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Transforming the Built Environment

المعهـد القطـري
للتصميم والتشـييد الفعّال
تغييـر بيـئة تصمـيـم وتشـيـيـد المشـاريـع

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Keep on Learning!

BIM as catalyst for enabling Lean practices towards transforming design and construction

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Webinar Facilitator

Nicos Dimos
Managing Director
i-Tekton P.C.

Webinar Facilitator

Theofanis Fanourakis
MSc, CM-Lean Sr. BIM Manager
Turner International Middle East (TIME) – Qatar
Associate Director of Collaborative Practice ExCom - LCI-Q

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The inefficiencies of Construction industry currently:

- Excessive waste
- Low profit margins
- Major risk
- Overruns in budget and schedule

Traditional Design and Construction environment

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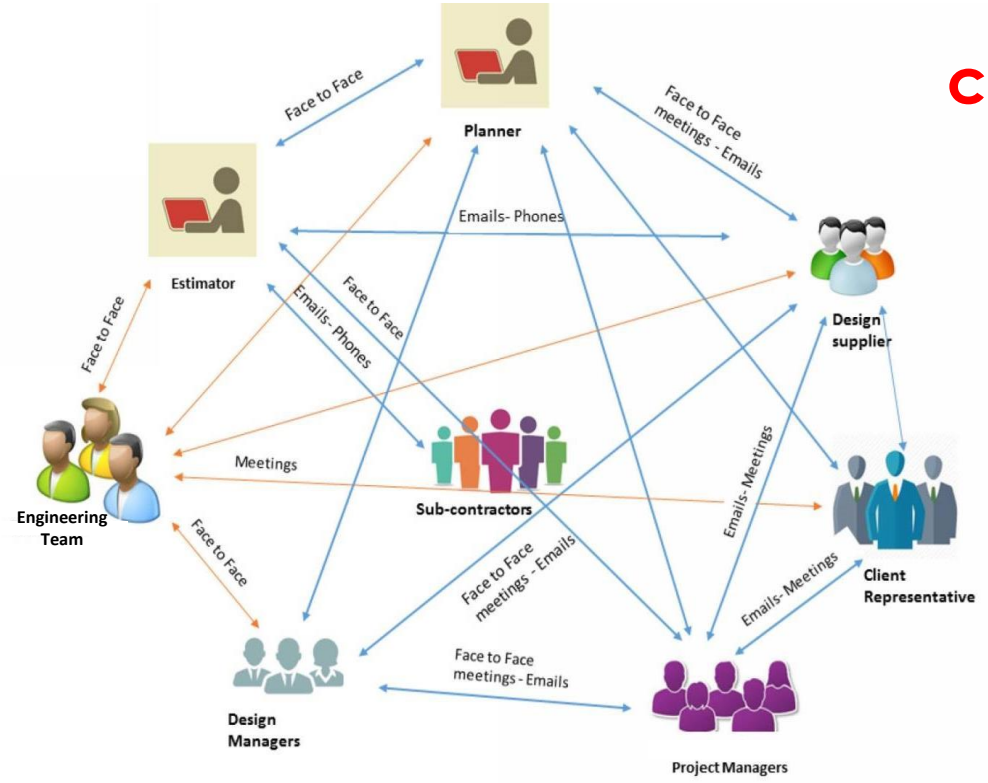
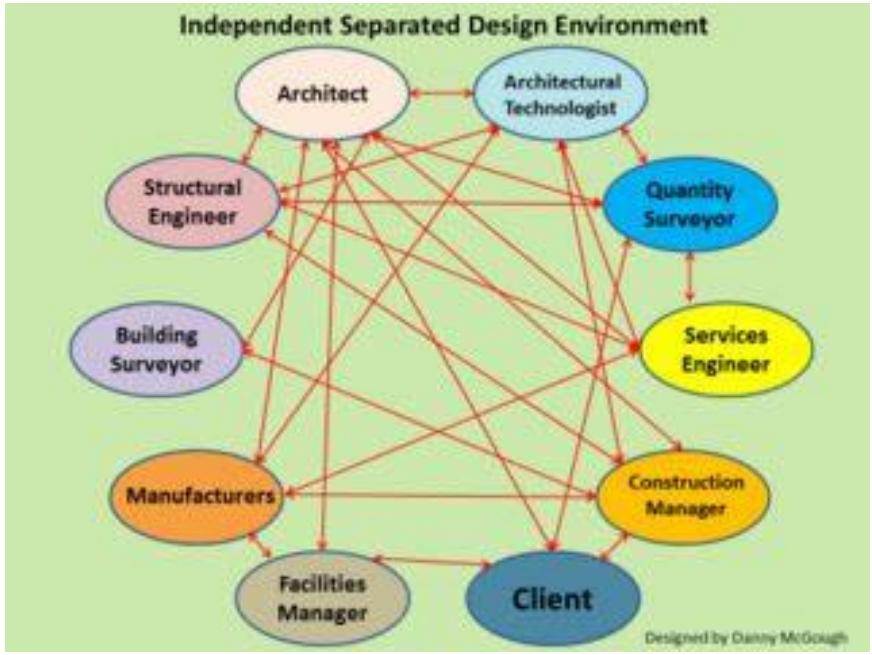


Fragmentation of communication in traditional design & construction environment



Project Deliverables and Handover Documentation

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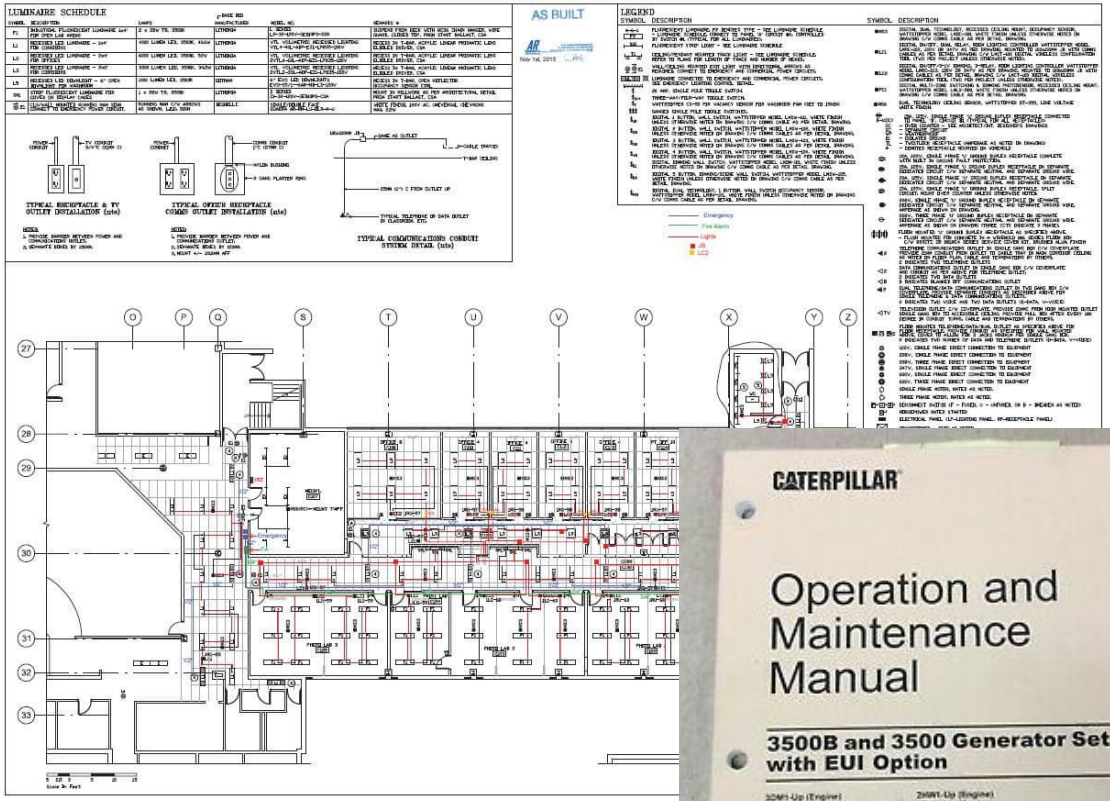
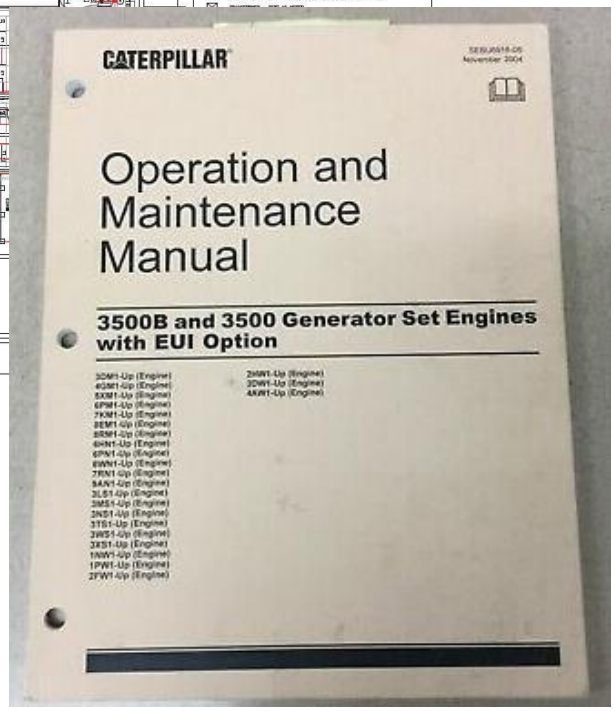


Project deliverables and Handover documentation are paper-based, often inaccurate and of low quality.

As-built Drawings

- Inaccurate geometry
- Do not depict as-built conditions
- Missing or contradicting drawings



Operation & Maintenance Manuals

- Many thousands of pages
- Disorganized Information
- Hard copies and Low-Resolution scans
- Little or no Correlation with As-built Drawings

Information exchange loss between project stages

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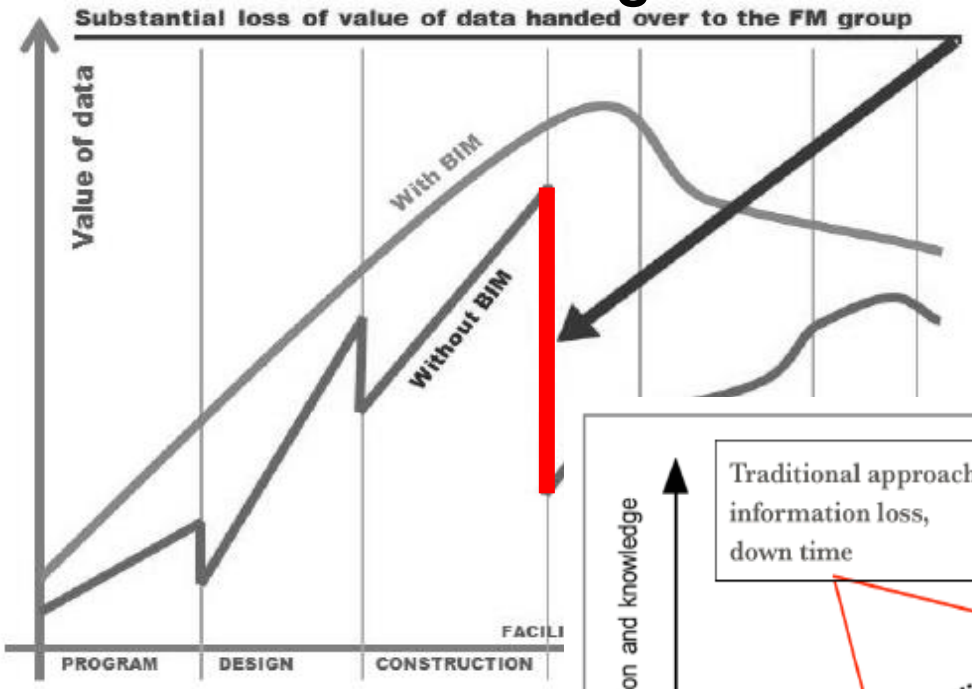
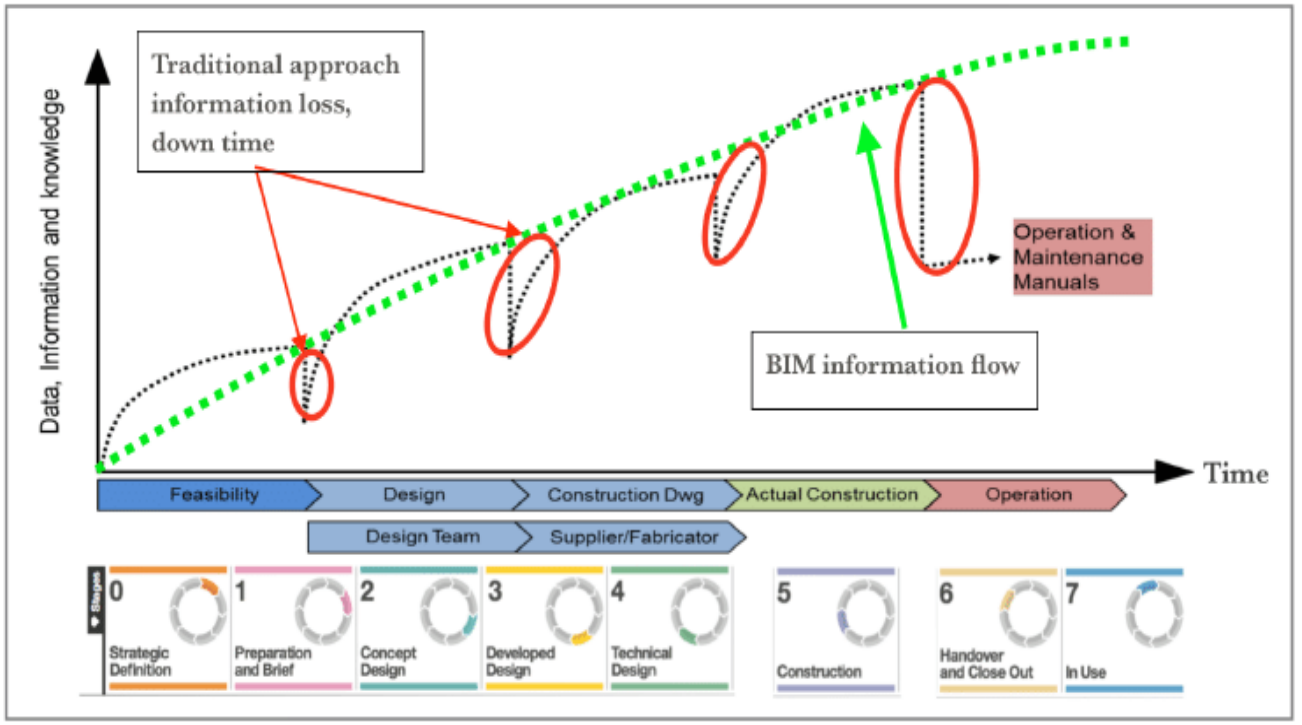
Information Exchange losses



Substantial cost and time impact



Today's construction ecosystem

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A highly complex, fragmented, and project based construction process…

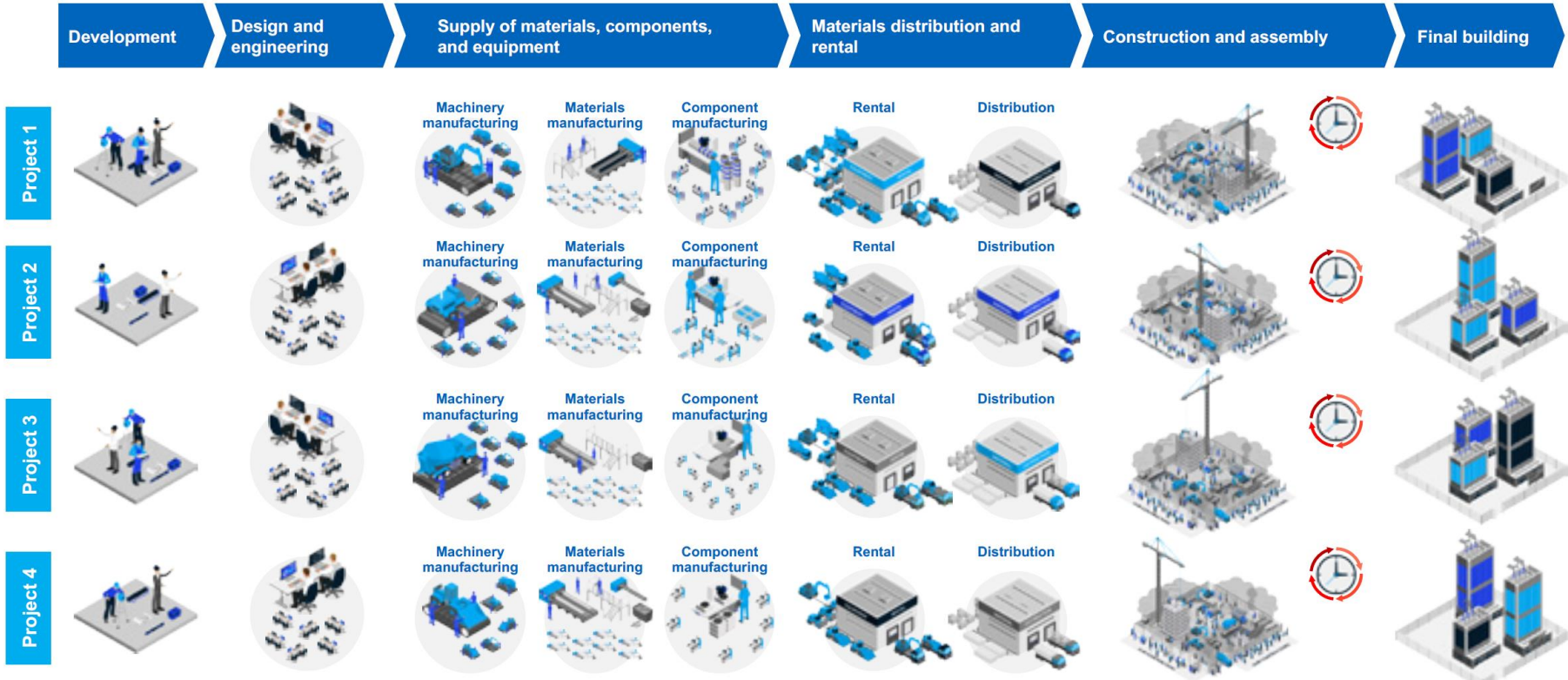

Image from McKinsey & Company, "The next normal in construction"

Waste in Construction projects currently

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As per statistics from multiple studies in UK & US in construction projects following the traditional approach:

- Rework up to 30% of construction cost
- Labour utilized at 40-60% efficiency
- At least 10% of site material wasted
- Accidents equal to 3-6% of project costs

TOTAL WASTE up to 50% of total cost!

