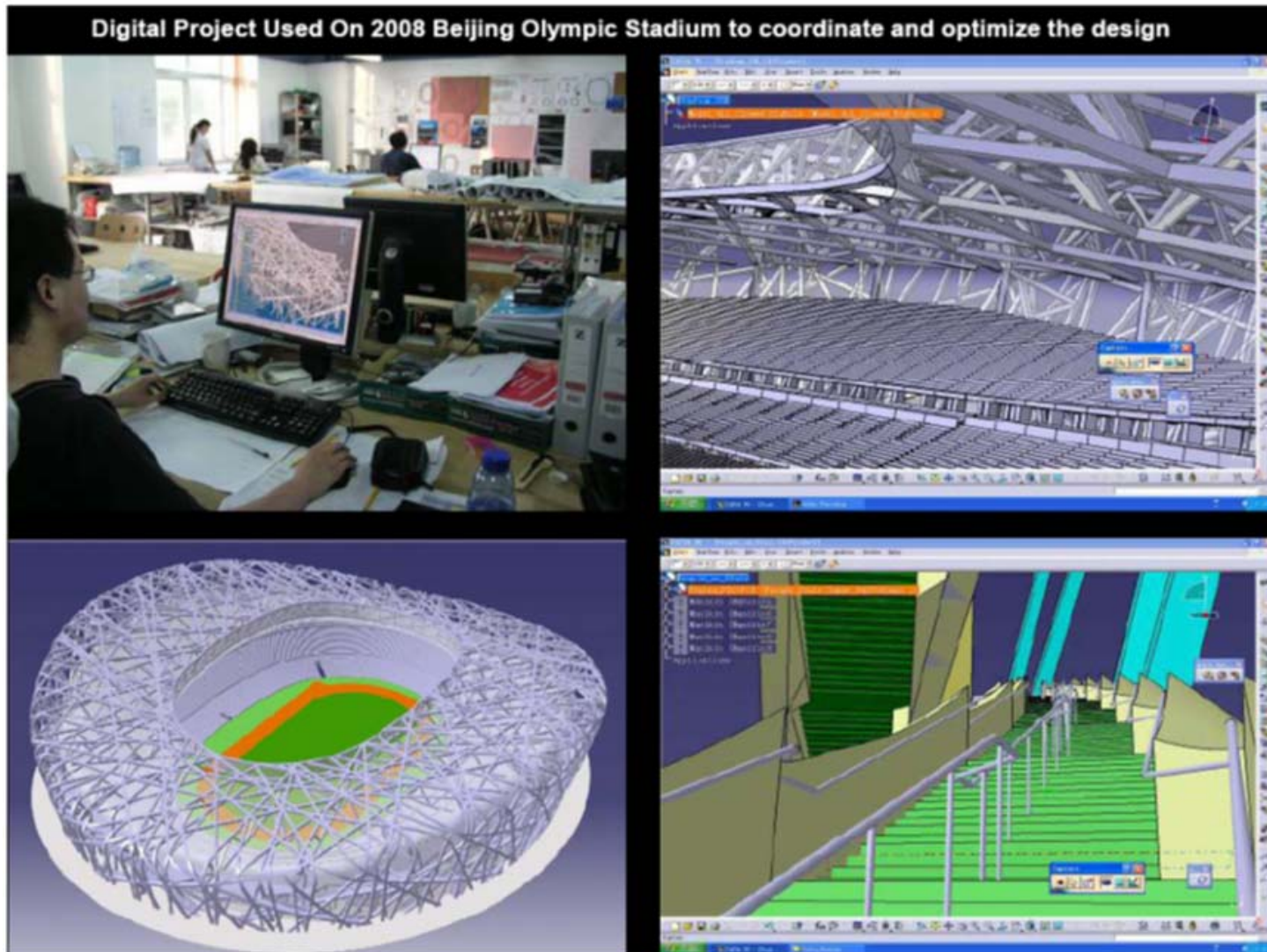
BIM Basics



BIM viewed as a sociotechnical system with a technological base and layers of social components

Image From:
Mondrup, T. F., Karlshøj, J., & Vestergaard, F. (2012). Communicate and collaborate by using building information modeling.
Paper presented at CIB W078 2012 Conference, Beirut, Lebanon.

BIM Basics



BIM Basics

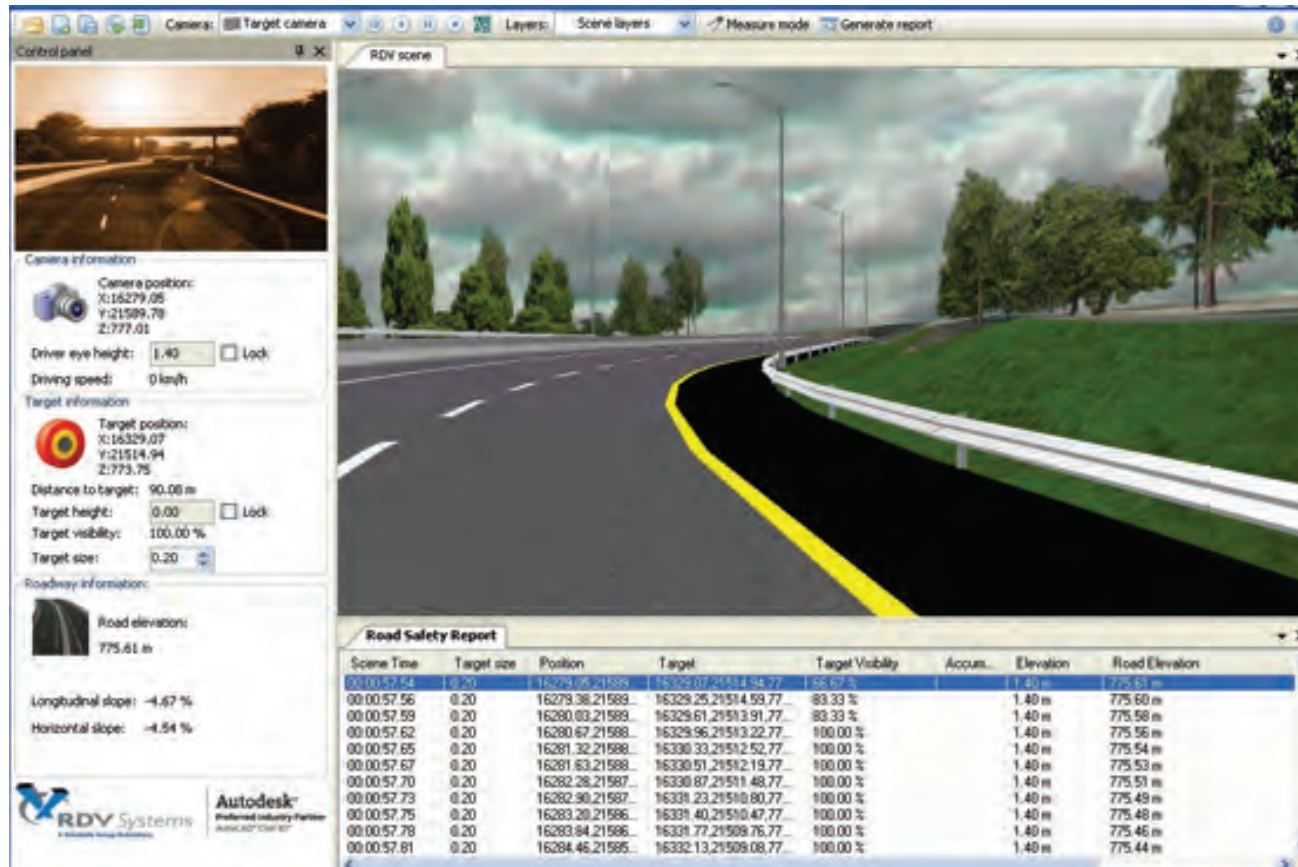
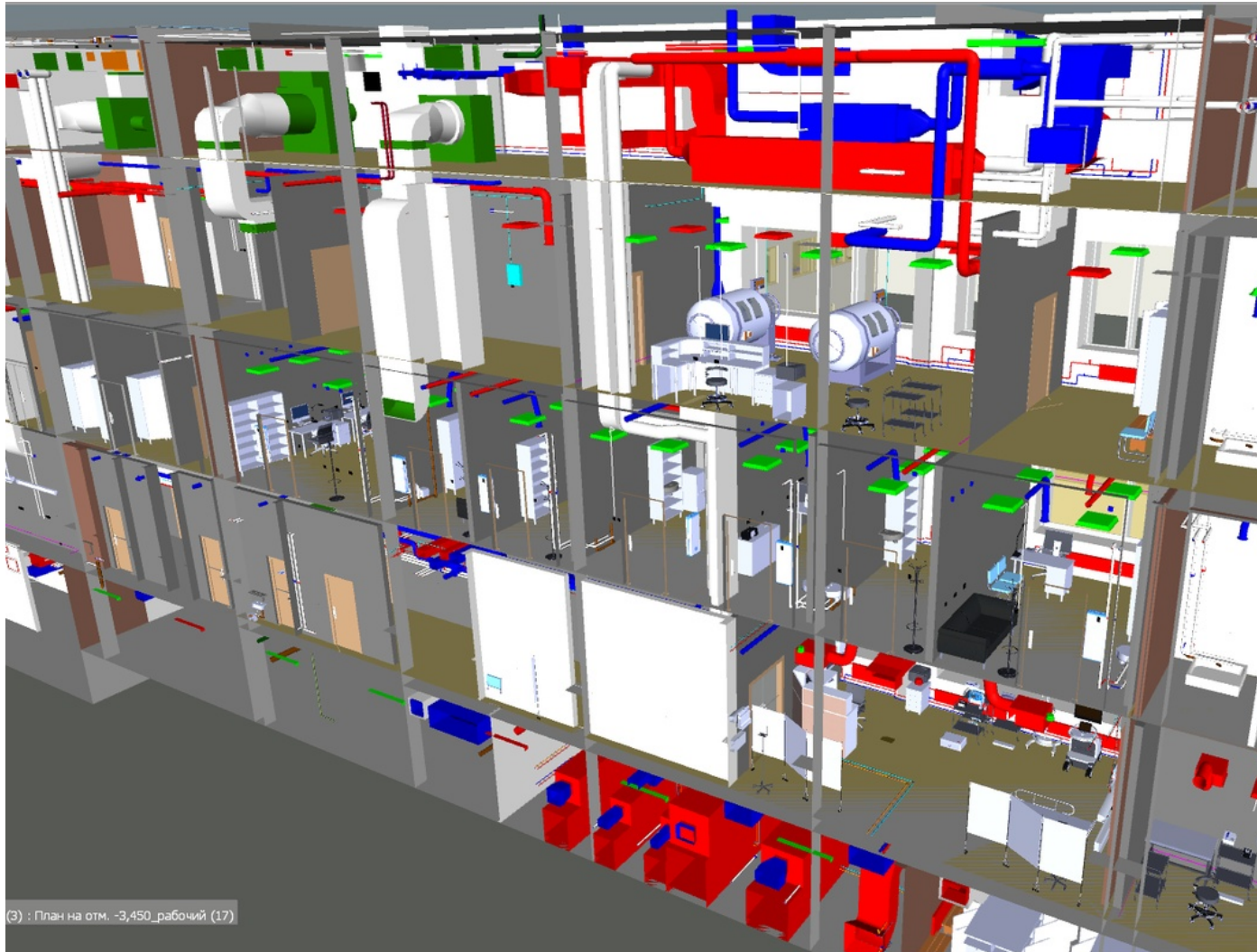


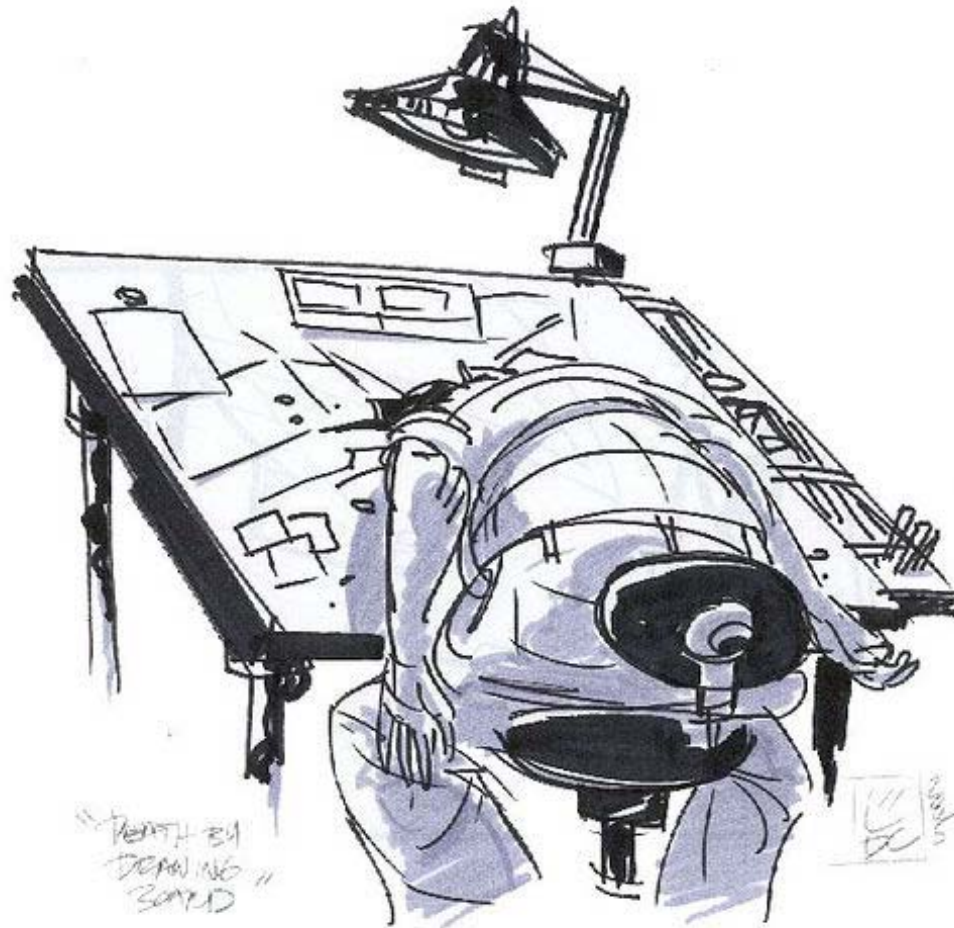
Figure 3: The Rapid Road Safety Analyzer from RDV Systems leverages the information model in AutoCAD Civil 3D, Autodesk's civil engineering software built for BIM, to identify whether the road geometry meets critical safety parameters.

BIM Basics



BIM systems model
Credit: WERFAU

BIM Basics



- Is it just for replacing the drawing board?
 - Is it simply another AutoCAD?

BIM Basics

- AutoCAD drawings only contain lines and arches, while BIM models contains information in each components.
- In a sense, design in a BIM environment is similar to playing Legos. You draw Lego pieces from a library, and form them into a BIM model.
- Three types of information contained in BIM:
 - (a) Geometric information includes size, volume, shape and spatial relationships,
 - (b) Semantic information information includes the type of individual construction component, specifications of material, construction schedule, and cost, and
 - (c) Topological information captures the dependencies of components.

BIM Usage Levels

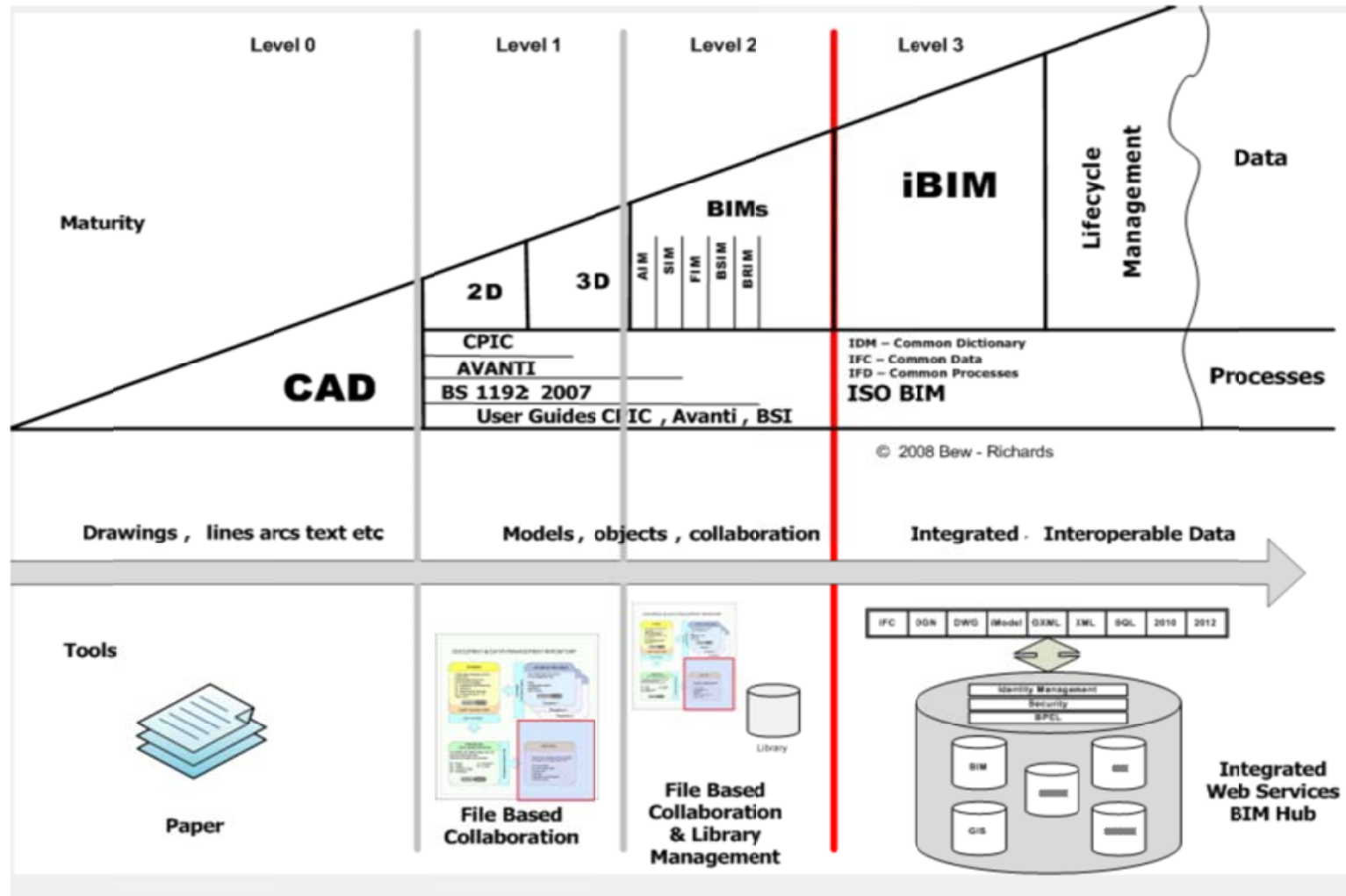


Figure 7: Maturity index illustrating the different levels of experience and approaches to BIM (BIM Industry Working Group of the BIS 2011)

BIM Usage Levels

1. Visualization



2. Coordination



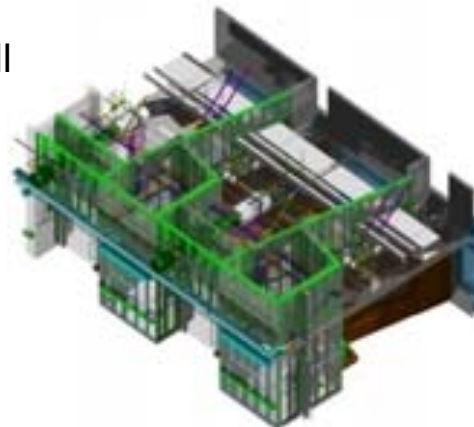
3. Constructability



4. Fabrication & Installation



Interior spaces and shell
 High-level MEP
 Fabrication-level MEP
 Everything...(?)



Visualization
 Permit Drawings
 High-level coordination
 Fabrication level MEP models, 4D Sequencing, 3D As-Built Models
 BIM Estimates, multi-trade racking, Supply Chain Management



Source: DPR Construction:
<http://dpr-review.com/fall-winter-2010/story/the-four-levels-of-bim>

BIM Trend

China	12 th 5-year plan (2011-2015)
UK	April 2016, for all central government clients to require BIM to be used on their projects.
USA	Compulsory for Government Project funded after 2017
Singapore	Compulsory after 2015
Hong Kong	The Hong Kong Housing Authority requires BIM for all its new projects after 2014.
Norway	Encouragement instead of Mandatory. For example, all projects of the state client Statsbygg have used BIM since 2010.
Denmark	Danish state clients such as the Palaces & Properties Agency, the Danish University Property Agency and the Defense Construction Service require BIM to be used for their projects.
Finland	The state property services agency, Senate Properties, requires the use of BIM for its projects by 2007.
Netherlands	Since 2012 the Dutch Ministry of the Interior requires BIM for large building maintenance projects.
South Korea	Compulsory for all large size projects and for all public sector projects by 2016.
Germany	National BIM standard has been completed in 2014.

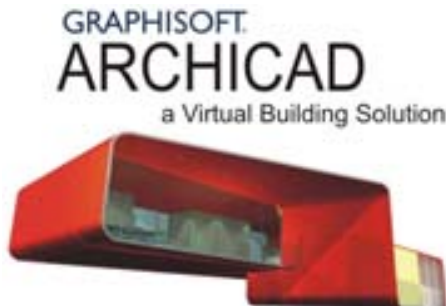
Note: Adapted from Zeiss (2013) and HKCIC (2014).