Need for change

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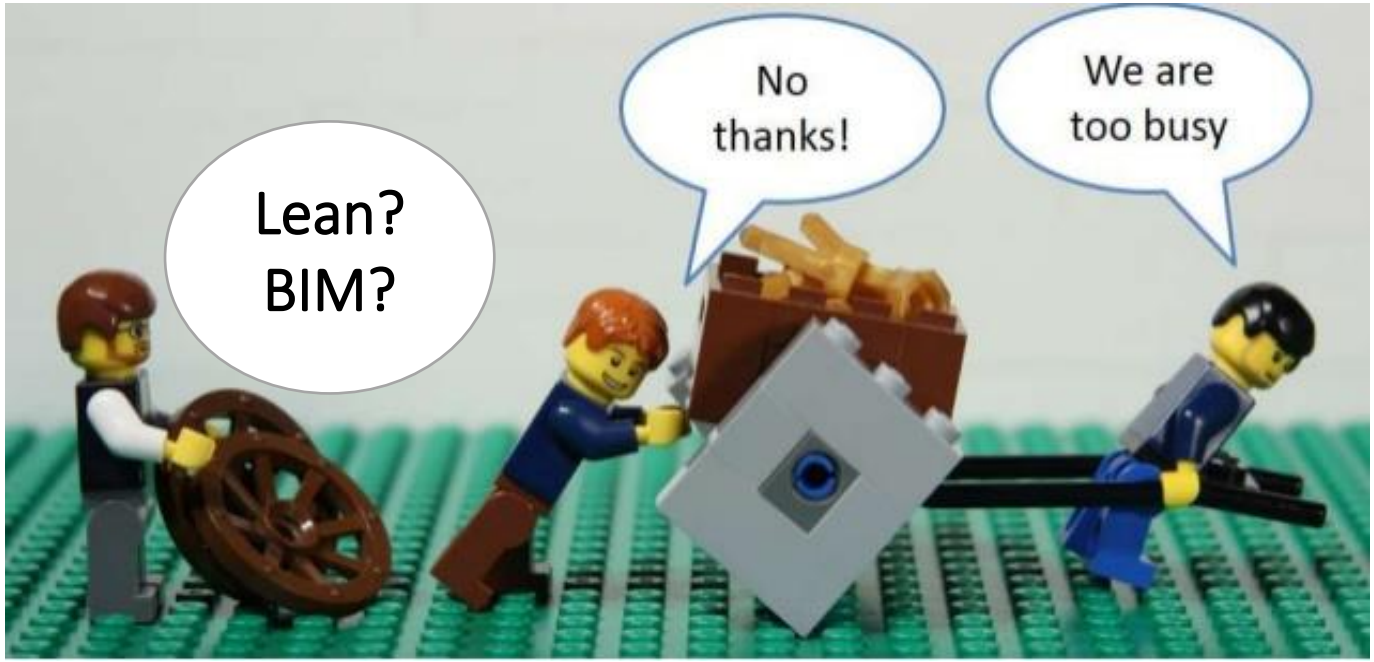
How we construct needs to change so that we can:

- **Meet the needs of an emerging digital change**
- **Minimise the impact on the environment**
- **Maximise the use and value of resources**
- **Provide economic viability and sustainability**



What is BIM?

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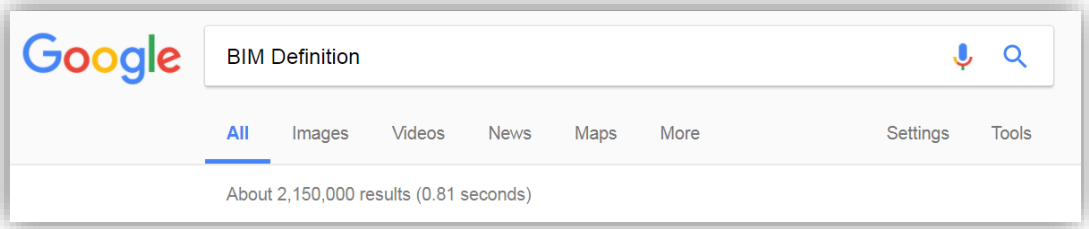
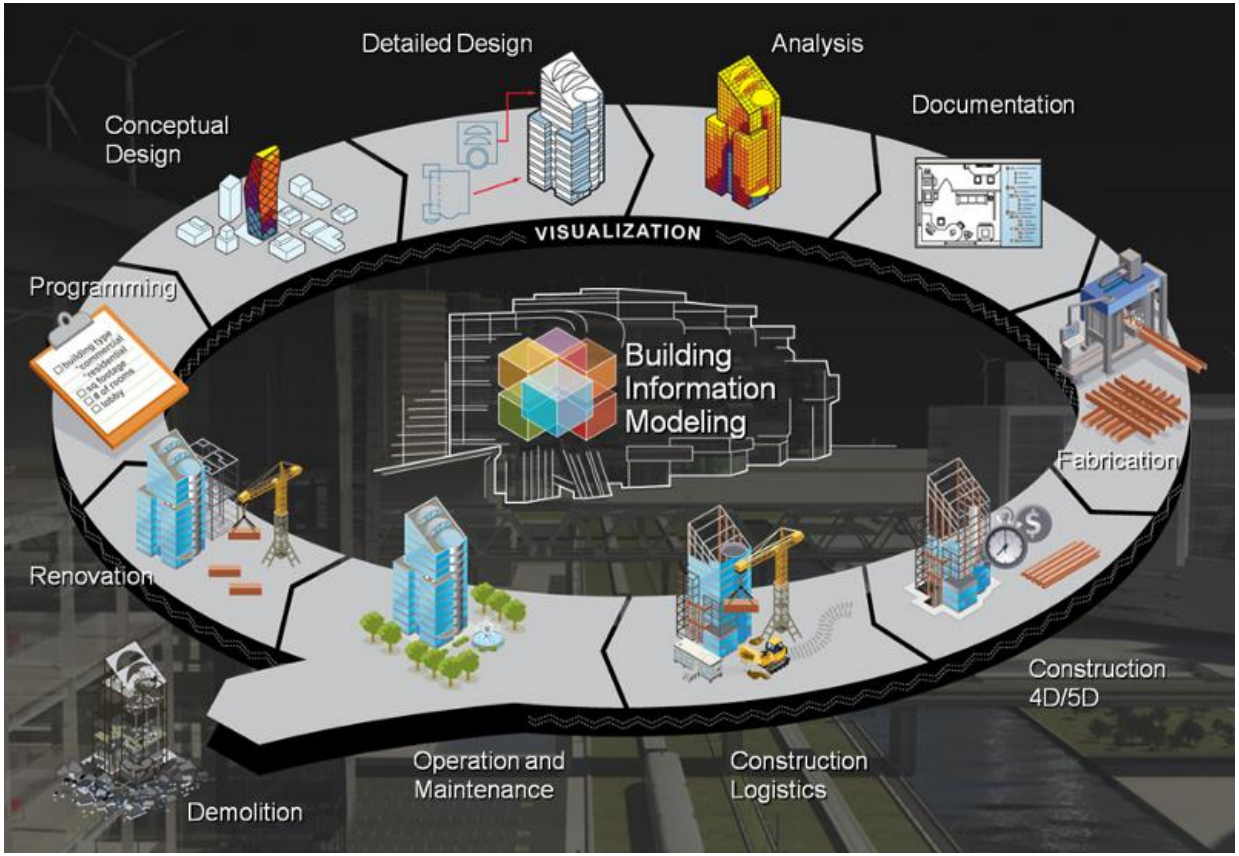


"...a digital representation of physical and functional characteristics of a facility; a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition." United States. NBIMS

BIM is a process!



What is BIM?

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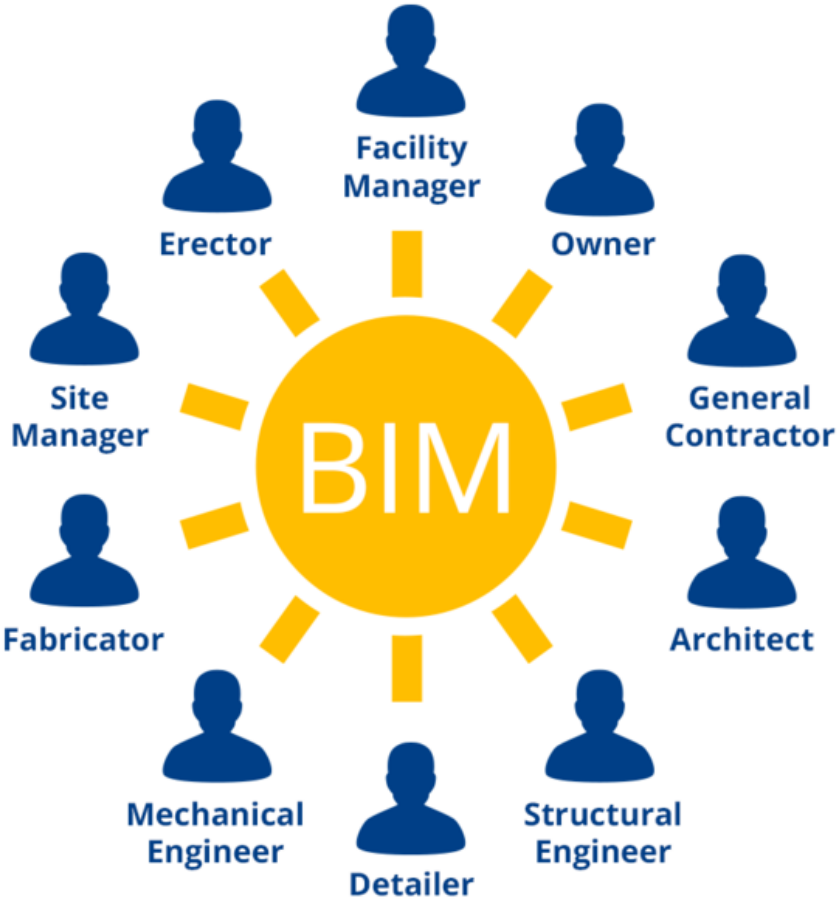
The strategic use of information technology and BIM, by integrating data, information, control and process, ...

is not just the use of new software tools, but a transformational approach to business and organizational mission

that includes a new way to work with multiple people together in a real time.

Collaboration!



BIM means….

Building Information Modelling

… is a **business process** for generating and leveraging building data to design, construct and operate the building during its lifecycle.

Building Information Model

...is the output of the business process resulting in a **digital prototype**, a virtual computer model of a project which holds selected structured data about the asset (design, quantity, time, cost, as-built, etc.).

Building Information Management

... Is the **organisation and control** of the business process using the digital prototype to effect the sharing of information over the entire lifecycle of an asset.

What is BIM?

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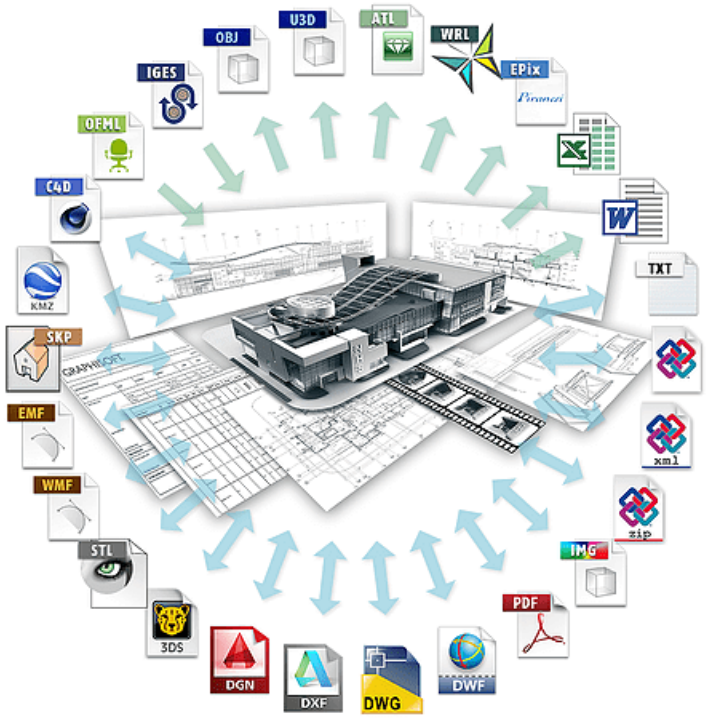
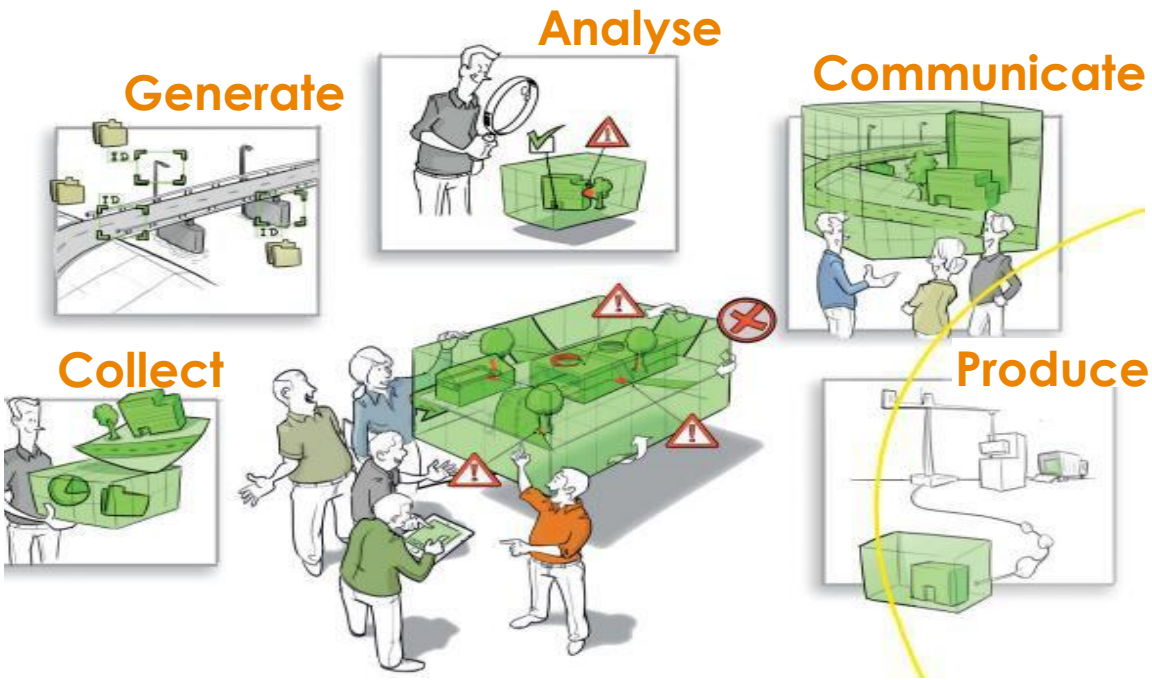
BUILDING INFORMATION MODELLING

...a **business process** for generating and leveraging building data to design, construct and operate the building during its lifecycle.





What is BIM?

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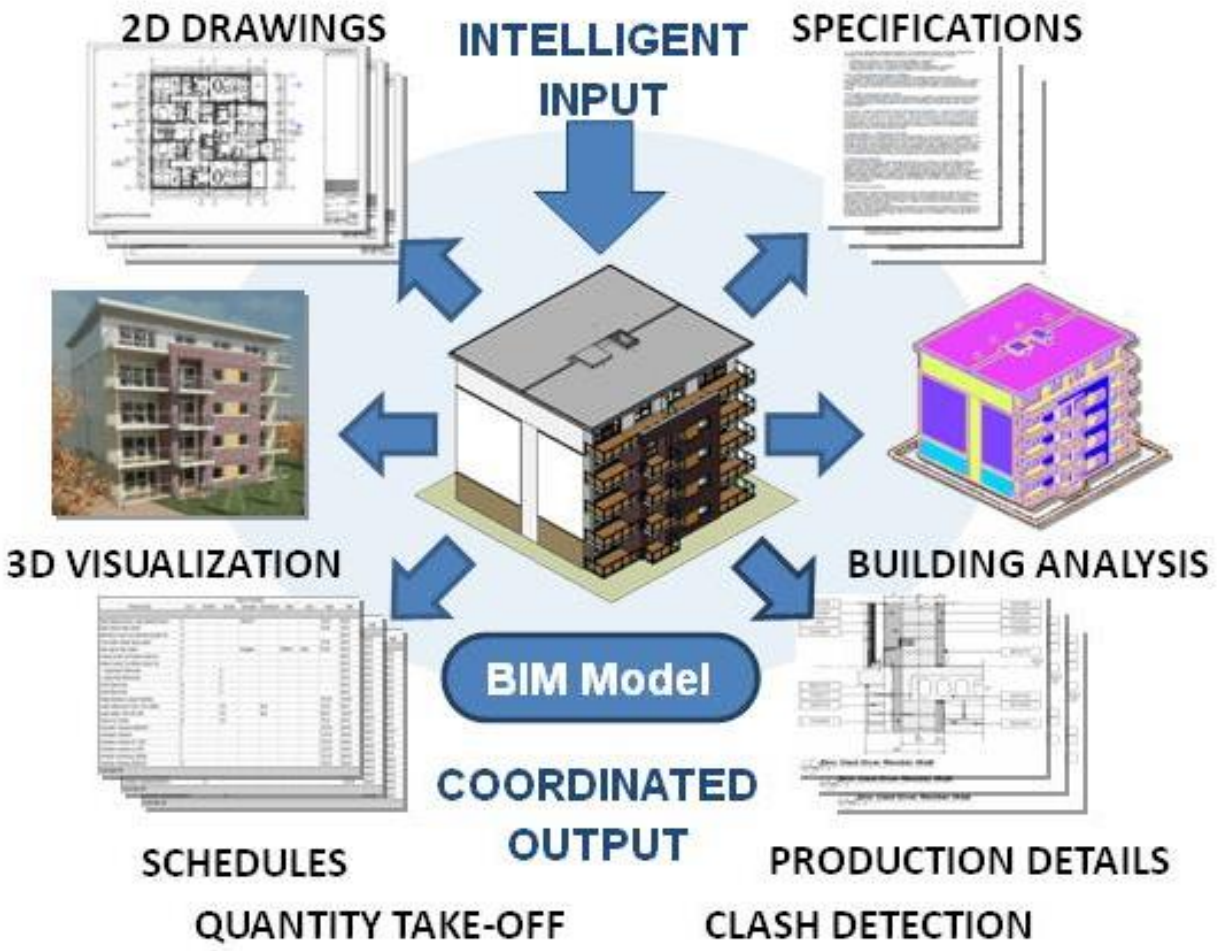
BUILDING INFORMATION MODEL

... the output of the business process resulting in a **digital prototype**, a virtual computer model of a project which holds selected structured data about the asset (design, quantity, time, cost, as-built, etc.).