BIM Trend

- A Research and Markets study found that the international building information modeling (BIM) market will reach \$11.7 billion by 2022, with a compound annual growth rate of 21.6% between 2016 and 2022.
- The research firm said it expects the Asia-Pacific region to experience the most growth in demand due to its rising construction activity and the push of BIM mandates.
- BIM is growing in all areas of construction around the world, and adoption — especially in Asia — has been driven by emerging BIM mandates, a thriving real estate market and acknowledgment by contractors and other industry player of the benefits of BIM.

BIM Software

- A variety of commercial software packages such as ArchiCAD, the Dassault Systemes (DS), AutoCAD Revit Architecture, AutoDesk NavisWorks, can be put under the umbrella of BIM, although one should not simplistically equate BIM with them.



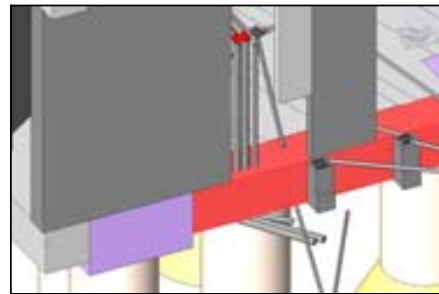
Autodesk



BIM Software: Building



Revit (BIM Modeling)



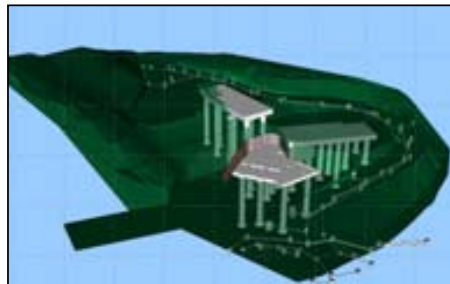
Navisworks (Collision Check)



Navisworks (4D Simulation)



3D Max (Photo-realistic Rendering)



Civil 3D (CE/GE Design)



Viewers (Viewing / Markup)



Ecotect (Performance Analysis)



Solibri (Code Checking)

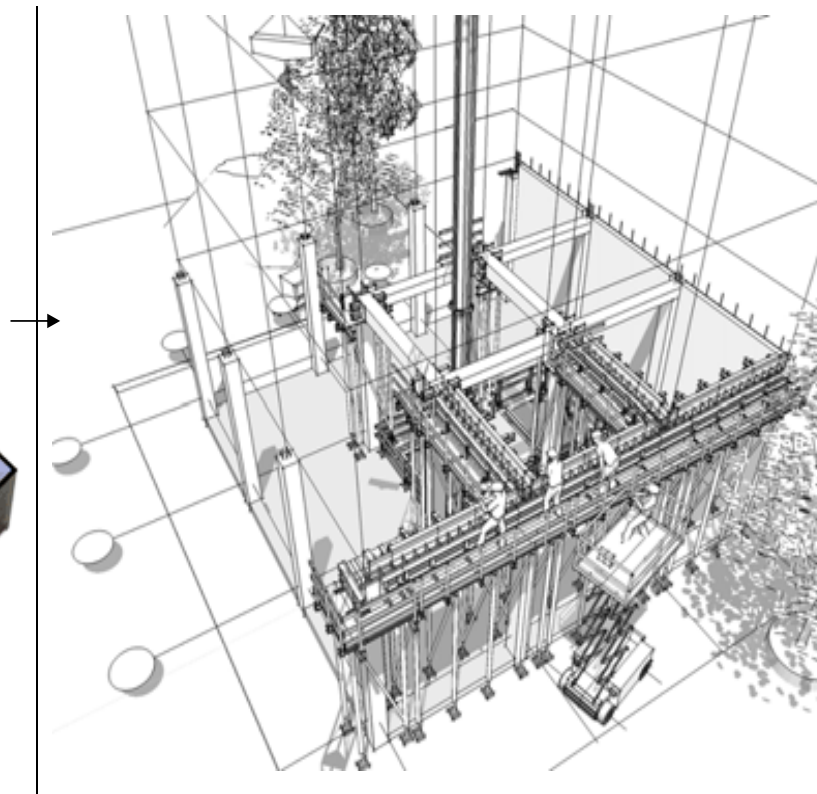
Type	Size	Duct Schedule	
		Top Elevation	Length
rod	1130-200	2070	17402
rod	1130-200	2070	867
rod	850-400	3075	3008
rod	250-250	2070	1457
rod	200-250	2070	4240
rod	1130-200	2070	2003
rod	750-200	3330	334
rod	450-250	3405	2838
rod	300-250	3435	3271
rod	450-250	3025	3940
rod	300-250	3075	8071

Cost X (Material Quantities)

BIM Benefits

- A. Fostering novel design

From 2D - 3D Design



BIM Benefits

- A. Fostering novel design

From 2D - 3D Design

The screenshot shows a search for 'chairs' on Google 3D Warehouse. The search bar contains 'chairs' and the results are sorted by relevance. There are nine search results displayed in a grid, each with a thumbnail image of a chair, the creator's name, a brief description, and a 'Download to Google SketchUp' link. The results include:

- Chair by [Acom](#): Wrought iron garden chair,...
- Chair by [MusicResponder](#)
- Chair by [Lori Allseits](#): Chair - edited from 3D...
- Chair by [Acom](#): This is one strange chair...
- Chair by [Chuk Norris!](#): Just a chair for your den or...
- Chair by [Titanic Master](#): This is a nice chair what in...

On the right side of the screenshot, there is a blue button that says 'Download Google SketchUp' with the text 'For Windows XP/Vista & Mac OS X (10.4+)'. Below this, there is a section for 'Google SketchUp Pro 7' with a description: 'SketchUp Pro, LayOut and Style Builder - a powerful combination.' It includes links to 'Learn more about Google SketchUp Pro >', 'Try Google SketchUp Pro 7 >', 'Find out about our SketchUp for Education program >', and 'Find out about our Go Green initiative >'. Below this is another section titled 'Experience the 3D world' with the text 'More Google tools to use with SketchUp:' and links to 'Google Earth', 'Google 3D Warehouse', and 'Building Maker'. At the bottom of this section is the text 'Make buildings for Google Earth' and a circular diagram showing icons for a pencil, a globe, and a tractor.

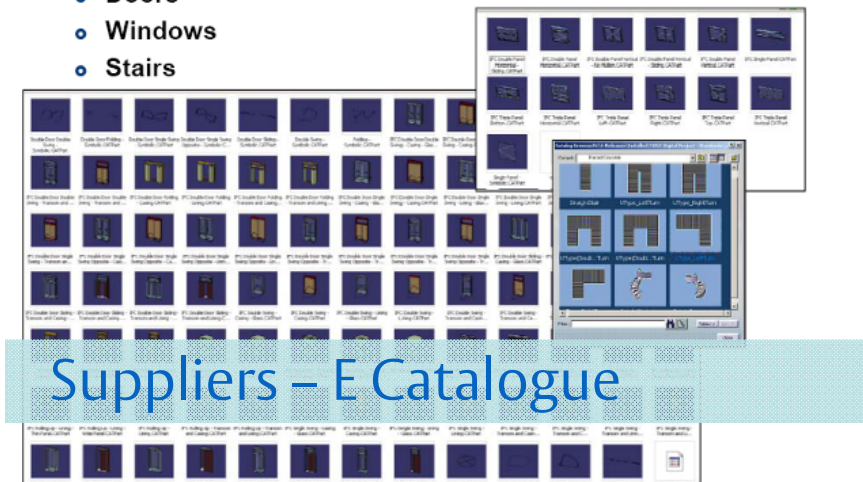
BIM Benefits

- A. Fostering novel design

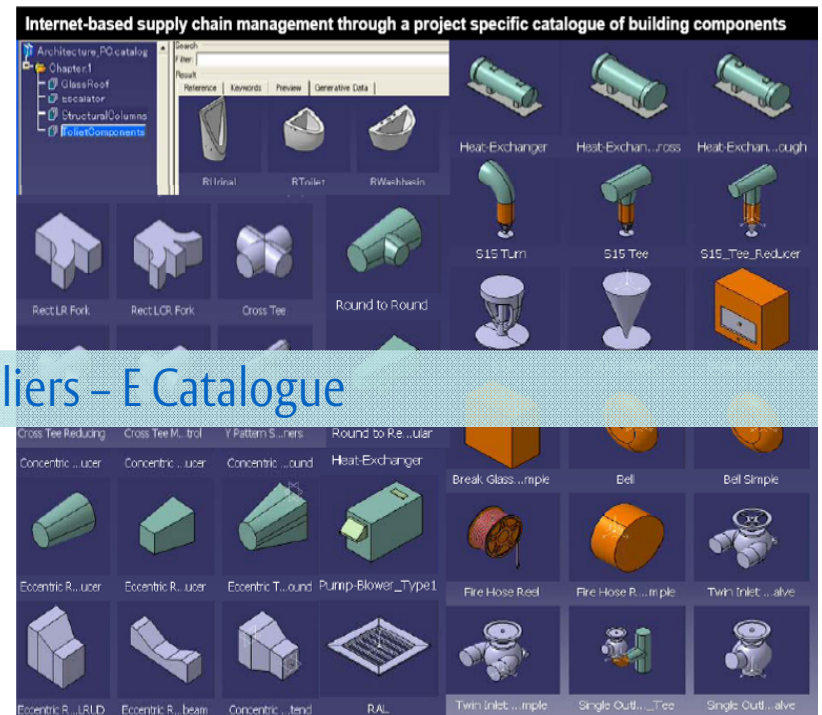
From 2D - 3D Design

Industry Foundation Classes (IFC) Compliant
Parametric Components

- Doors
- Windows
- Stairs



Suppliers – E Catalogue



Suppliers – E Catalogue

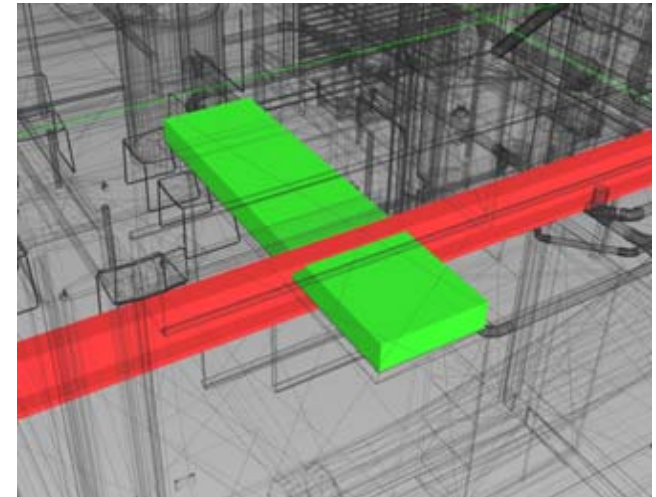
BIM Benefits

- A. Fostering novel design
- Design and Simulate: Lighting, Acoustics, Thermal, Visual, etc.



BIM Benefits

- B. Design error detection
- BIM-based designer errors detection has been and is still one of the most widely implementable functions that can bring direct, immediate benefits.
- Clash is a typical design error.
- There may be:
 - Hard clashes: two objects occupying the same space
 - Soft clashes: objects that demand certain spatial/geometric tolerance or buffers or buffers having objects within their buffer zone for access, insulation, maintenance or safety
 - Workflow clashes: clashes for work crews, equipment/materials fabrication, delivery clashes, and other project timeline issues.



BIM Benefits

- C. Construction site and project management

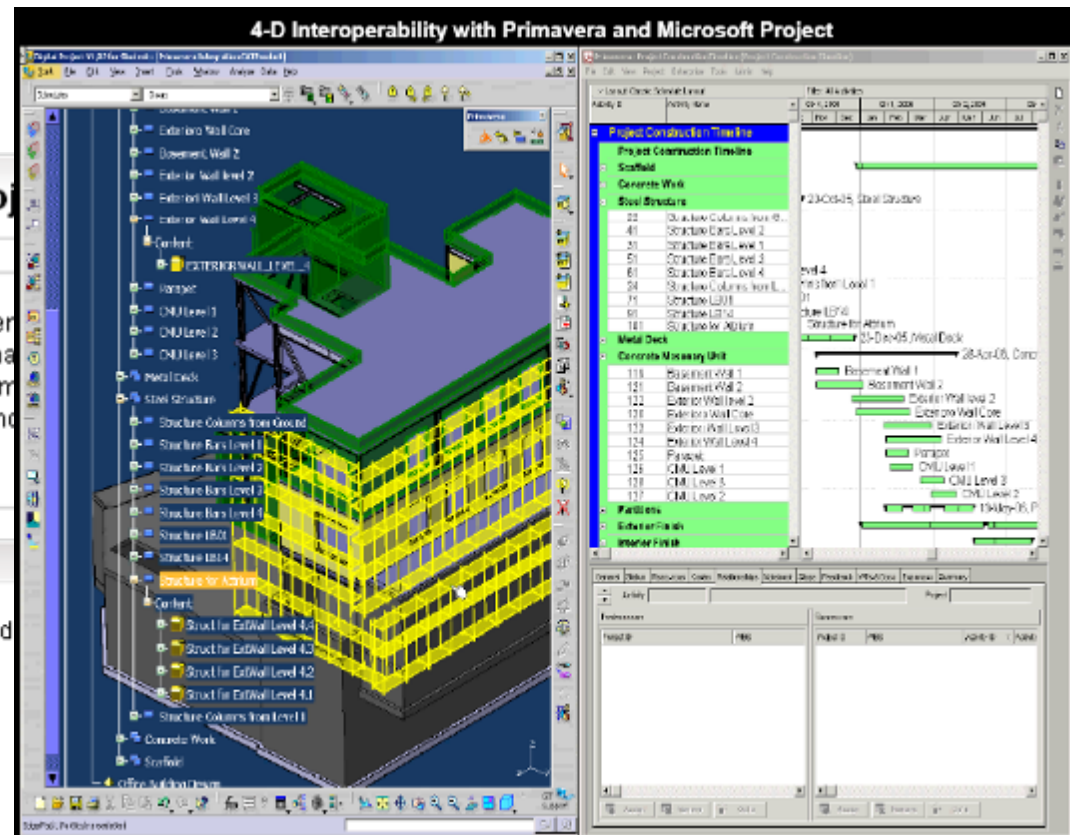
From 3D or nD

Oracle's Primavera P6 Enterprise Project Portfolio Management

Oracle's Primavera P6 Enterprise Project Portfolio Manager is a powerful tool for executing projects, programs and portfolios. Oracle's Primavera P6 Enterprise Project Portfolio Manager comprises role-specific functionality to satisfy each team member's needs. It adapts to various levels of complexities within a project, and provides a single source of truth for your project team.

BENEFITS

- Plan, schedule and control large-scale programs and individual projects
- Select the right strategic mix of projects
- Balance resource capacity
- Allocate best resources and track progress
- Monitor & visualize project performance vs. plan
- Foster team collaboration
- Integrate with financial management and human capital management systems

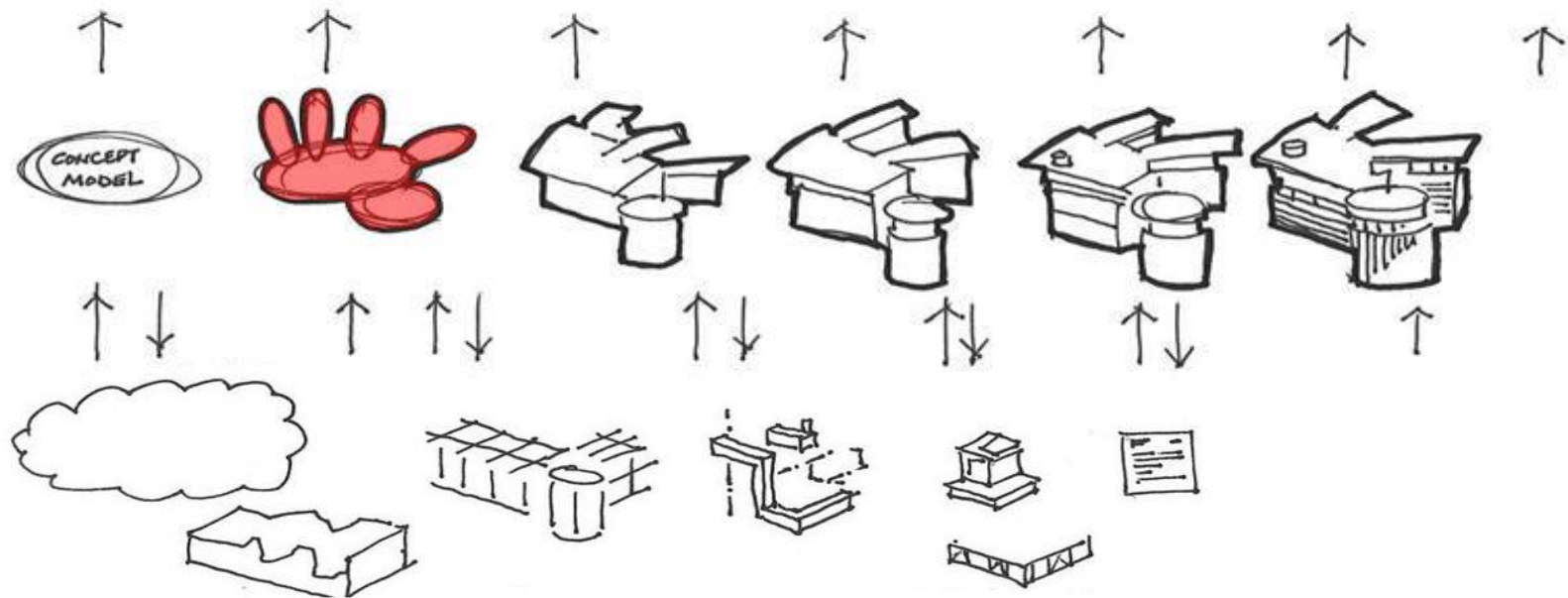


BIM Benefits

- C. Construction communication
- D. Construction plan rehearsal and optimization
- E. Detection of unsafe areas
- F. Project information and knowledge management
- G. Whole life cycle costing approach

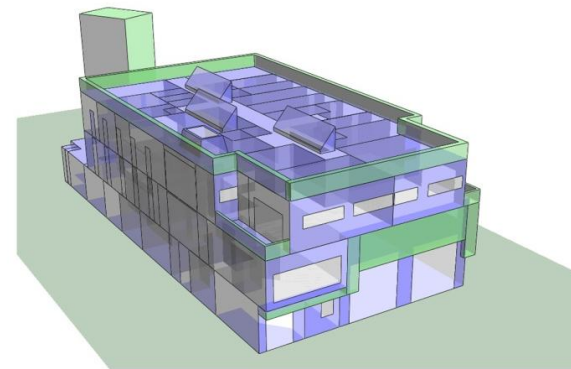
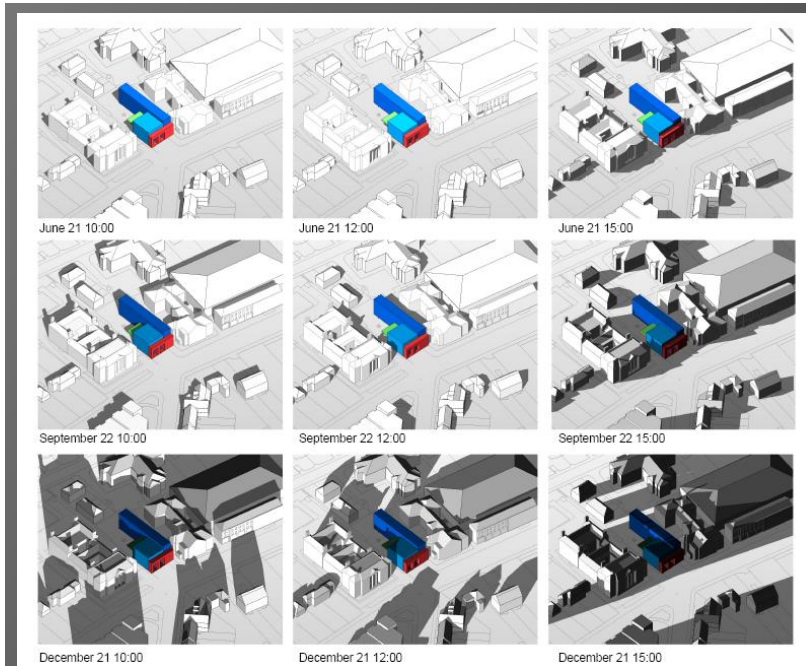
BIM Process