What is BIM?

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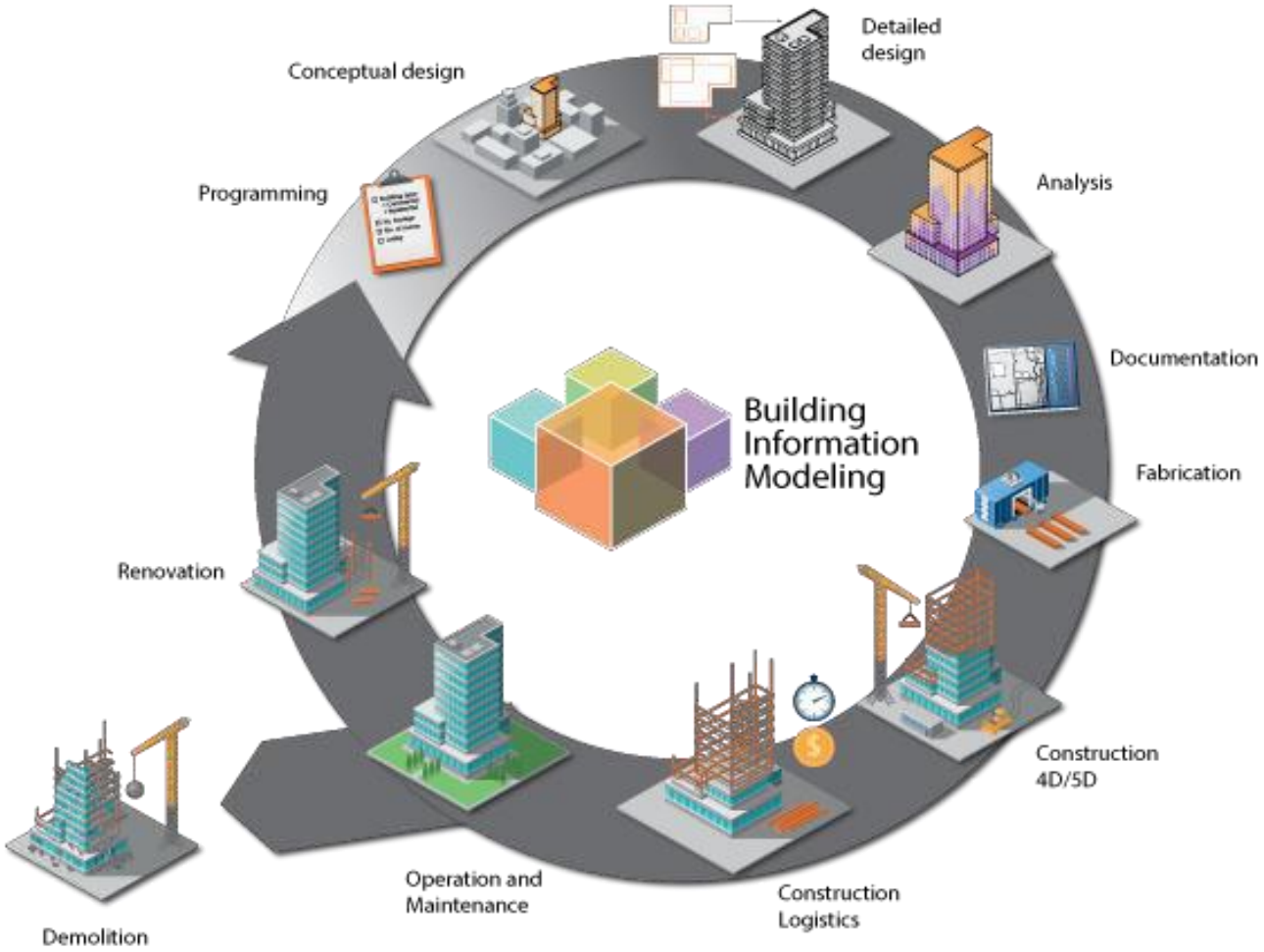
BUILDING INFORMATION MANAGEMENT

... the **organisation and control** of the business process using the digital prototype to effect the sharing of information over the entire lifecycle of an asset.

Information are:

- **Graphical**
- **Non-Graphical**
- **Documents**



International Standards for BIM

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ISO 19650

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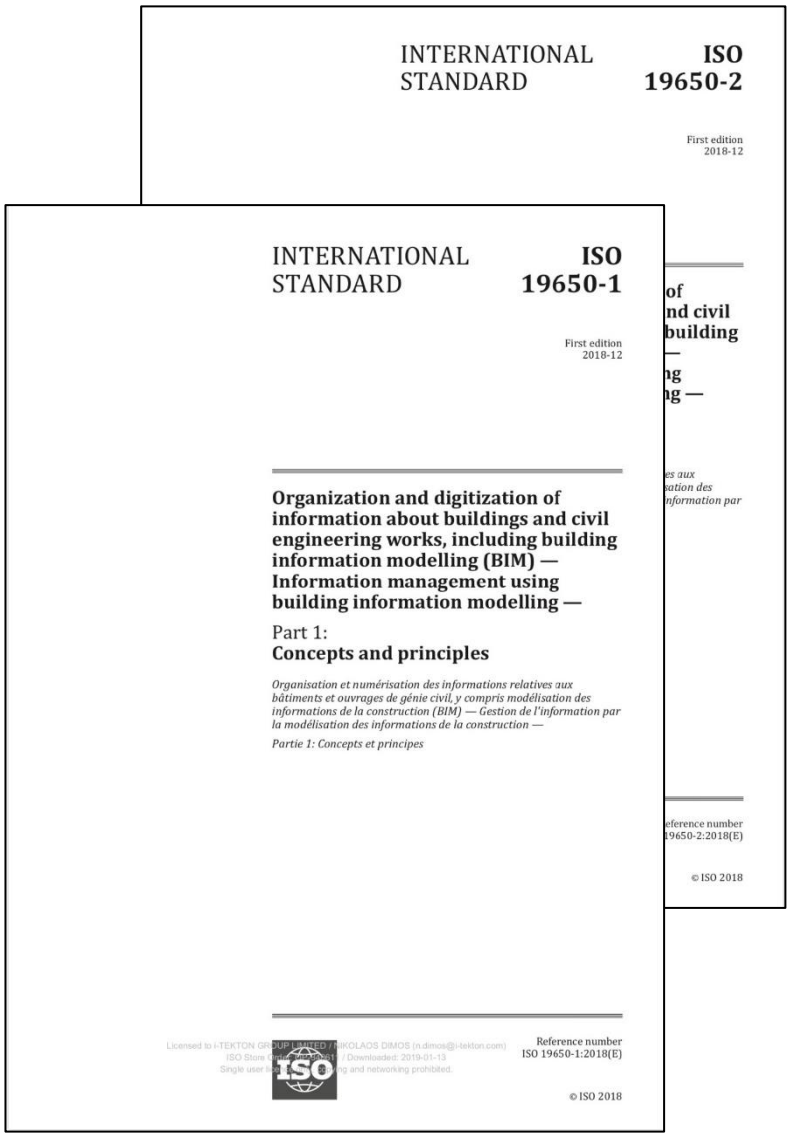

- **BS EN ISO 19650–1** Organisation of information about construction works – Information management using building information modelling – Part 1: concepts and principles
- **BS EN ISO 19650-2** Part 2: Delivery phase of assets.
- **BS EN ISO 19650-3** Part 3: Operational phase of Assets.
- **BS EN ISO 19650-5** Part 5: Security minded approach to information management.

LOD definition

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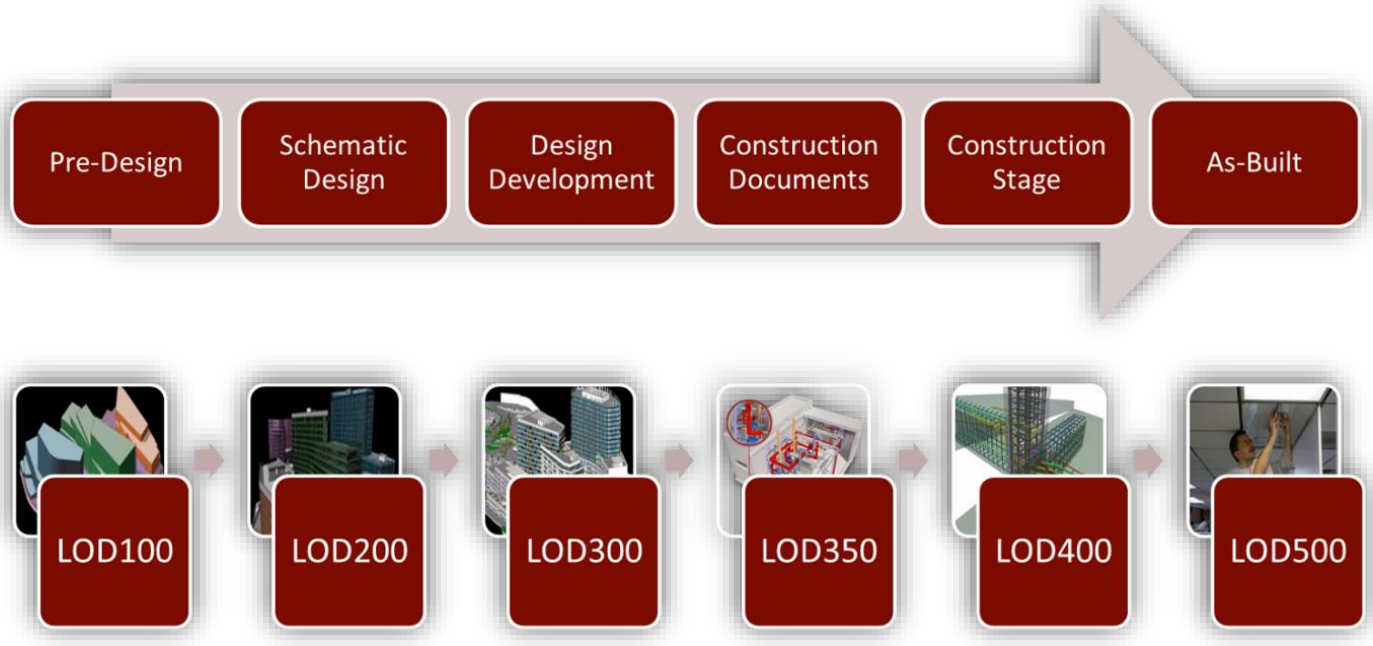
Level of development (LOD)

- **LOD 100**: Information can be conveyed with massing forms, written narratives, and 2D symbols.
- **LOD 200**: Modelled elements have approximate relationships to quantities, size, location, and orientation. So
- **LOD 300**: Modelled elements are explained in terms of specific systems, quantities, size, shape, location, and orientation.
- **LOD 400**: Continuation of LOD 300 with information added to facilitate fabrication, assembly, and installation.
- **LOD 500**: Modelled elements as installed and can be utilized for ongoing facilities management.



LOD

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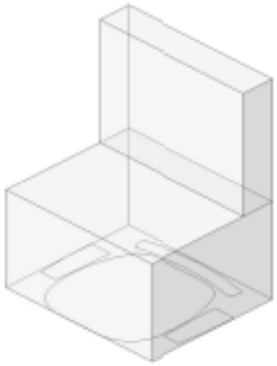
LEVEL of DEVELOPMENT

LOD 100	LOD 200	LOD 300	LOD 400	LOD 500
				
Concept (Presentation)	Design Development	Documentation	Construction	Facilities Management
DESCRIPTION: **Office Chair** Arms, Wheels WIDTH: DEPTH: HEIGHT: MANUFACTURER: Herman Miller, Inc. MODEL: Mirra LOD: **100**	DESCRIPTION: **Office Chair** Arms, Wheels WIDTH: **700** DEPTH: **450** HEIGHT: **1100** MANUFACTURER: Herman Miller, Inc. MODEL: Mirra LOD: **200**	DESCRIPTION: **Office Chair** **Arms, Wheels** WIDTH: **700** DEPTH: **450** HEIGHT: **1100** MANUFACTURER: Herman Miller, Inc. MODEL: Mirra LOD: **300**	DESCRIPTION: **Office Chair** **Arms, Wheels** WIDTH: **685** DEPTH: **430** HEIGHT: **1085** MANUFACTURER: **Herman Miller, Inc** MODEL: **Mirra** LOD: **400**	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)

LOD

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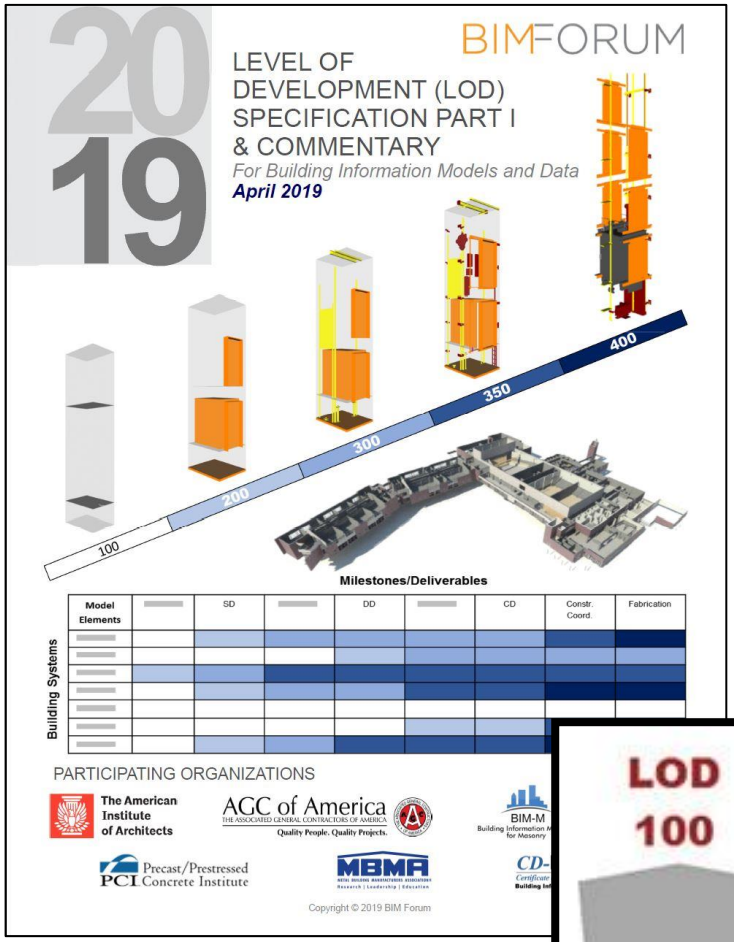
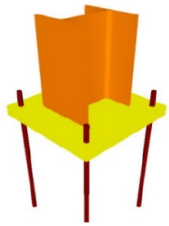
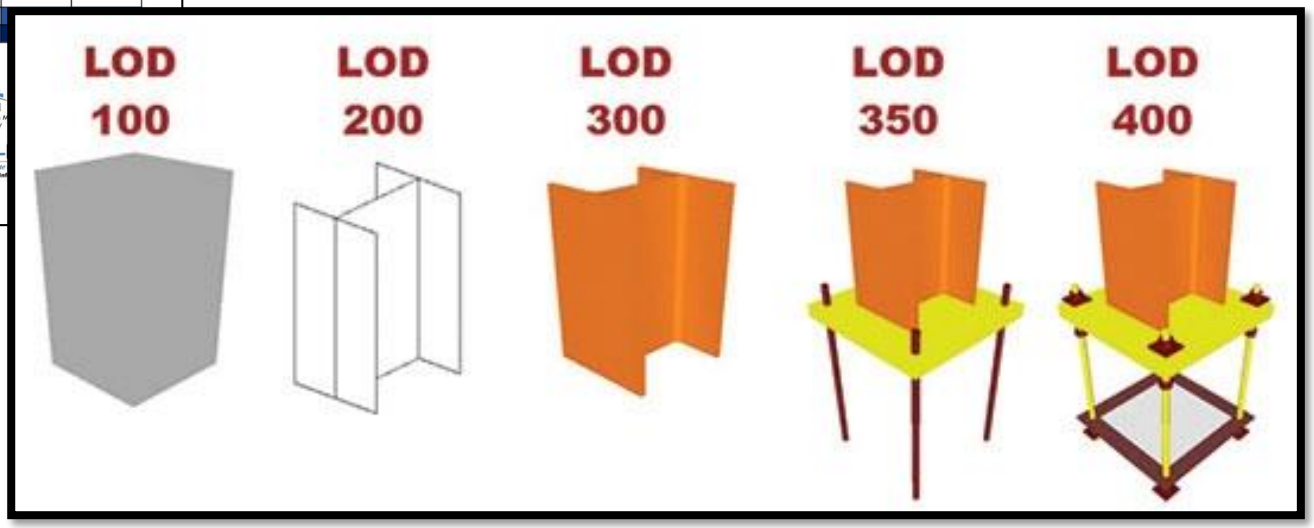