- Concept Phase

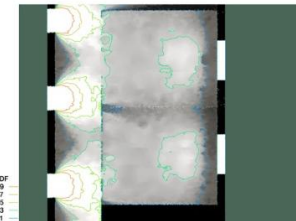


BIM Process

- Concept Phase: Environmental Assessment



DF 075531
First floor corridor



DF 075531
'Borrowed light' to Station Manager

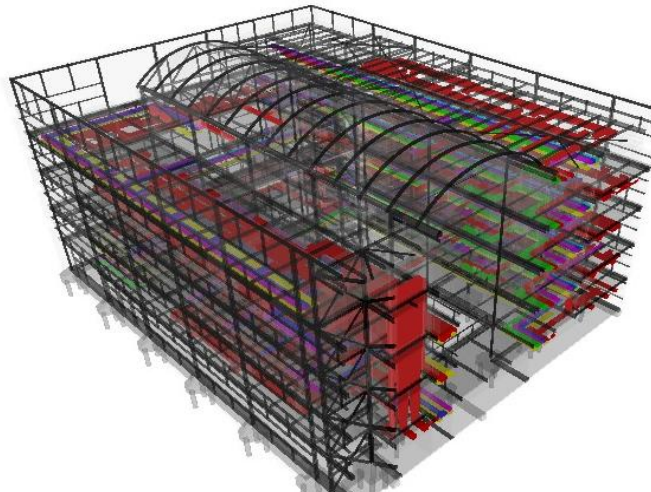
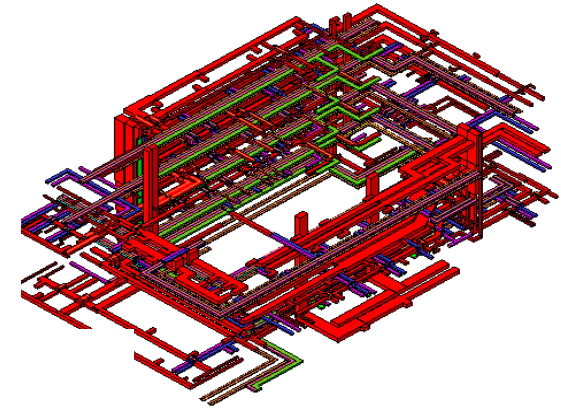
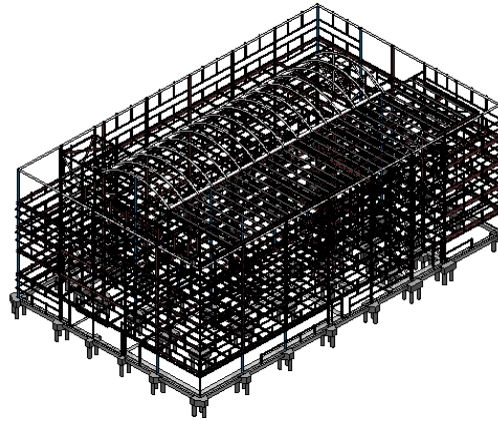
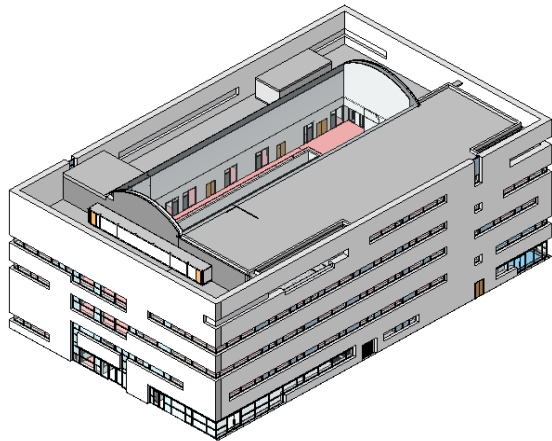


DF 075531
Daylight to appliance bay

Early stage daylight studies

BIM Process

- Design Development: Design Integration



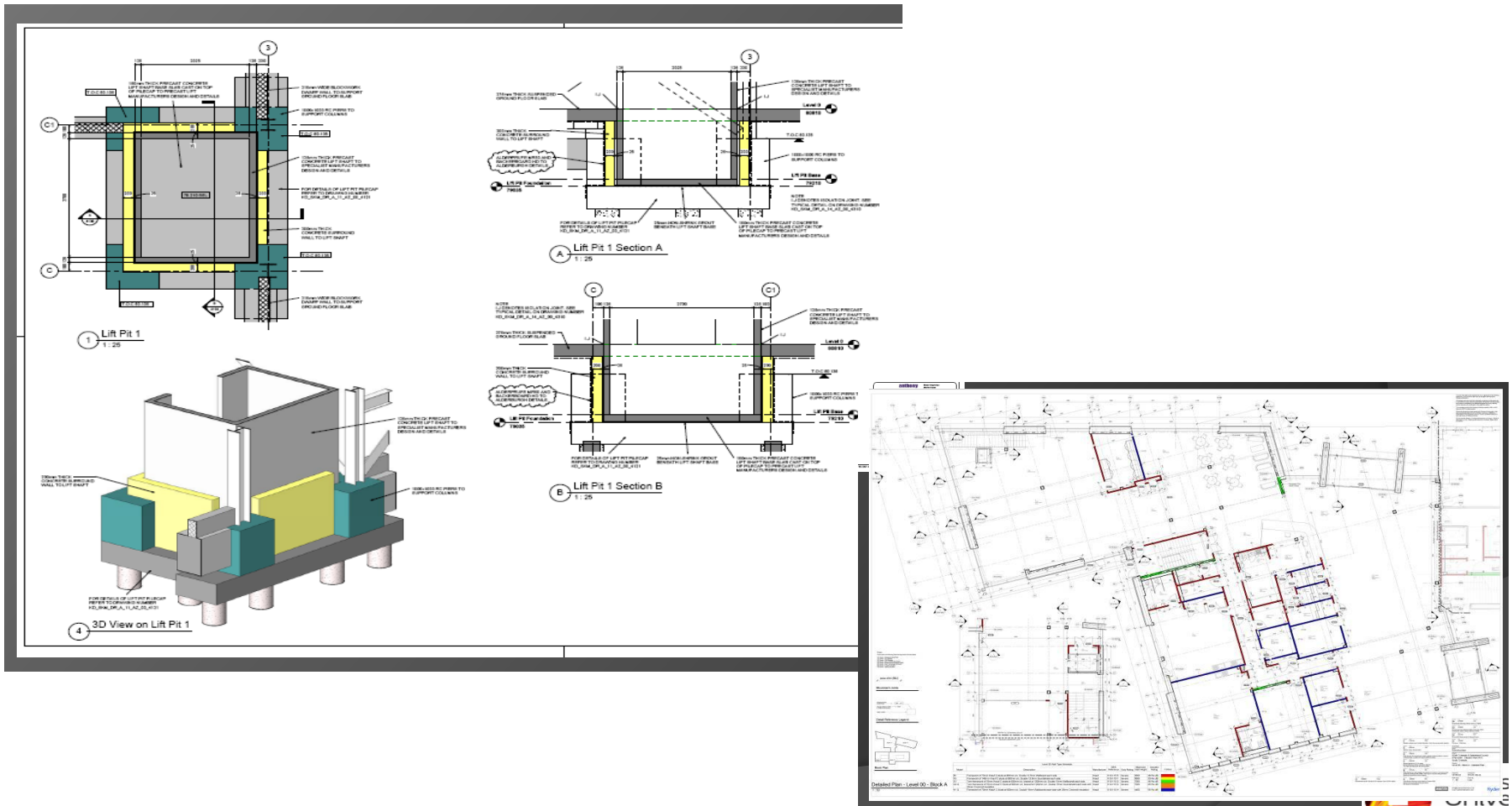
BIM Process

- Design Development: Floor Detailing



BIM Process

- Technical Design: Quantities, Components and Scheduling, Specification and Keynoting



BIM Process

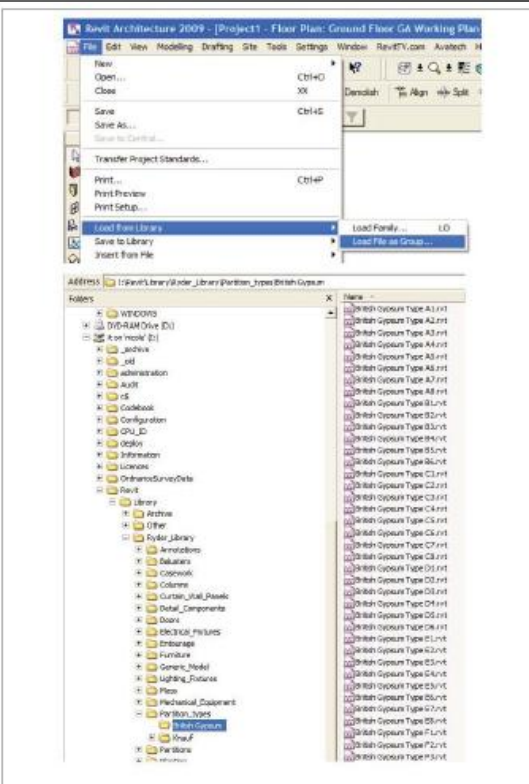
Standardization: Such as Doors

5.0 Importing Partitions into Revit Model

Load partitions into the Revit project model as a group.

The partition catalogue can be found at I:\Revit\Library\Ryder_Library\Partition_Types

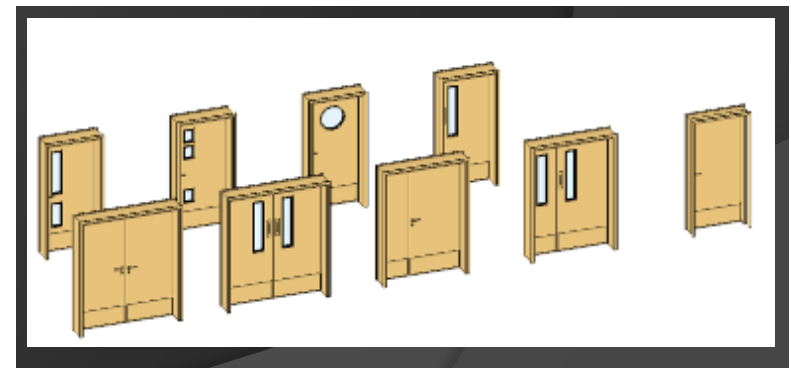
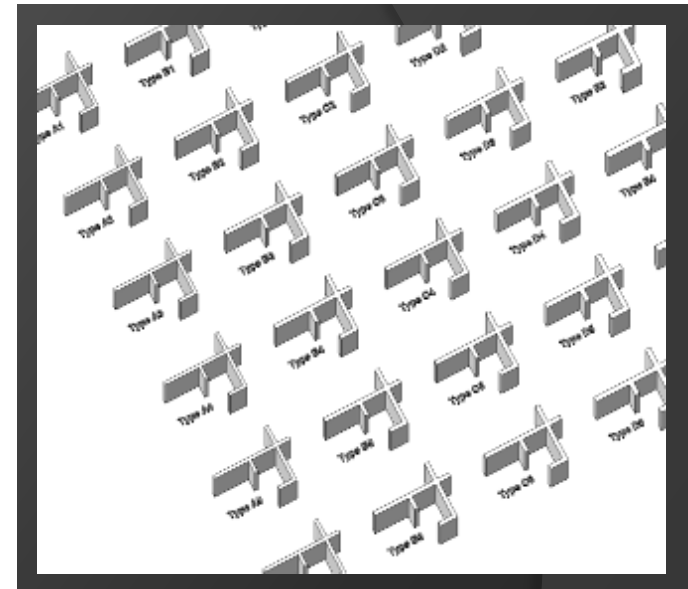
To load the partitions into the project model select file, load from library, load file as group.



Detail 16
Deflection head to underside of roof
1 : 5

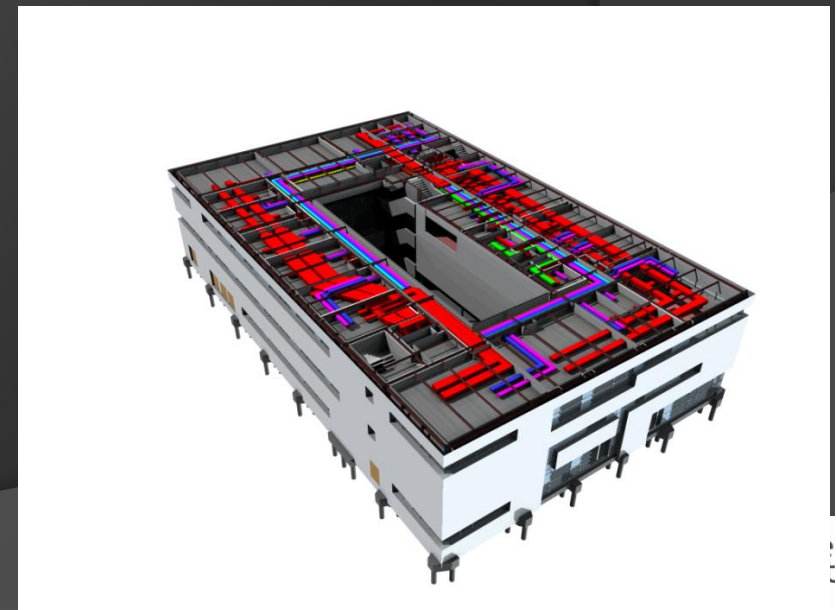
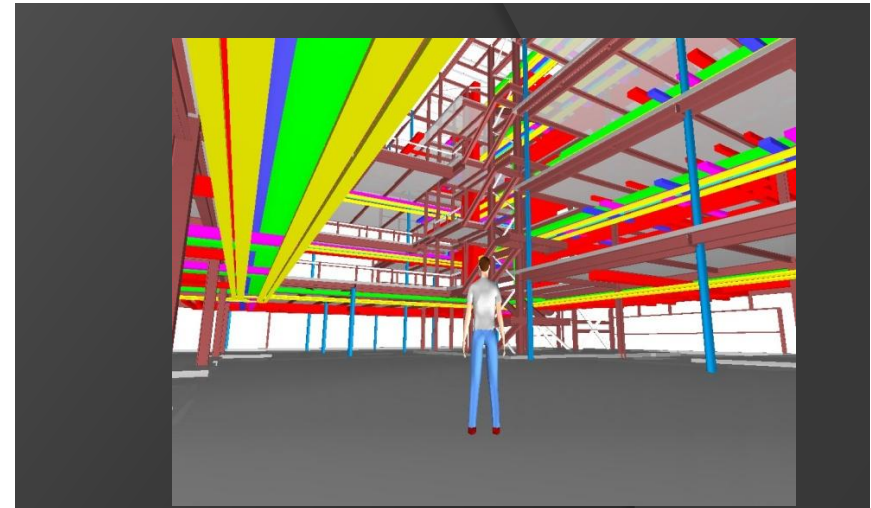
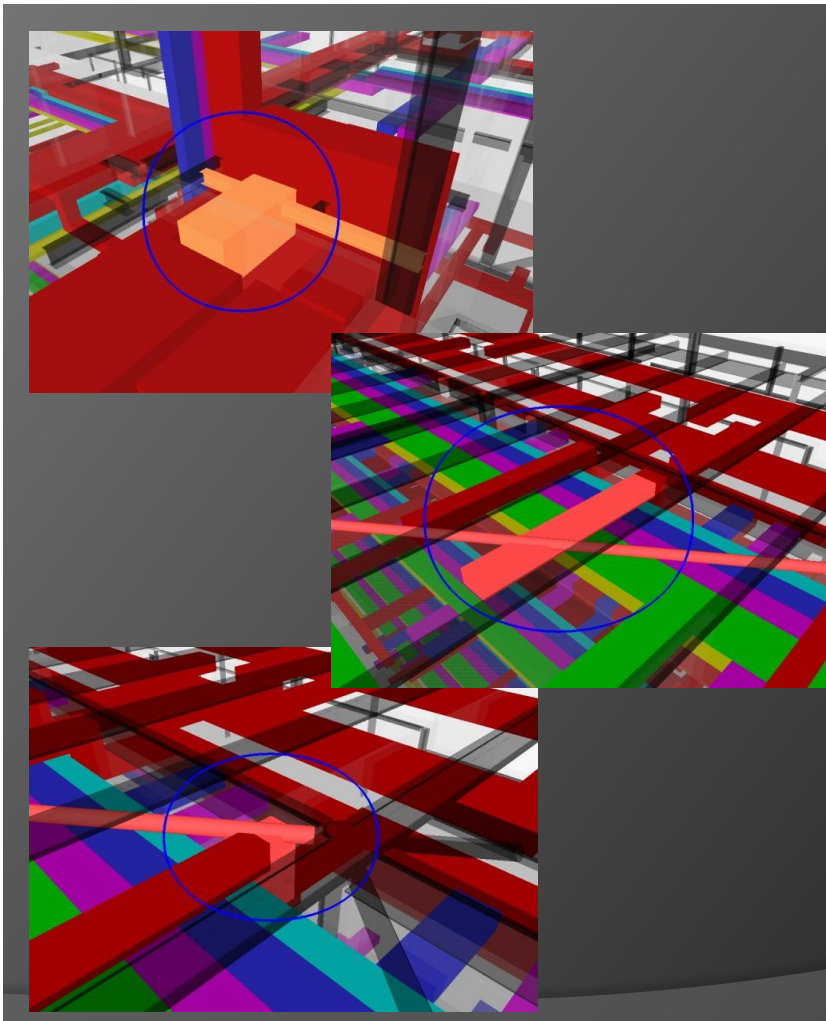
Detail to be read in conjunction with GA plan, partition schedule and NBS specification