300	Element modeling to include: • Specific sizes of main vertical structural members modeled per defined structural grid with correct orientation Required non-graphic information associated with model elements includes: • Structural steel materials defined. • Connection details • Finishes, i.e. painted, galvanized, etc.	 *21 B1010.10-LOD-300 Floor Structural Frame (Steel Framing Columns)*
350	Element modeling to include: • Actual elevations and location of member connections • Large elements of typical connections applied to all structural steel connections such as base plates, gusset plates, anchor rods, etc. • Any miscellaneous steel members with correct orientation • Any steel structure reinforcement such as web stiffeners, sleeve penetrations, etc.	 *22 B1010.10-LOD-350 Floor Structural Frame (Steel Framing Columns)*



Common Data Environment

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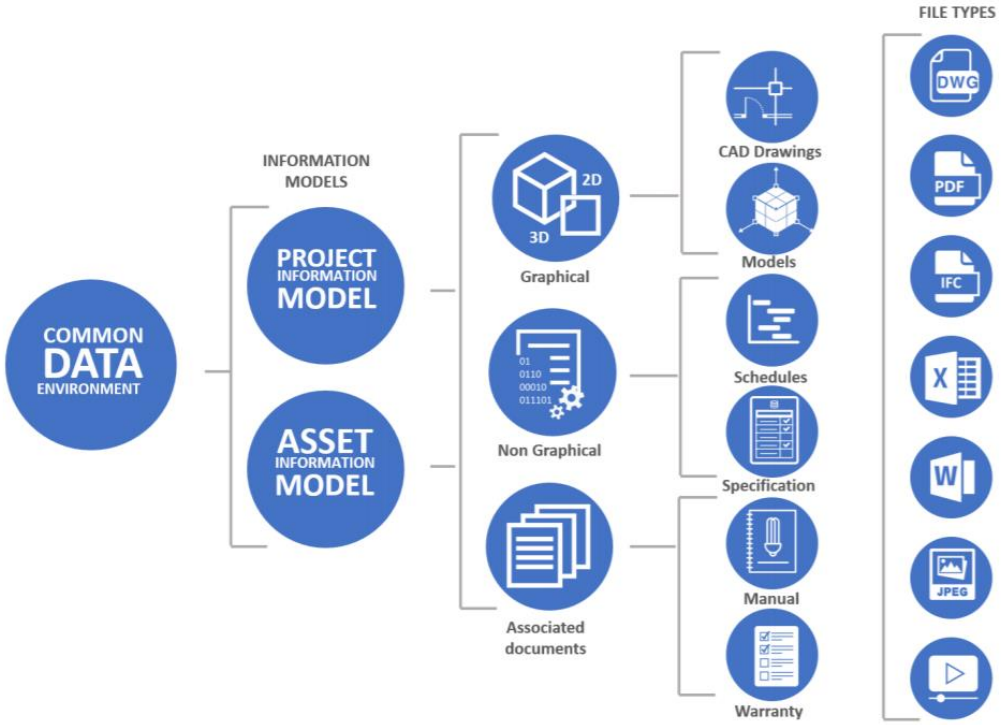
- Latest valid information is available to all stakeholders
- Much faster coordination/review cycle
- Search time for any document drastically reduced.
- Easy Filtering.
- Documents have attributes and can be linked.
- Can upload/share document in seconds.
- WIP/Share/Publish status



Common Data Environment (CDE) is the basis for BIM Implementation!

BIM Dimensions

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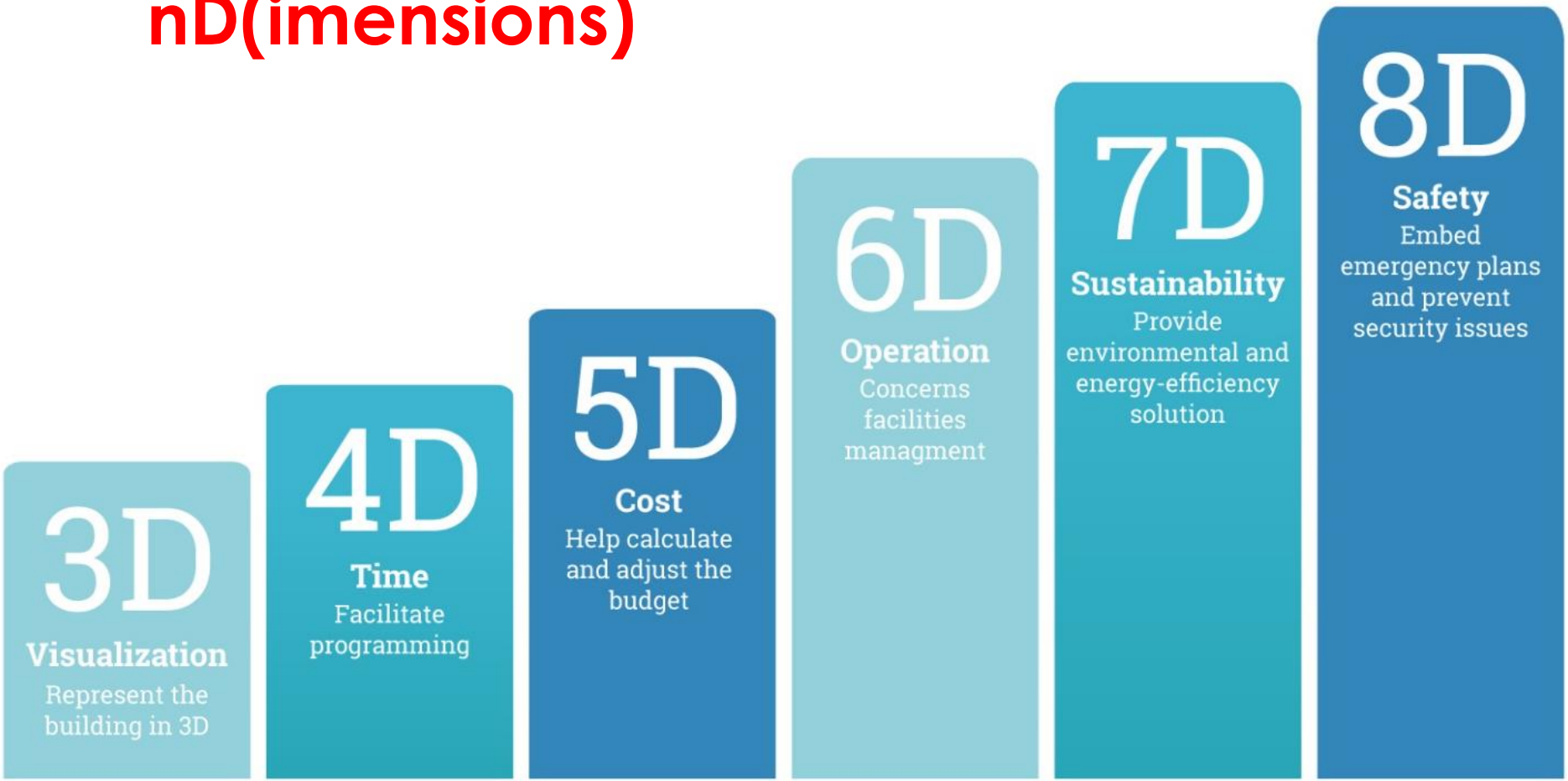
nD(imensions)



BIM and Design software integration

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Bi-directional link to design software platform →
always up-to-date model design and documentation

Choosing the right tools!

Drawings and Project Documentation

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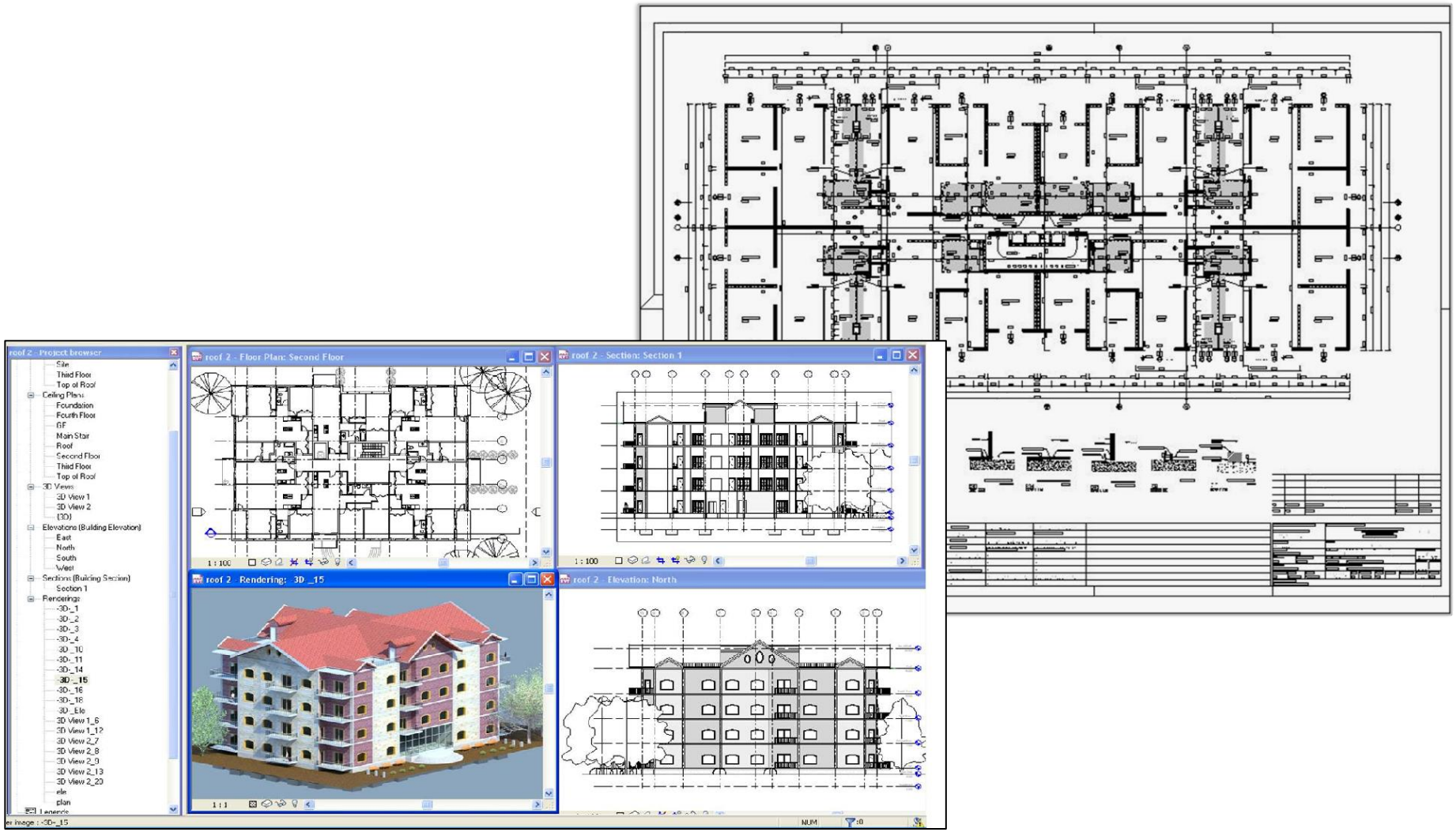
- Automated drawings and schedule extraction
- Documentation always up-to-date
- Minimal revision time



Smart Objects Libraries

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Libraries of smart objects, linked with the relevant attributes and materials are provided by manufacturers, promoting standardization and minimizing errors.

Parametric Data Driven Design Development

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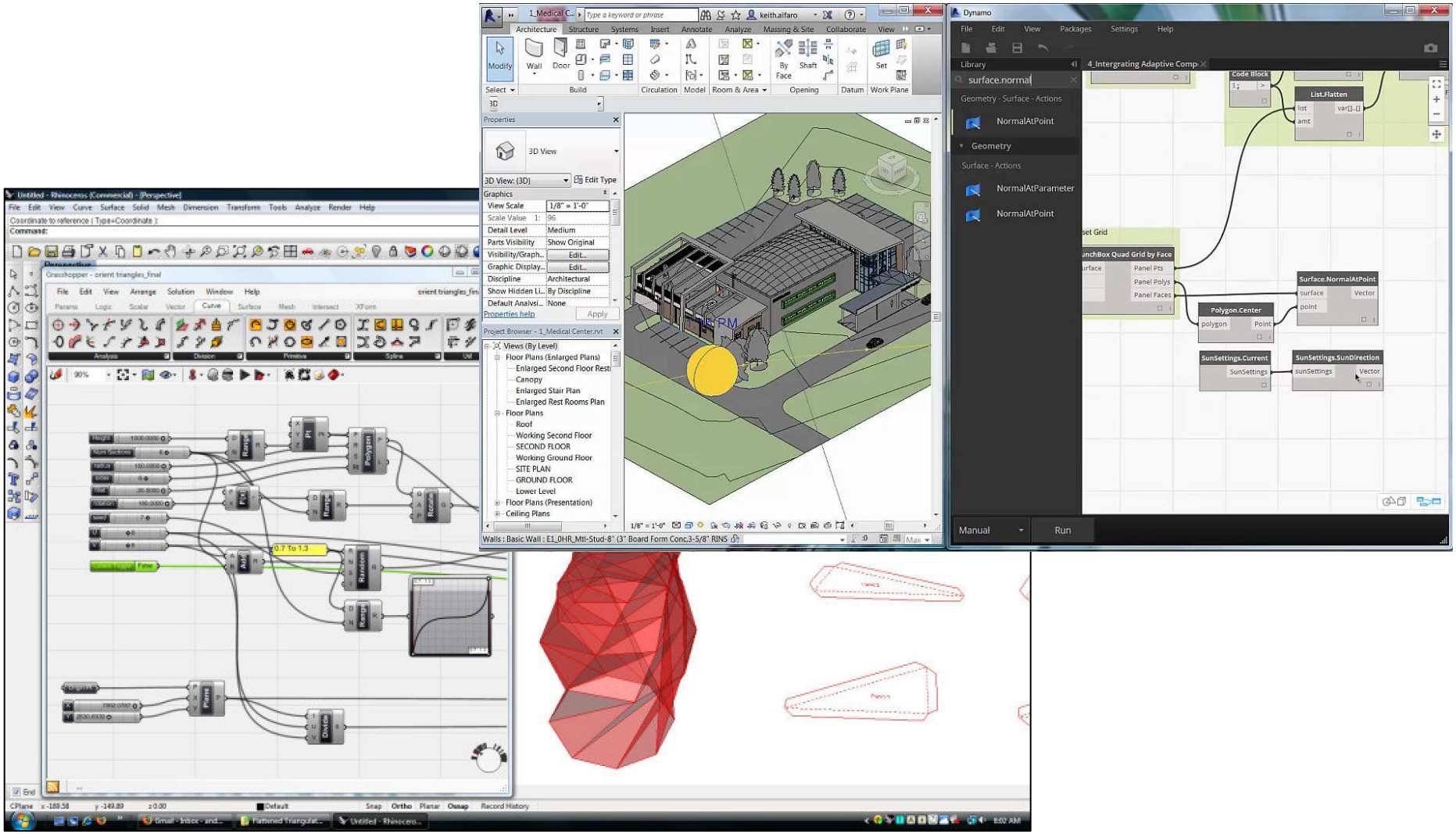
Visual programming – Dynamo, Grasshoper



Clash Avoidance and Spatial Coordination

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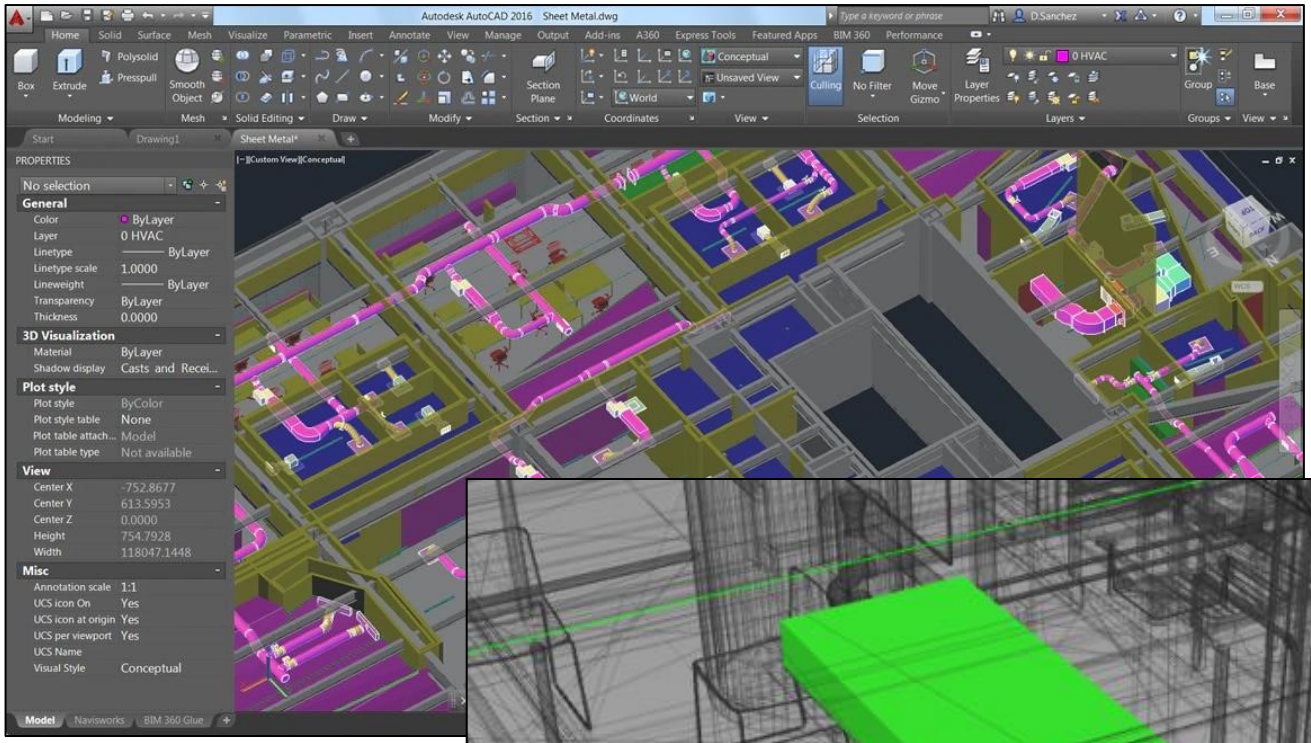