Importing Partitions into Revit Model



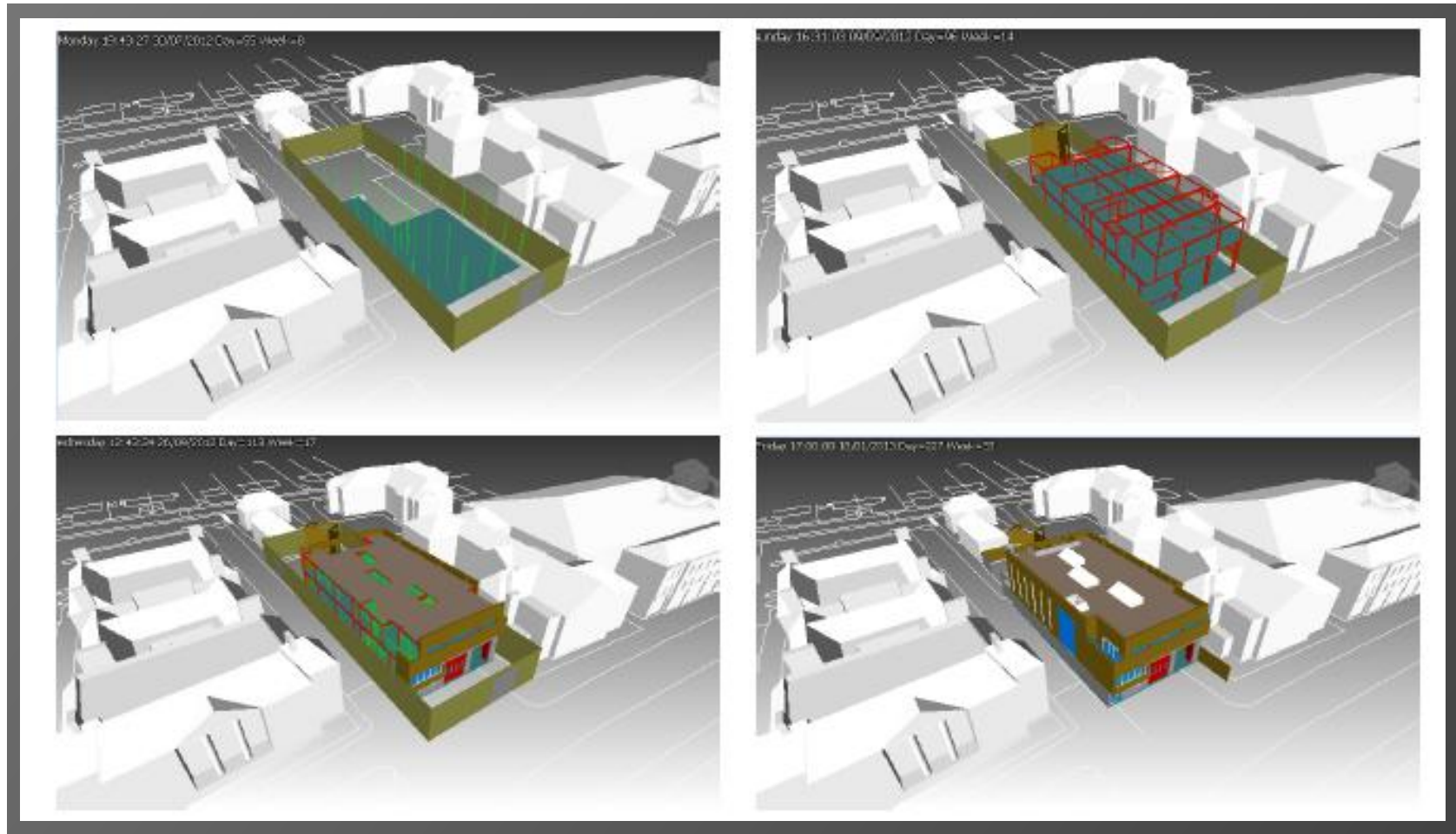
BIM Process

- Design Coordination



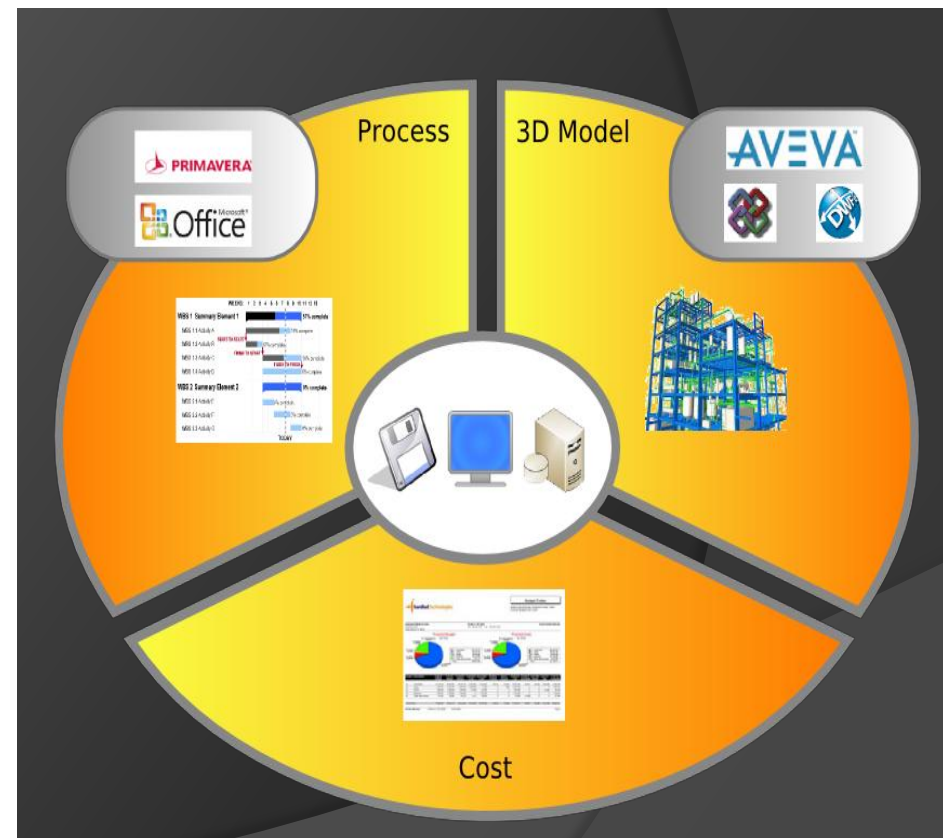
BIM Process

- 4D Planning: 3D + Time



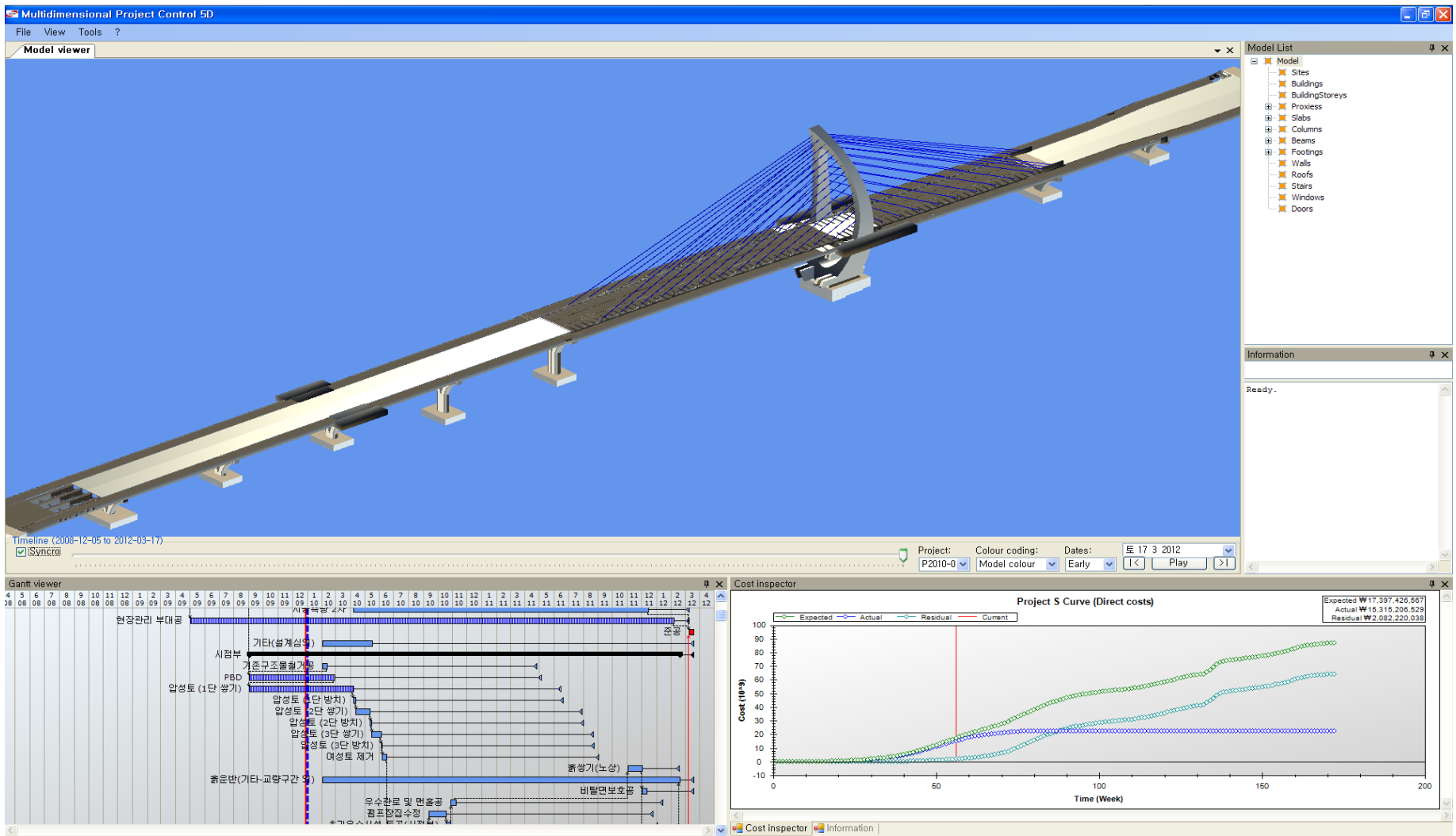
BIM Process

- 5D Planning: 3D + Time + Cost
 - Quantity takeoffs
 - Cost library linking
 - Review and analysis
 - Supply chain management



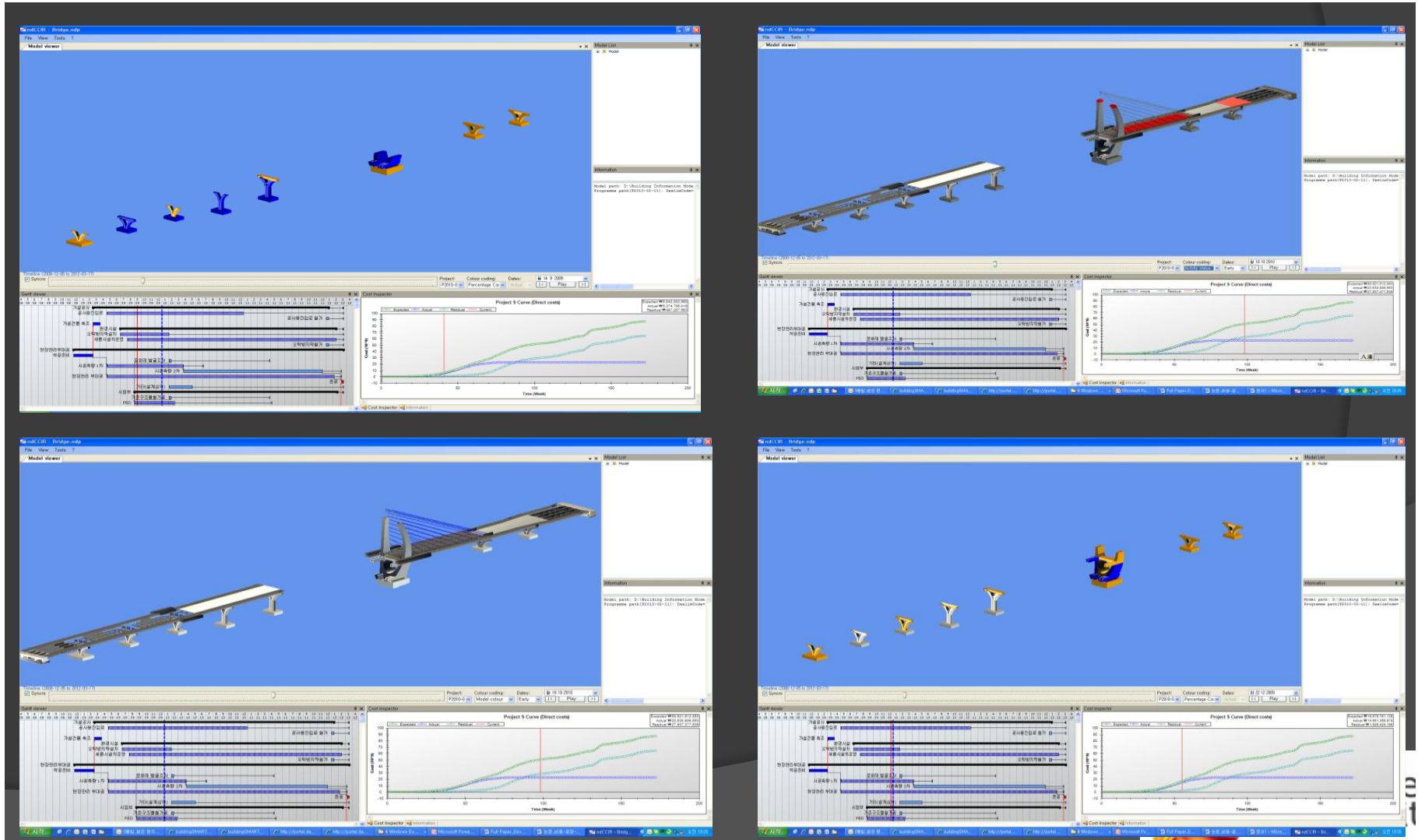
BIM Process

- 5D Planning: 3D + Time + Cost



BIM Process

- 5D Planning: 3D + Time + Cost



BIM Process

- 5D Planning: 3D + Time + Cost

The screenshot displays the ndCCIR - Bridge.ndp software interface, which integrates 3D modeling, project scheduling, and cost management. The main 3D model shows a bridge structure with a cable-stayed design. A 'Product information' dialog box is open, providing details for a steel beam:

- Manufacturer: VSL
- Manufacturer's URL: <http://www.vsl.com>
- Material: Steel
- Strength: 180MPa
- Cable Type (only for cables): Paralle Strand Cable
- Cable Section (only for cables): $\phi 15.7\text{mm}-103\text{EA}$
- Cable Diameter (only for cables): 315mm

The 'Model List' on the right shows a hierarchy of elements, including columns and beams (e.g., Beam 1 to Beam 19). The 'Information' panel provides detailed data for a selected beam (Beam 19):