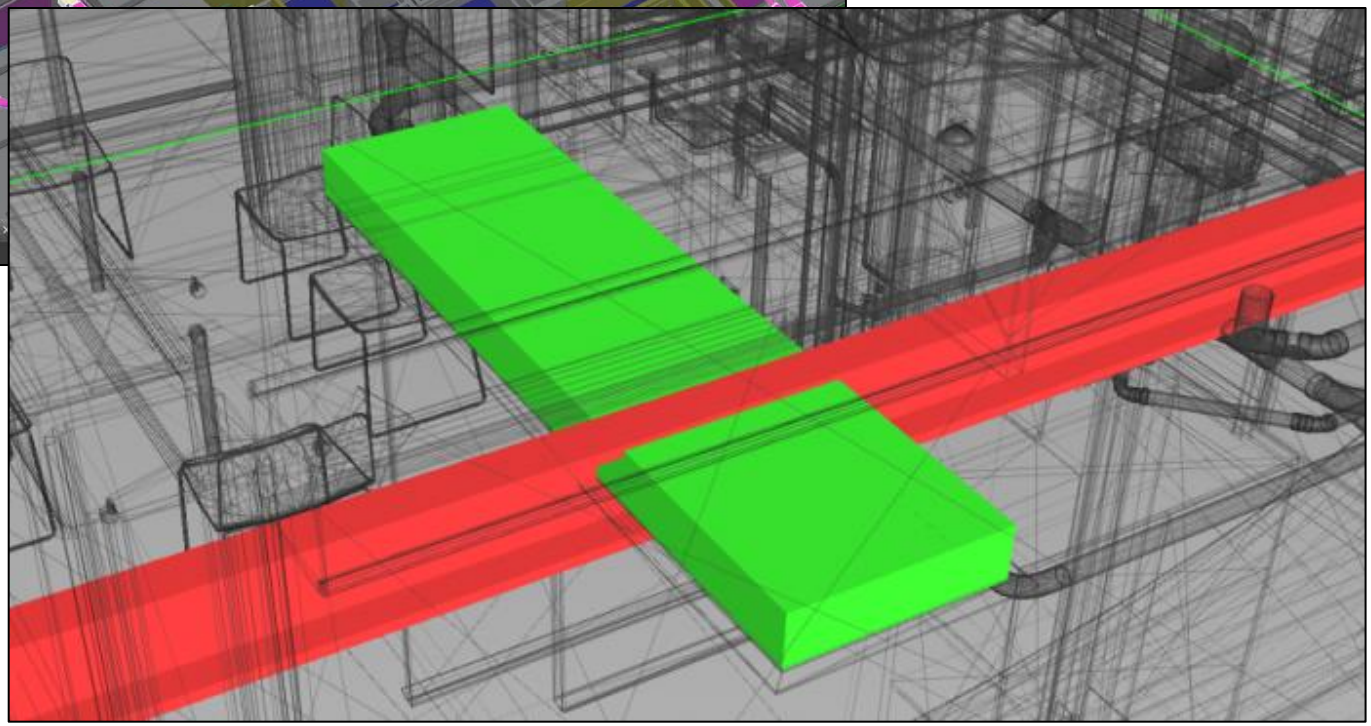

Design Verification and Constructability studies

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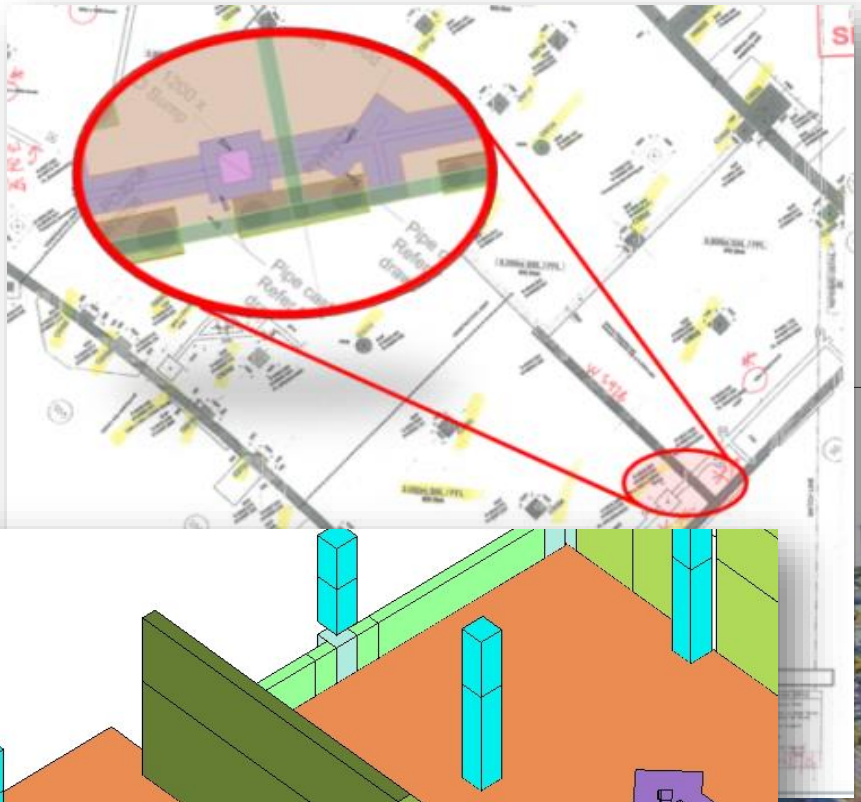

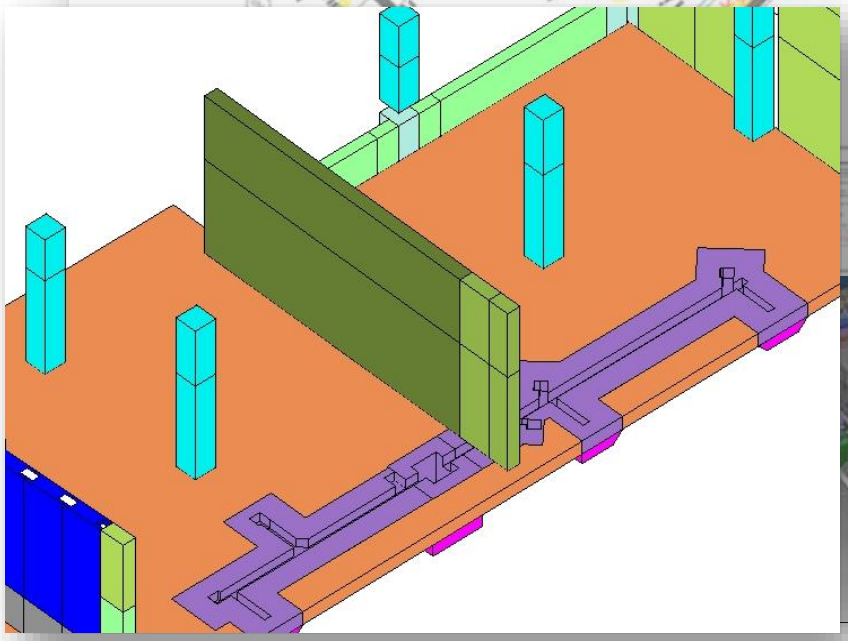

Room Schedules and Data Sheets

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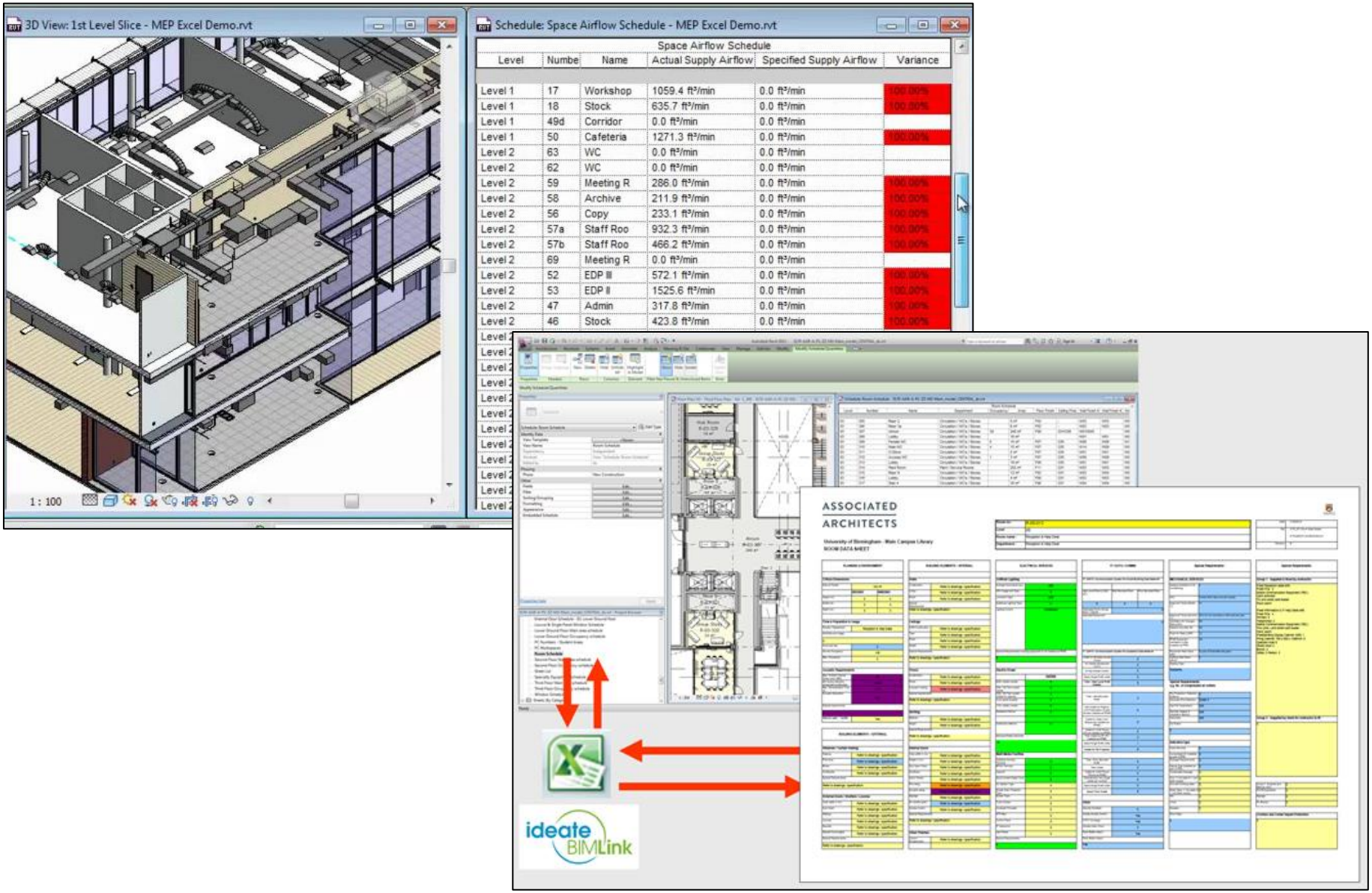

Visualization - Detailing - Rendering

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4D Simulations – Construction Sequence

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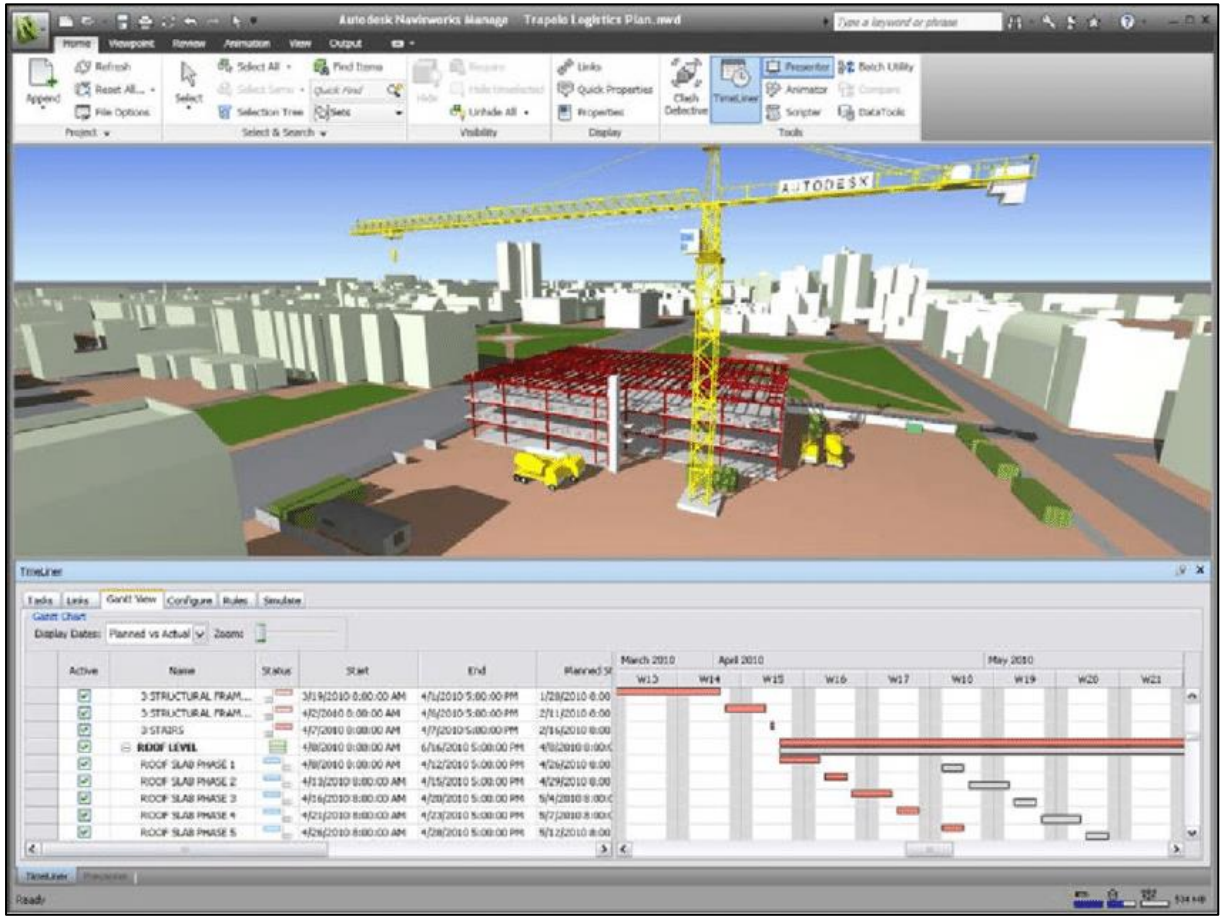
- Activity Simulation
- Optimize and adjust construction sequence
- Visualize what-if scenarios
- Report actual versus projected
- Improved Schedule interference and logistics studies.



Progress Reporting – Actual vs Planned

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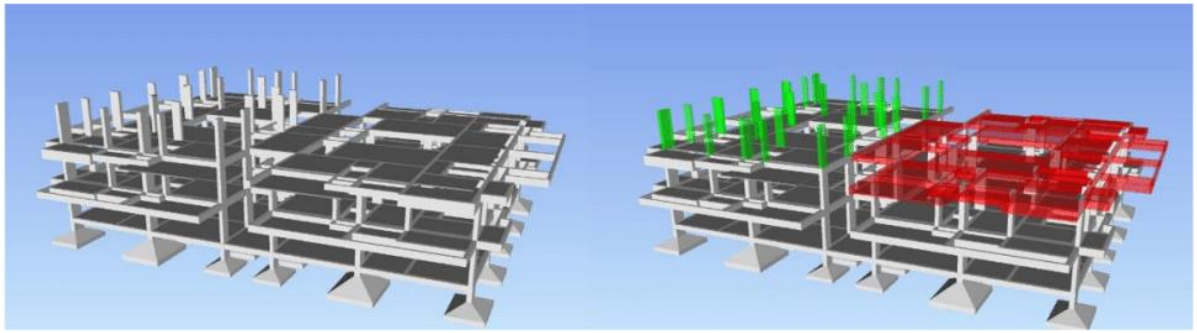
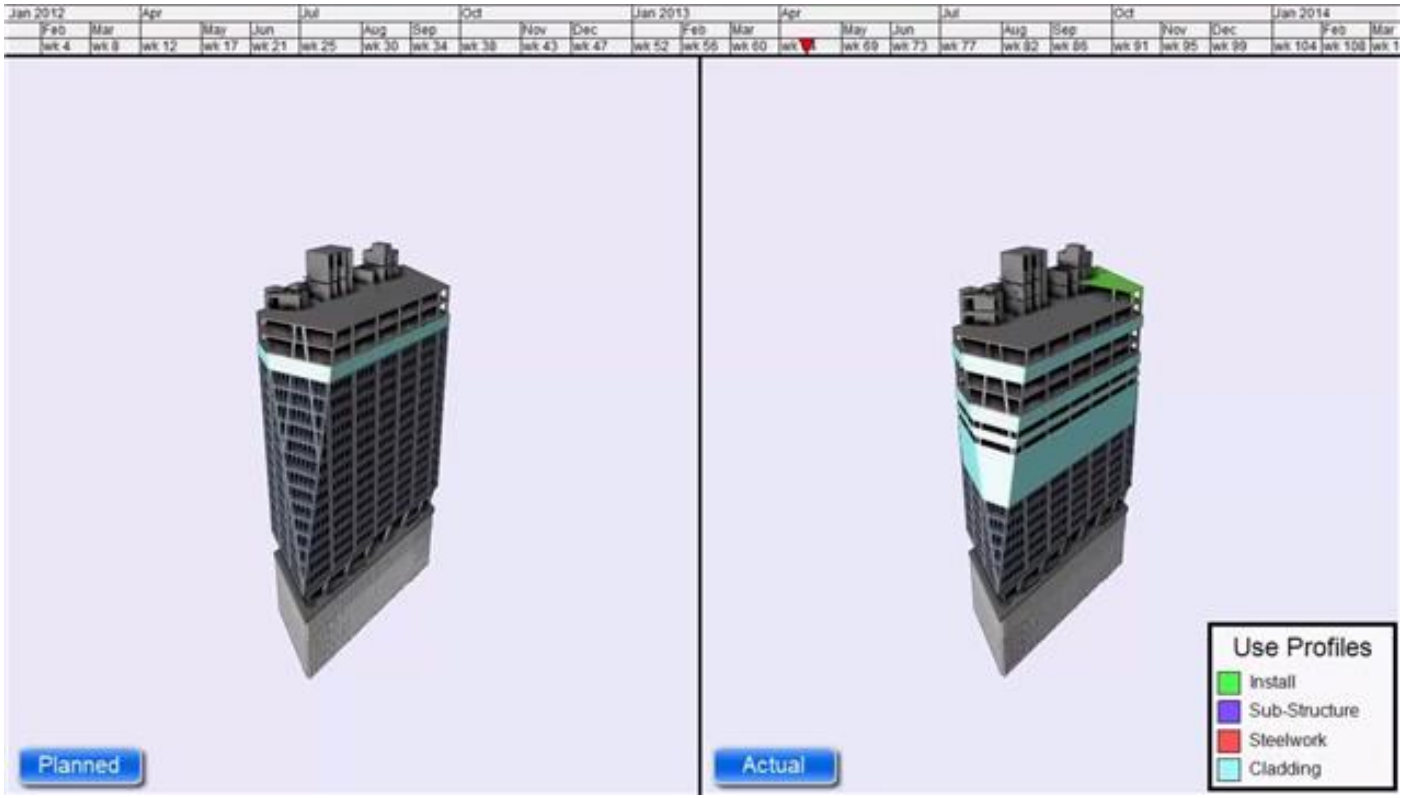


Planned Status

Actual Status



Scope Analysis and Work Packaging

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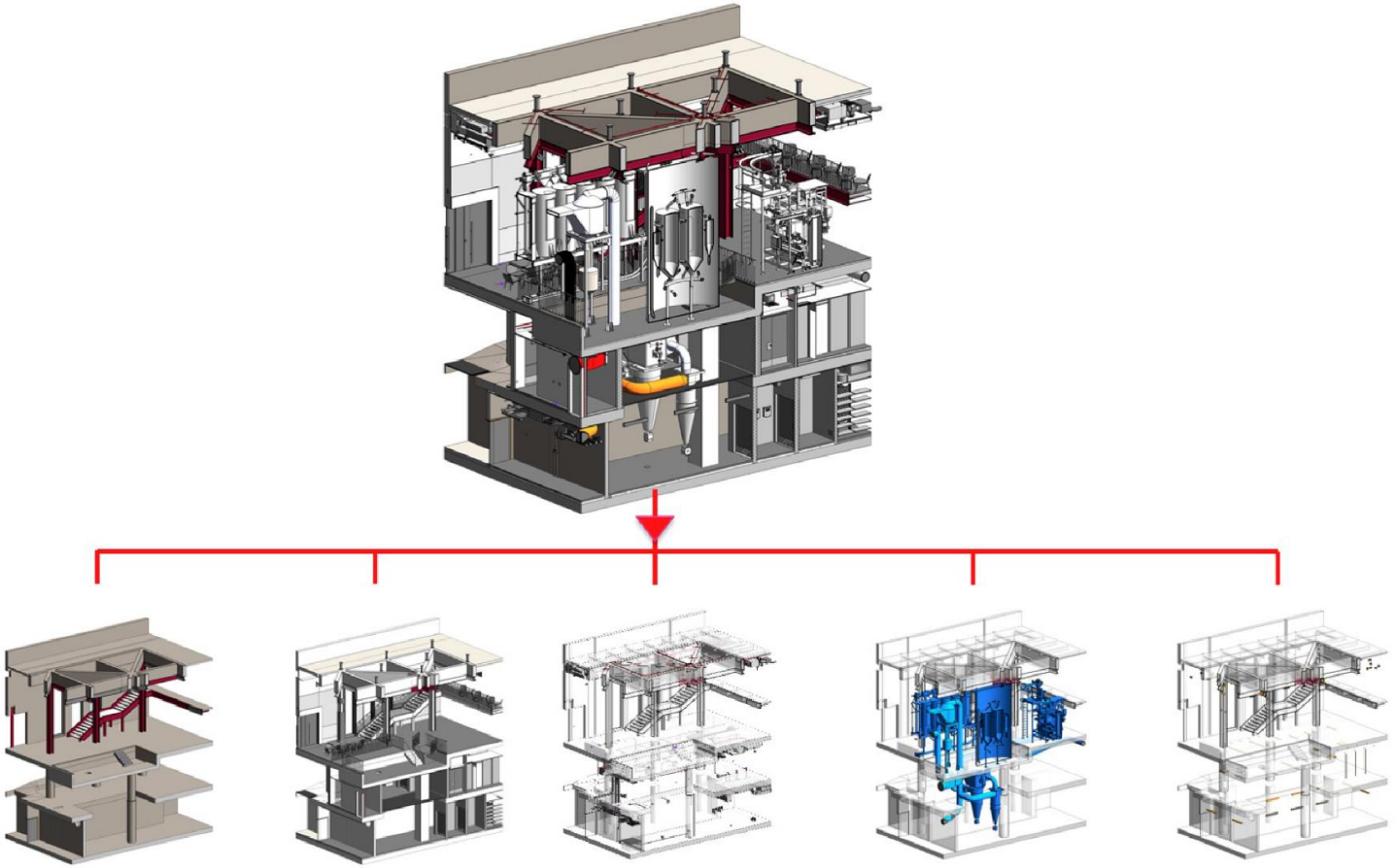

5D Quantities and Costing

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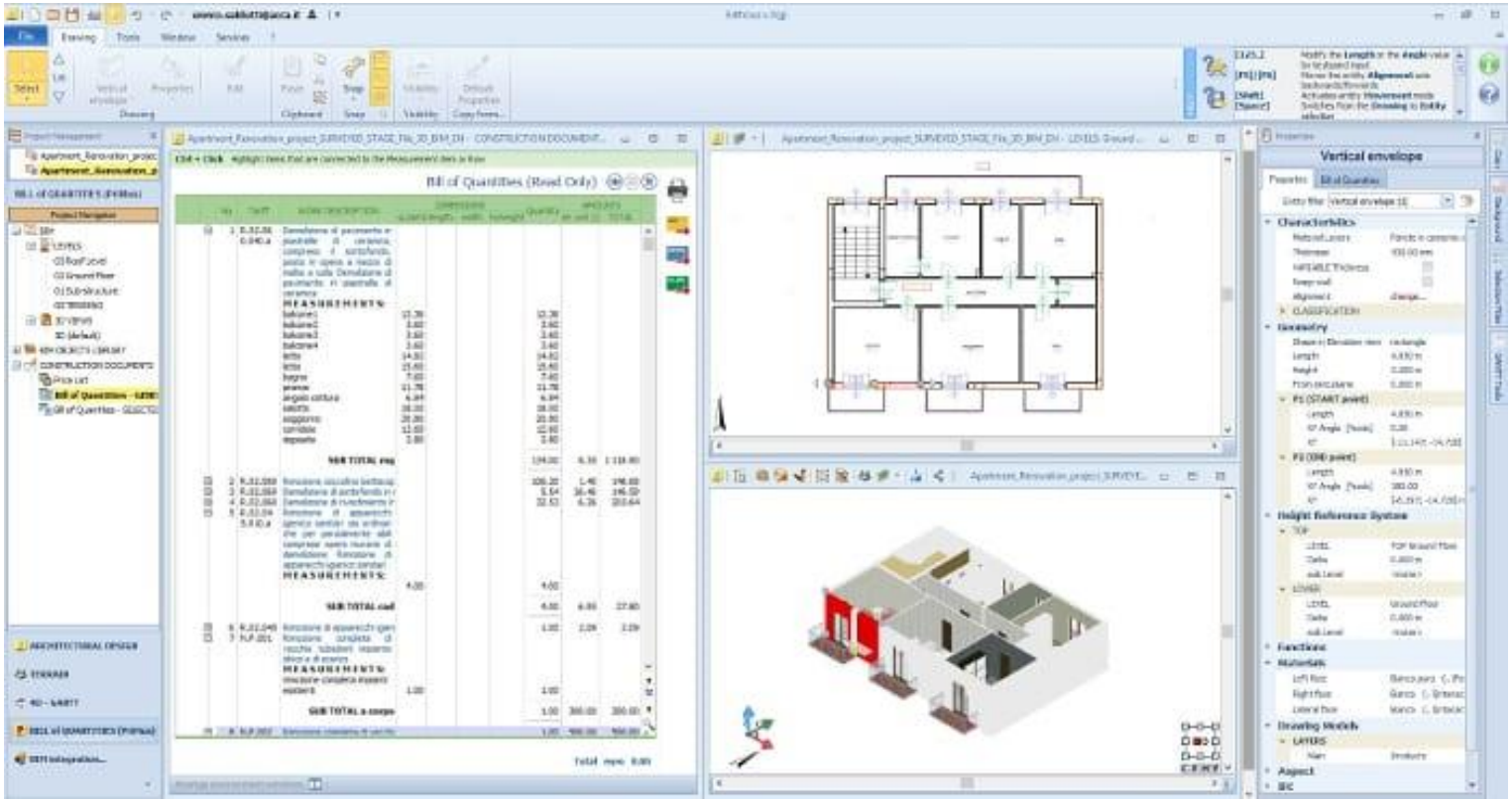
- Accurate reporting to the Object Level.
- Take-Offs and measurements can be (re)extracted within seconds
- Automated and always up-to-date Schedules.
- Management and visualization of VEs and VOs.
- Revisions/changes can be easily traced and quantified.



Side Logistics – Crane Management

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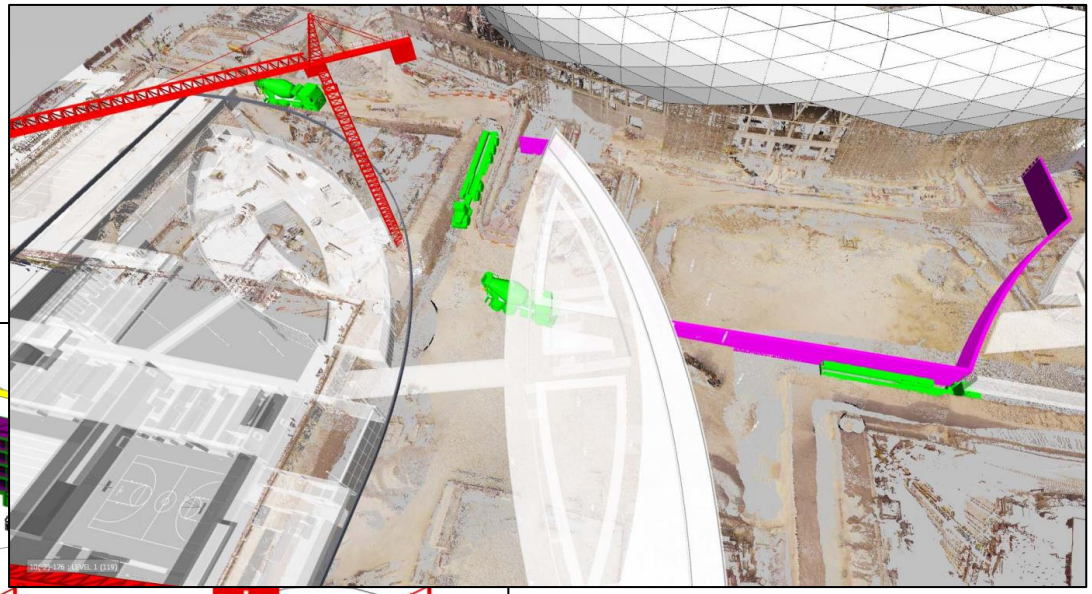
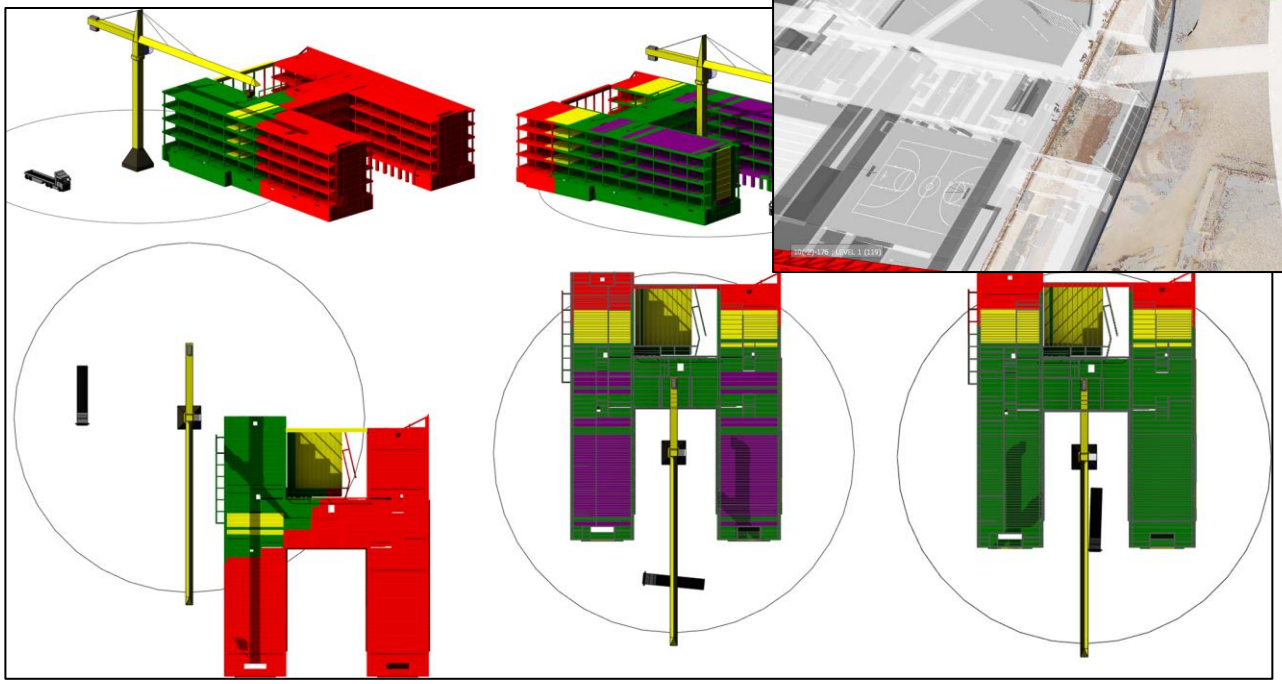
Tower Crane Management & Site Logistics

- **Location of Towers is being checked location-wise and Planning-wise.**





Value Engineering

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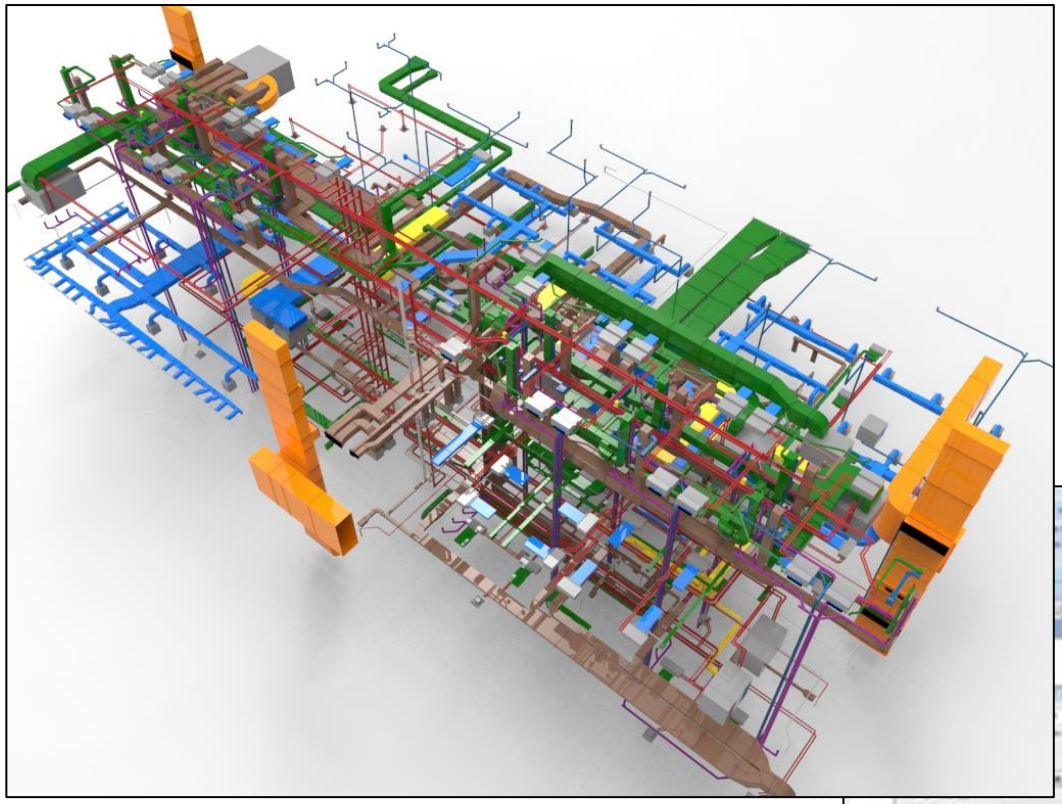