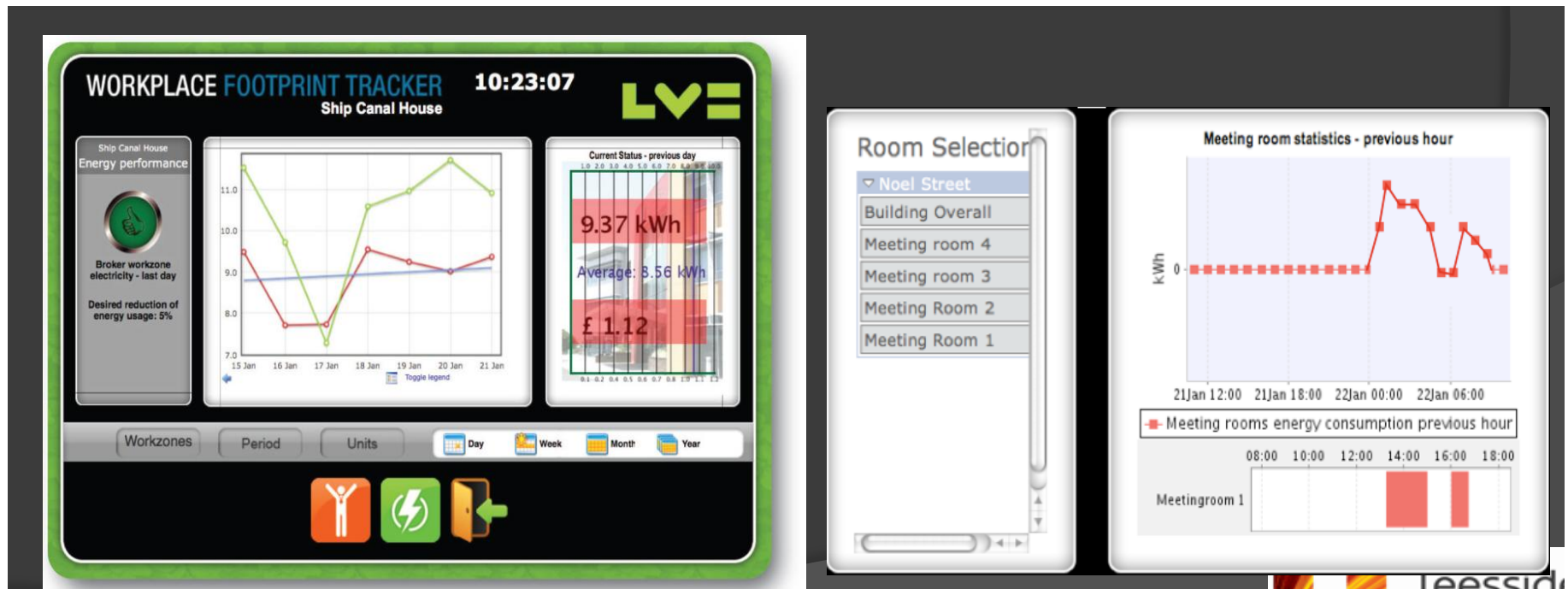
- Object: 'Beam 19(?? ??:400mm:660242)'
- Tag: C12504C451625050-1
- Size: 98,494
- Area: 250,062,400kxy
- Vol: 10,914,290,000,000
- Bounding box: Min: 107103.2, Max: 8609.069
- Linking information: P2010-02-11: C12504C451625050 / 거머설거

The 'Gantt viewer' at the bottom left shows a project schedule from 2008-12-05 to 2012-05-17, with tasks such as '공사용진입로' (Construction access road) and '시공속량 1차' (Construction acceleration 1st phase). The 'Cost Inspector' at the bottom right displays a 'Project S Curve (Direct costs)' graph, plotting Cost (10^9) against Time (Week). The graph compares Expected, Actual, Residual, and Current costs over a 200-week period. A summary table indicates:

Expected	₩67,511,551,919
Actual	₩22,626,168,399
Residual	₩44,832,055,529

BIM Process

- 6D Planning: 3D + Time + Cost + Sustainability
 - Post Building Performance Monitoring
 - Technology Integration
 - Internet based energy management system
 - Reducing energy wastage and running cost

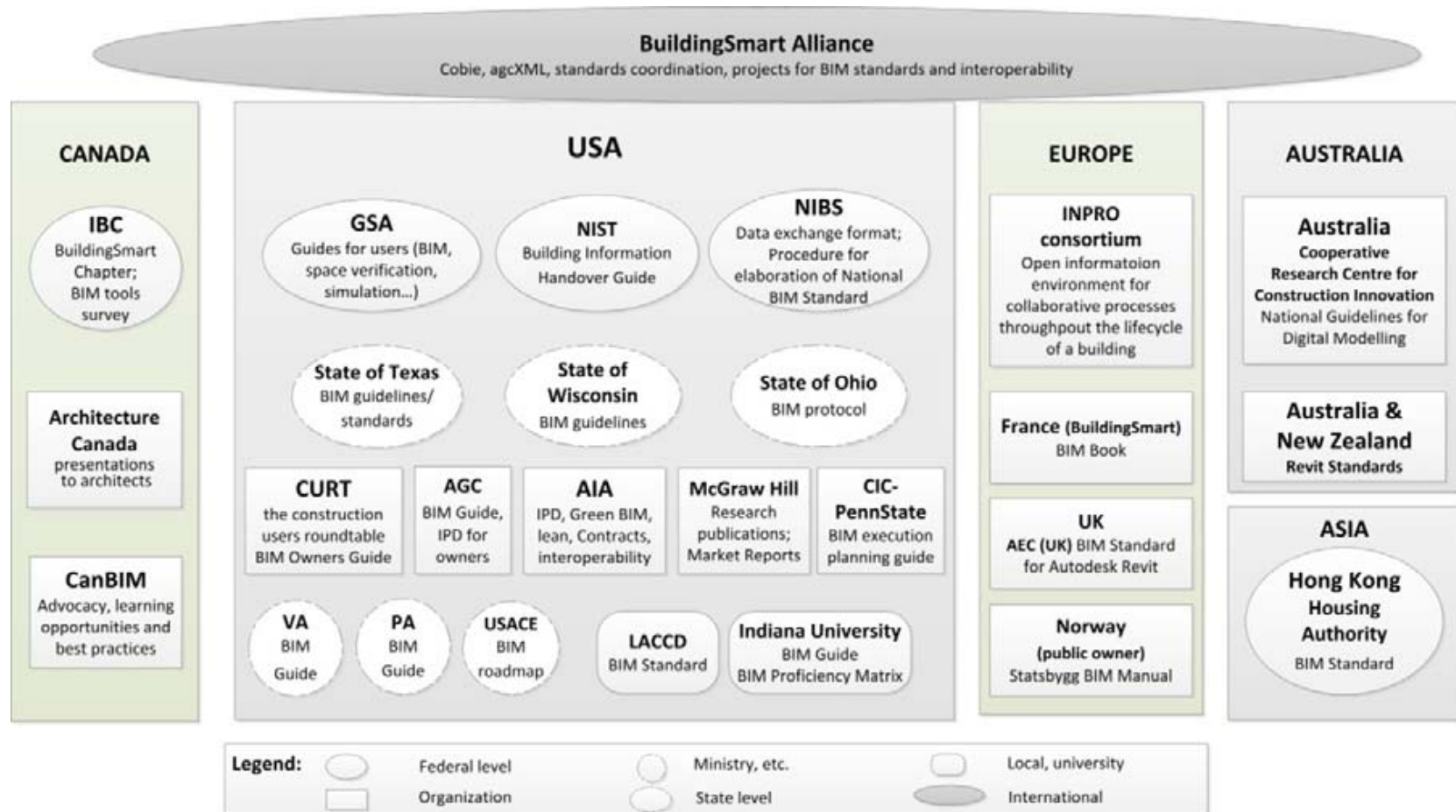


BIM Challenges

- Technical challenges
 - BIM is supposed to improve interoperability but existing BIM solutions present a new challenge; the lack of software compatibility makes it difficult to communicate between different BIM solutions, Industry Foundation Classes (IFC).
 - Design speed is another problem when using BIM in real-life projects. It takes a long time to create all the detailed 3D models of building, temporary work and plant, to the desired level of detail and accuracy (Huang et al., 2007).
- New costs
 - While bringing many benefits, BIM increases cost. Companies face the extra cost of learning BIM and unlearning their old approaches.
 - The cost–benefit relationship of BIM needs to be quantitatively measured (e.g. Gilligan and Kunz, 2007; Huang et al., 2007).

BIM Challenges

- Lack of legal framework
 - Standards: UK, USA, etc. have developed standards



BIM Challenges

- BIM and Project Delivery Method
 - Deep BIM implementation requires collaboration among parties, and Integrated Project Delivery Method is recommend often

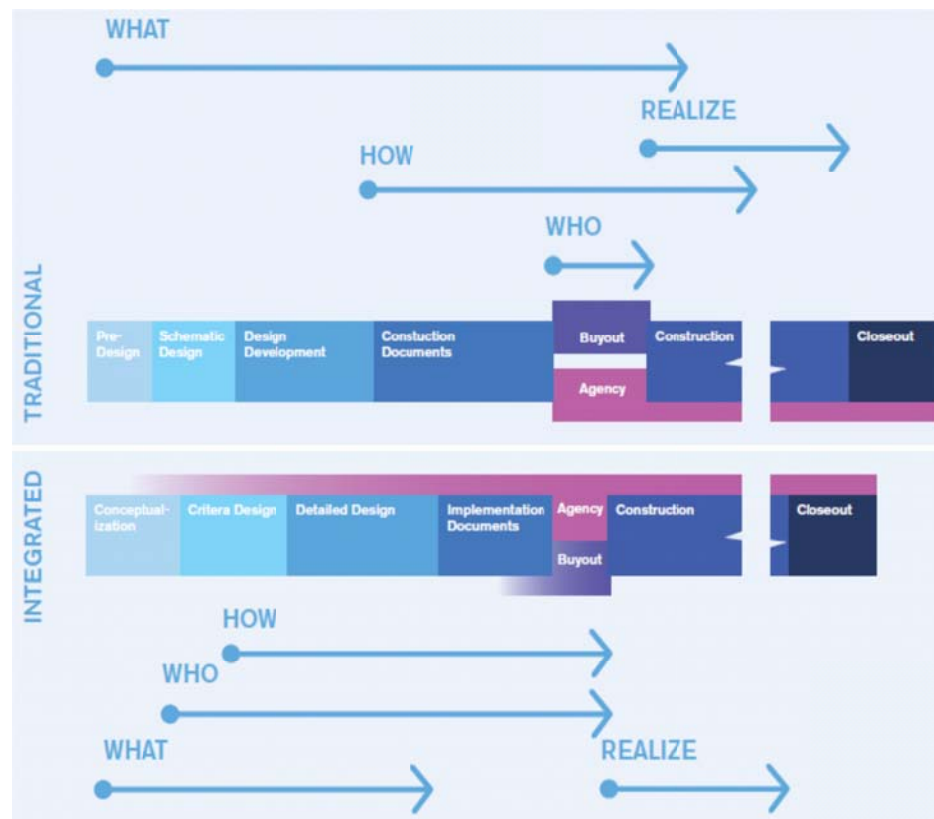


Figure 3: Differences between Integrated and Traditional Project Delivery (AIA California Council 2007)

References:

- Lu, W. (2017). *Introduction to Building Information Modelling (BIM). Presentation, Addis Ababa, Ethiopia.*
- Staub-French, S. (2012). Organizing BIM Projects: Issues and Lessons Learned, BIM Workshop, University of Alberta, Edmonton, Canada.
- Dawood, N. (2012). BIM? A whole Life Cycle View, BIM Workshop, University of Alberta, Edmonton, Canada.