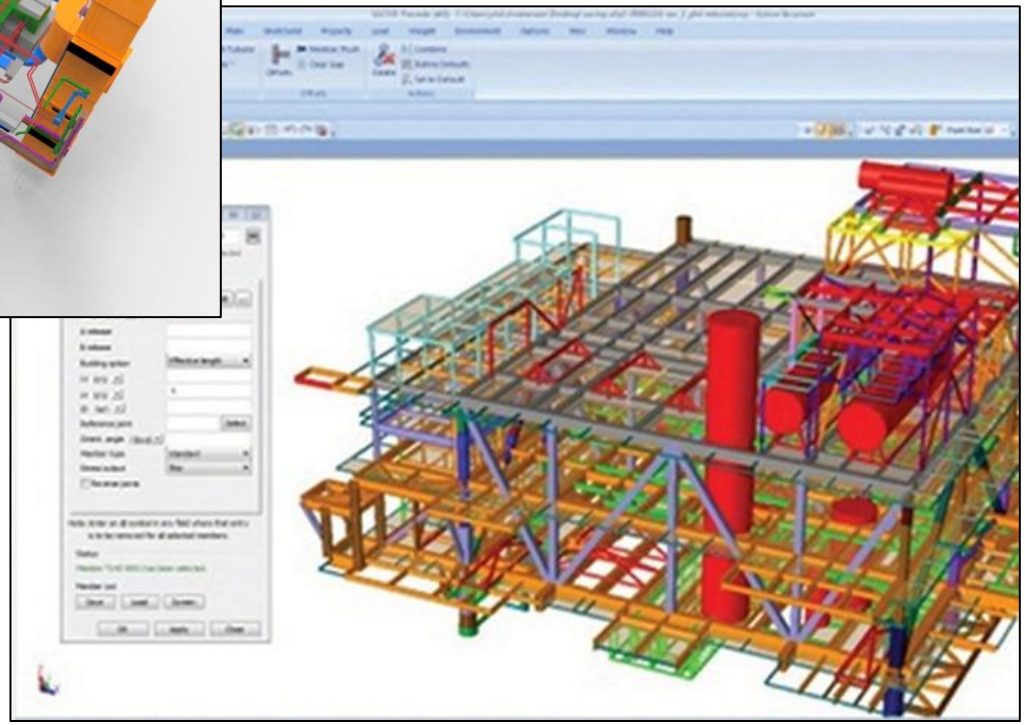

Construction Methodology & Erection Sequence

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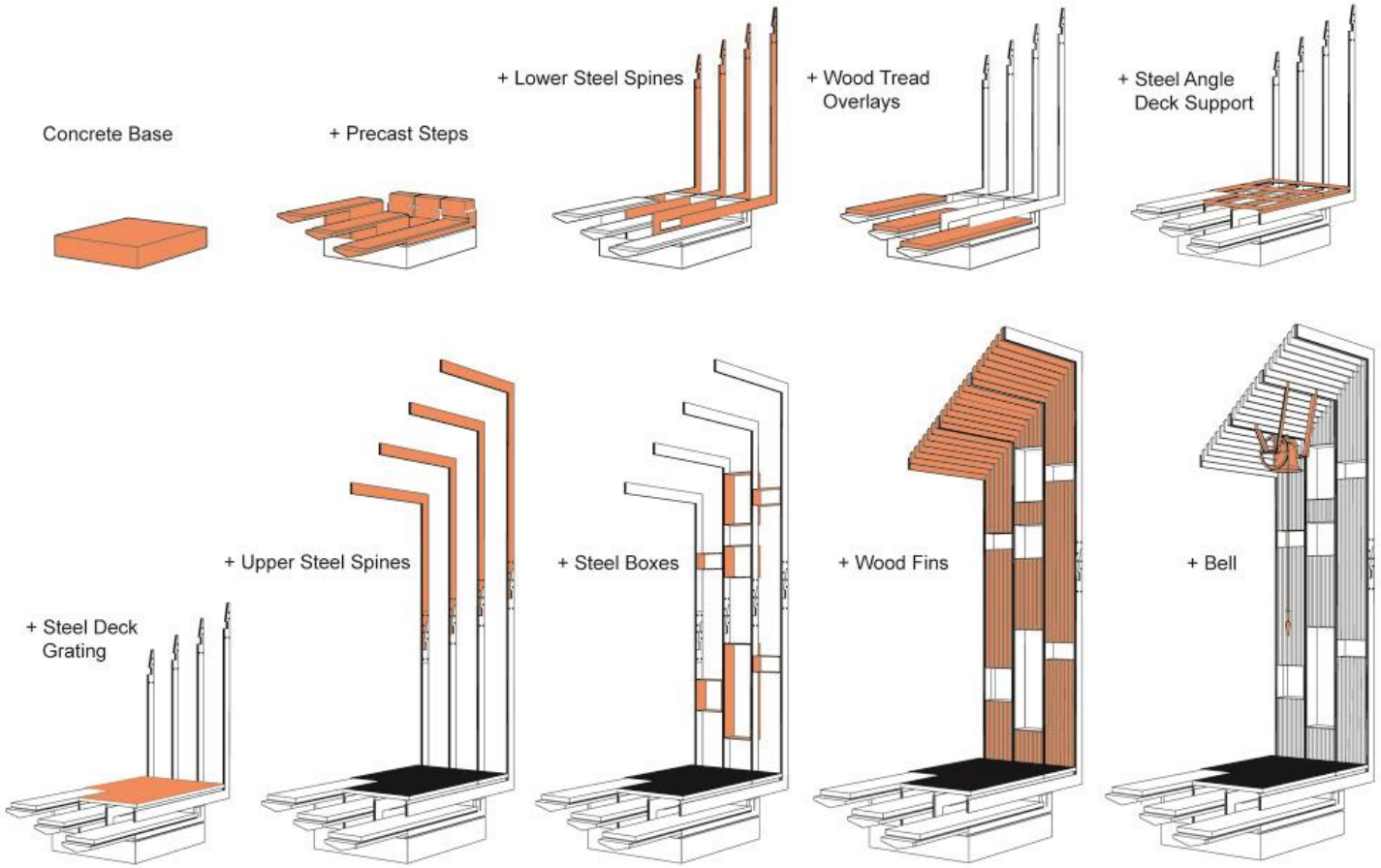

Laser Scanning

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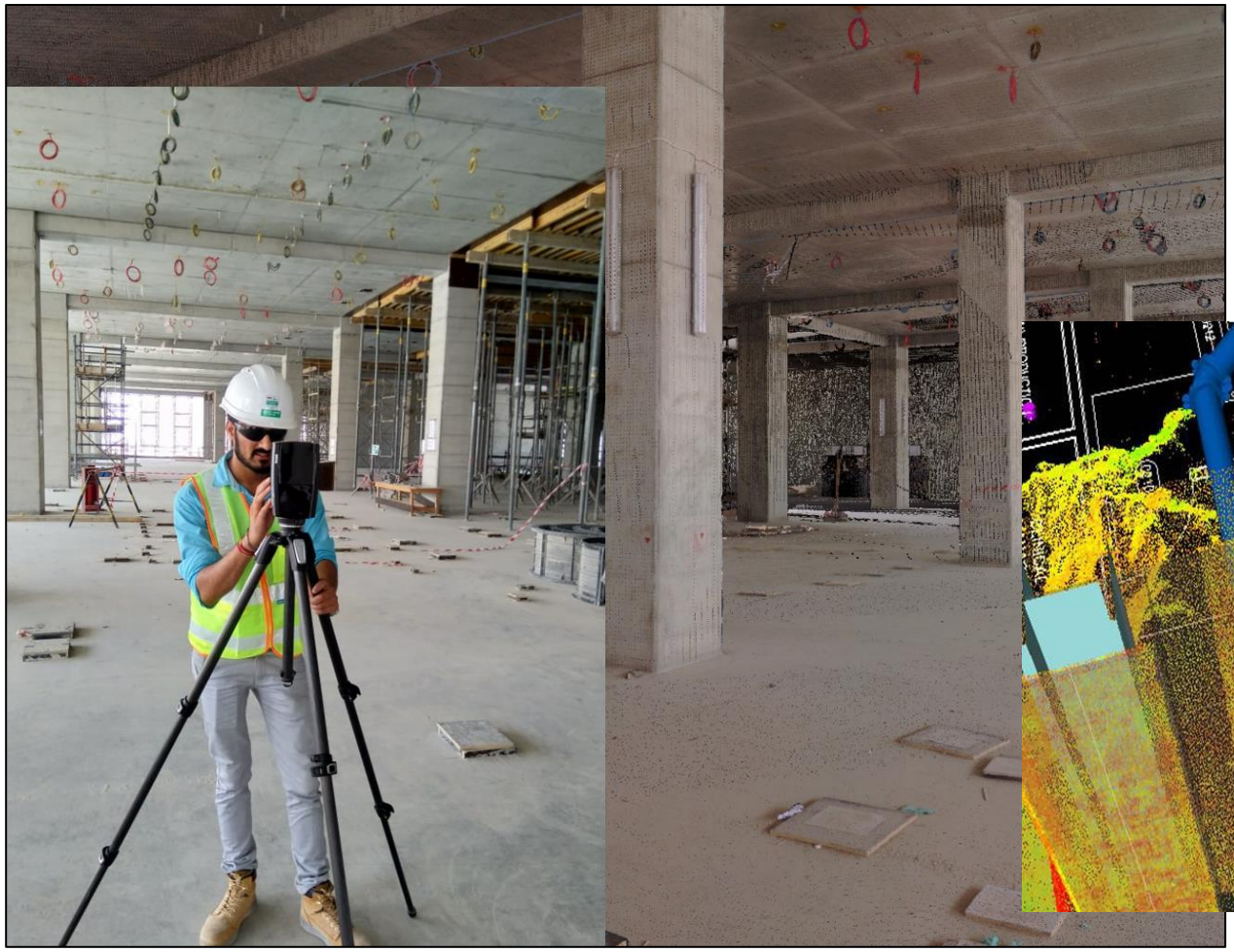
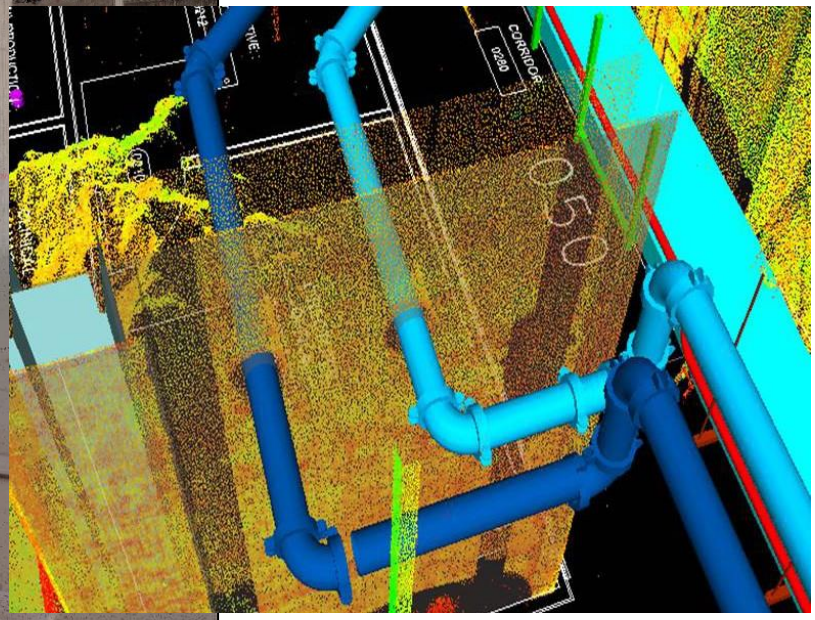
Laser Scanning for Construction Verification





Laser Scanning - Earthworks Management

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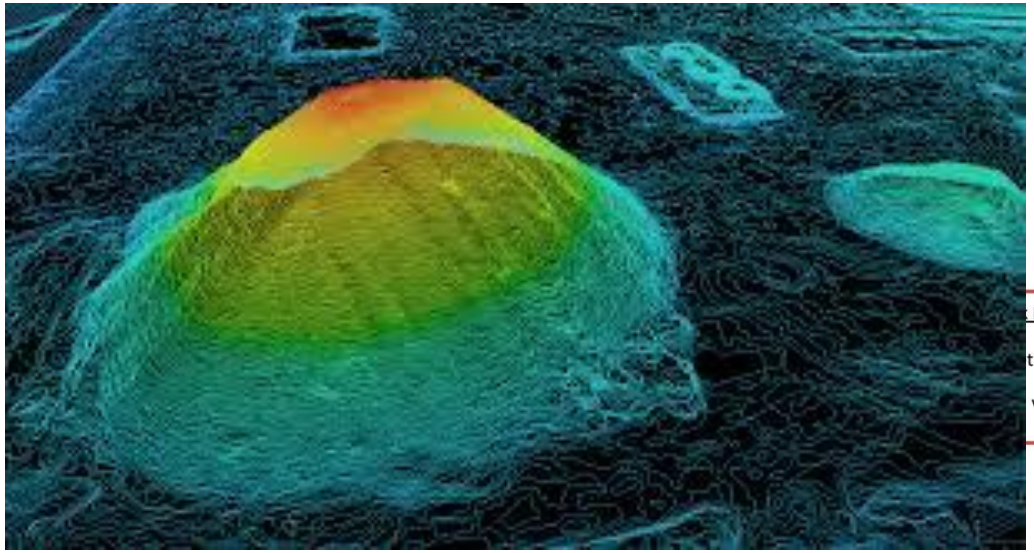
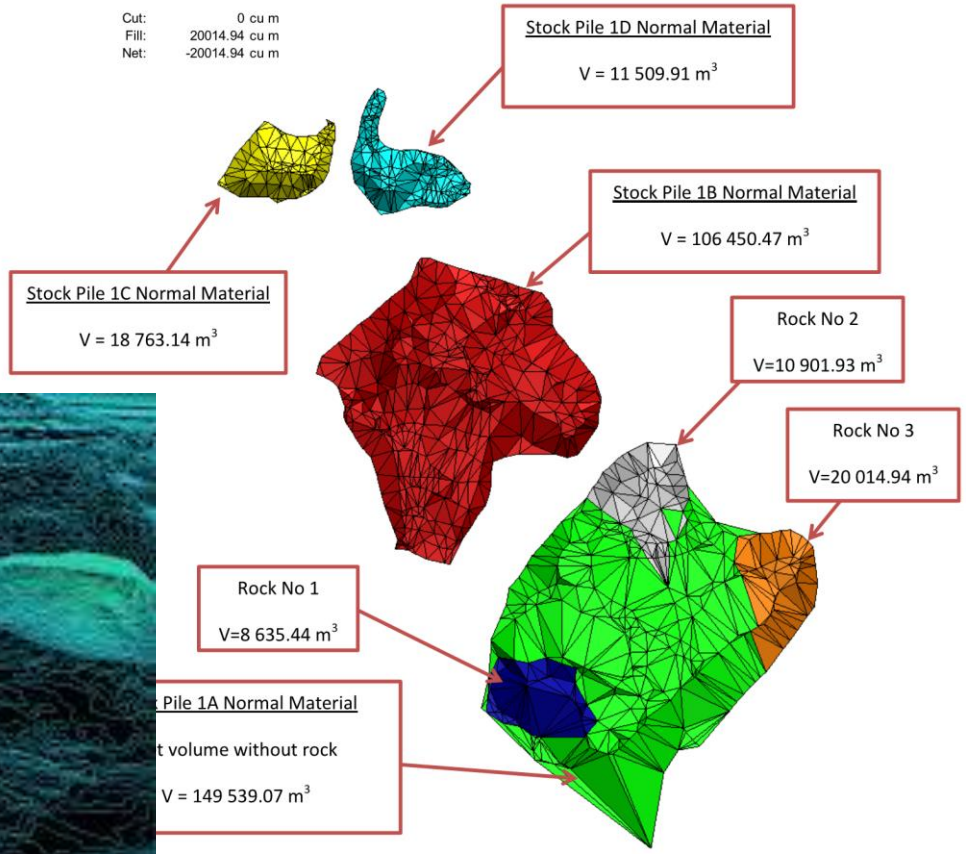
Earthworks Management & Documentation

- **Design documentation again will be extracted from the laser scanned Digital Terrain Models.**
- **The Earthworks Management will be continuously performed through the regular laser scans.**





Digital Collaboration / BIM-to-Field

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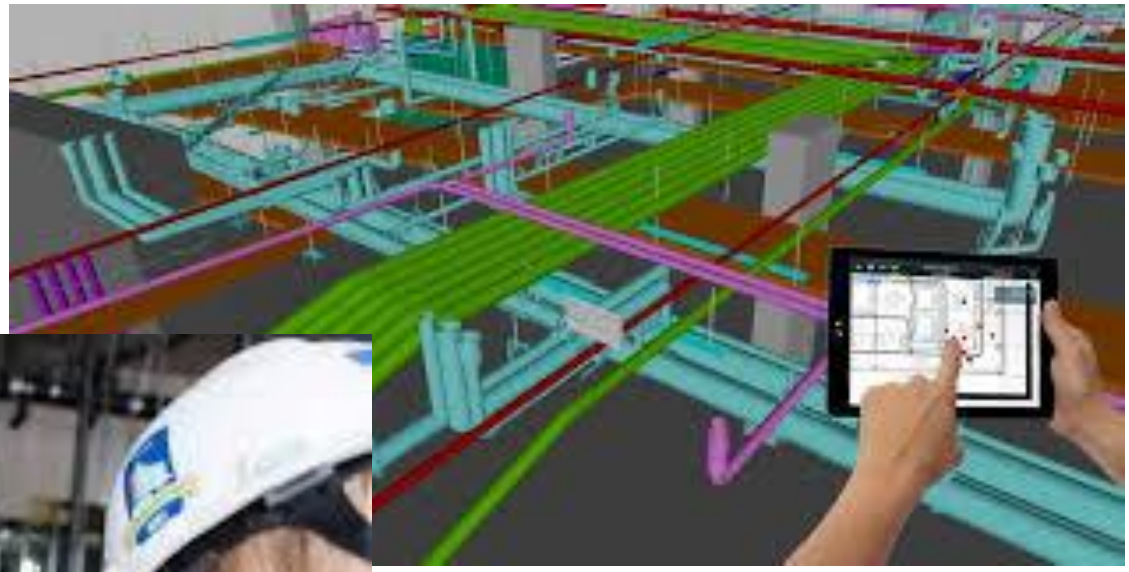

Augmented & Virtual Reality

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BIM and CDM / H&S

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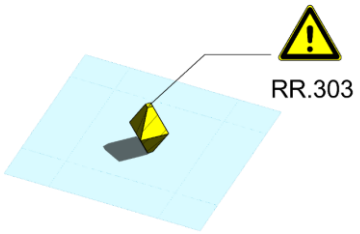
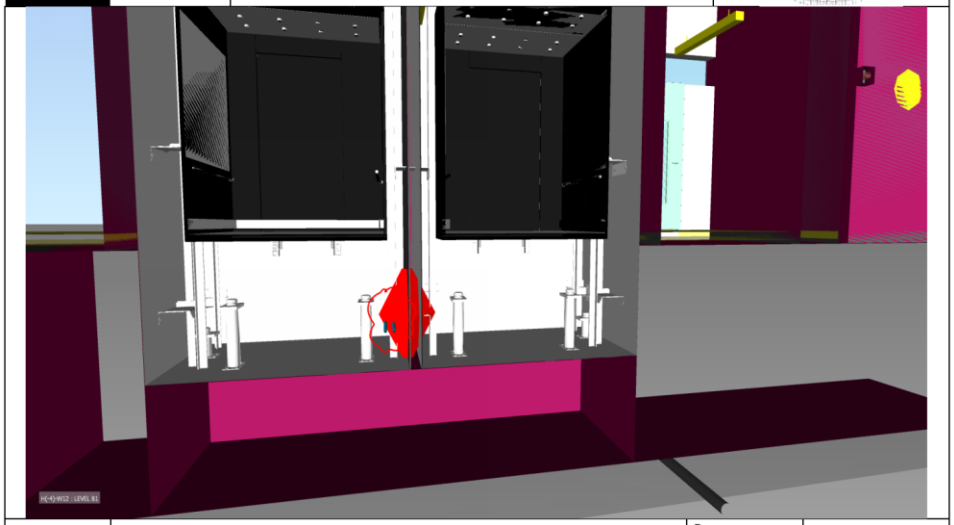
CDM 2015 and Health and Safety provisions



Issue Number	0013	Element(s) Id	S-LF-10E
Discipline	Elevators	There are conduits inside the shaft. Element ID: 1326602	
Level	All Levels		
Status	Pending		
Date Found	25-Nov-17		

Key-plan



Response 1		By	
		Response Date	25-Nov-17
Response 2		By	
		Response Date	30-Nov-17

BIM and CDM / H&S

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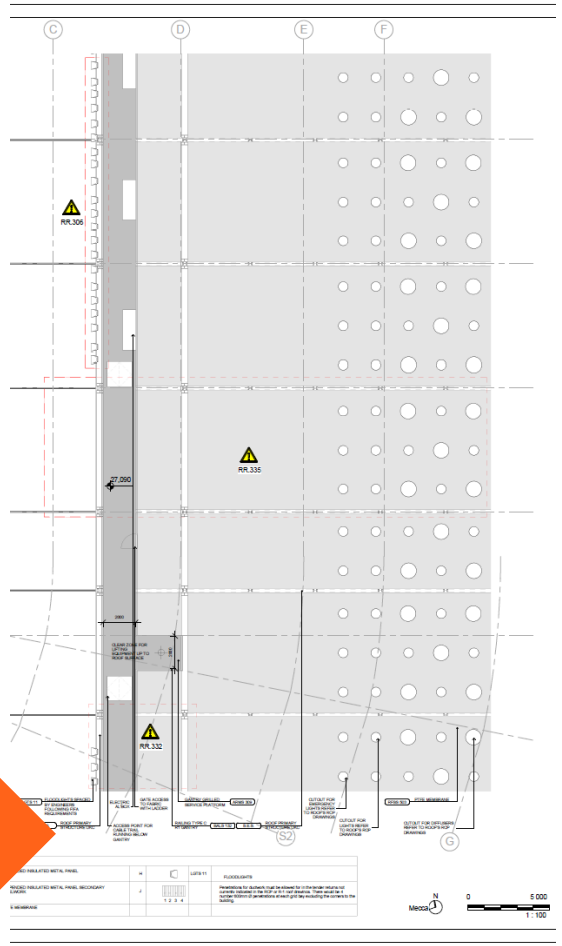
CDM 2015 and Health and Safety provisions

BIM Item	Owner (Company/Init s)	Date Raised	Hazard Area	Persons at Risk/Phase	Hazard Details	Risk Level (Pre-Mitigation)	Mitigation of Risk Employed by Designer	Risk Level (Post-Mitigation). See Note 4	Method of C SHE Box
~~RR.304~~	~~Pattern~~	~~30/10/13~~	~~Ground / Lower ground level~~	~~Construction~~	~~Reduced level dig for plant areas to basement. Risk of ground collapse, falling from height.~~	~~Medium~~		~~Low~~	~~TBC~~
RR.305	~~Pattern~~	~~30/10/13~~	~~Roof Level~~	~~Construction~~	~~Reduced level dig for plant areas for water feature~~	~~Medium~~	~~Design omitted~~	~~None~~	~~Reduced level dig for plant areas for water feature~~
RR.306	Pattern	30/10/13	Roof Level	Construction Operation and Maintenance	Stadium Floodlights and House lights. Risk of injury from sills, trips and falling from height, risk of injury from objects falling from height.	High	Coordination workshops held with design team to discuss the overall coordination of the structure and services and the associated access and maintenance issues at roof level. DC has incorporated a gantry at Level R1 which runs the full perimeter of the pitch to provide safe access to floodlights. House lights are mounted level with the surface of the walkable mesh. These lights are retractable, affording safe access for maintenance and equipment replacement from within the walkable mesh level. MC to ensure that appropriate access is afforded to ensure that installation and maintenance activities can be undertaken safely.	Low	Risk of falling from height. Risk of objects falling from height. Contractor to provide Method statement for review prior to the installation.
~~RR.307~~	~~Pattern~~	~~30/10/13~~	~~Roof Level~~	~~Construction Operation and Maintenance~~	~~Installation of wind screen. Risk of injury from falling from height, risk of injury from objects falling from height.~~	~~High~~	~~Coordination workshops held with design team to discuss the overall coordination of the structure and services and the associated access and maintenance issues at roof level. DC to ensure that appropriate access is afforded to ensure that installation and maintenance activities can be undertaken safely. Windscreen to be assembled at roof level from prefabricated sections, hoisted into place using pitch mounted crane. Temporary scaffolding required to provide access to full height of windscreen.~~	~~Low~~	~~TBC~~
~~RR.308~~	~~Pattern~~	~~13/11/13~~	~~Exterior envelope of stadium~~	~~Construction~~	~~Installation and maintenance of Cyclorama (fabric screen behind media~~	~~High~~	~~Design omitted~~	~~None~~	~~Installation and maintenance of Cyclorama (fabric screen behind media~~
RR.309	Pattern	13/11/13	Roof shading	Construction Operation and Maintenance	Retractable shading. Installation and maintenance of dynamic fabric shading structure to stadium oculus. Risk of injury from falling from height, risk of injury from objects falling from height.	High	DC has liaised with specialist installer and maintenance team to establish construction sequencing and construction methods and access and requirements. Roof design adjusted to ensure adequate space is provided around the installation to meet the requirements of safe installation and maintenance.	None	Risk of falling. Main Contractor to provide Method Statement describing the construction and maintenance activities associated with the installation prior to installation.
RR.310	Pattern	13/11/13	Building Envelope	Construction Operation and Maintenance	Unusual curved forms of built envelope. Risk of injury from slips, trips and falling from height, risk of injury from objects falling from height. GRP facade panels mounted at various angles. Various installation techniques required. DC has liaised with Bahraini Fibre Glass (BFG) to devlop the construction details for the facade to ensure a simple assembly.	Medium	Various installation techniques required. DC has liaised with Bahraini Fibre Glass (BFG) to develop the construction details for the facade to ensure a simple assembly. Installation of panels to be undertaken by operatives in MEWP's.	Low	Risk of falling. Main Contractor to provide Method Statement describing the construction and maintenance activities associated with the installation prior to installation.
~~RR.311~~	~~Pattern~~	~~13/11/13~~	~~Access road~~	~~Construction Operations and Maintenance Demolition~~	~~Elevated access road into the west elevation of the stadium. Construction, maintenance and demolition of elevated vehicular route presents risk of injury from falling from height, risk of injury from objects falling from height.~~	~~Medium~~	~~DC to liaise with Structural Engineer to ensure best practice construction methods are incorporated into the design and contract documentation~~	None	
~~RR.312~~	~~Pattern~~	~~13/11/13~~	~~Access road~~	~~Construction~~	~~Construction of footings to elevated access road. Risk of electrocution from encountering buried services.~~	~~Medium~~	~~DC to liaise with Civils and Electrical Engineer to review site surveys for presence of buried services. Civil and Electrical Engineers ensure best practice construction methods are incorporated into the design and contract documentation. Where necessary, commission further surveys to establish status of services in the relevant area~~	None	



BIM & 3D Printing

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Benefits include:

- Printed products only use as much material as needed = less waste
- Reduced transportation costs if products are printed on-site.
- Can achieve shapes that conventional techniques cannot.
- Lower labor costs.
- Reduced cost of customized design
- Reduced health and safety risks.

BIM and FM Integration

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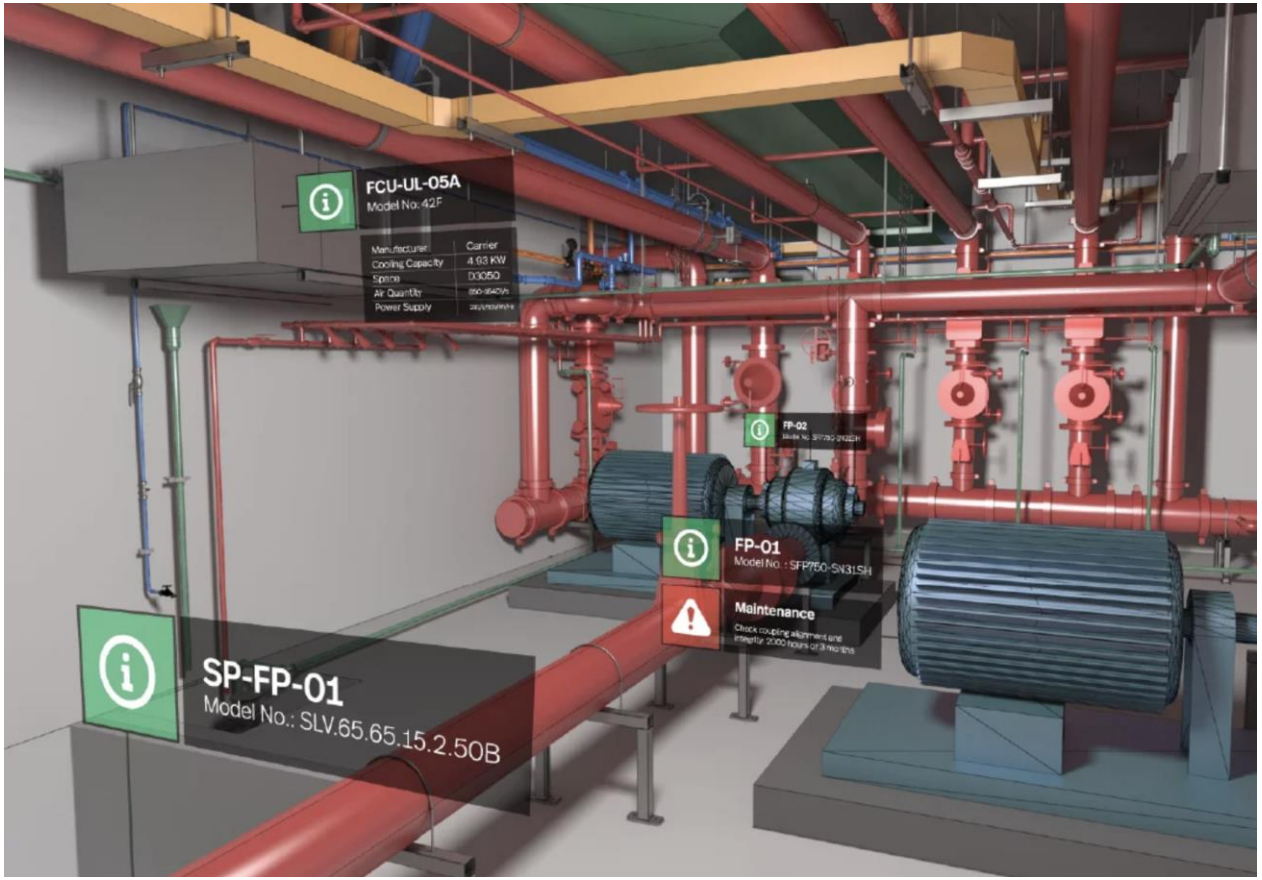
- **Streamline projects handover**
- **Integrate FM data with BIM models**
- **CoBie worksheet**
- **Asset Information Model (AIM)**



BIM and FM Integration

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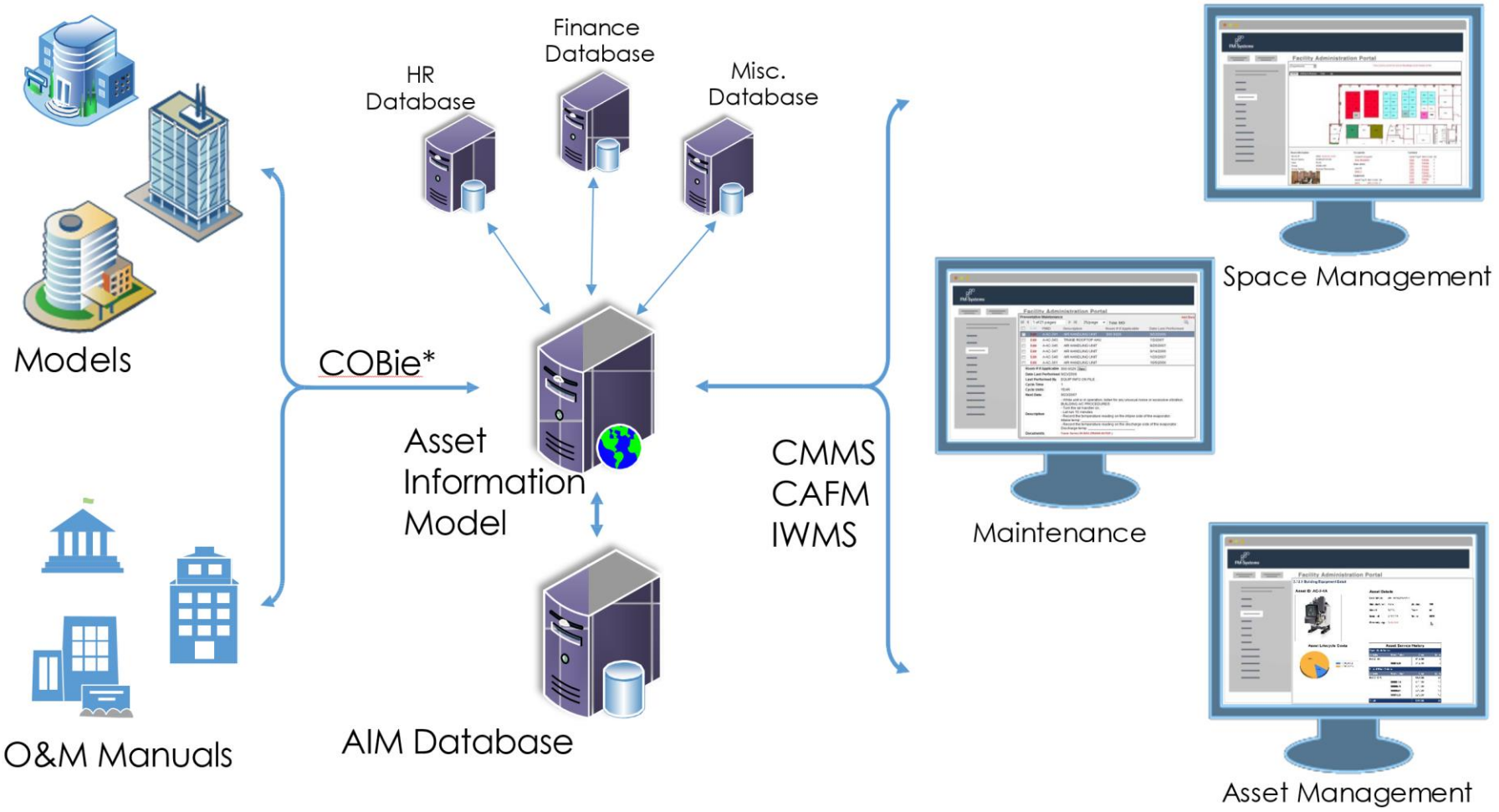

BIM & Digital Twin

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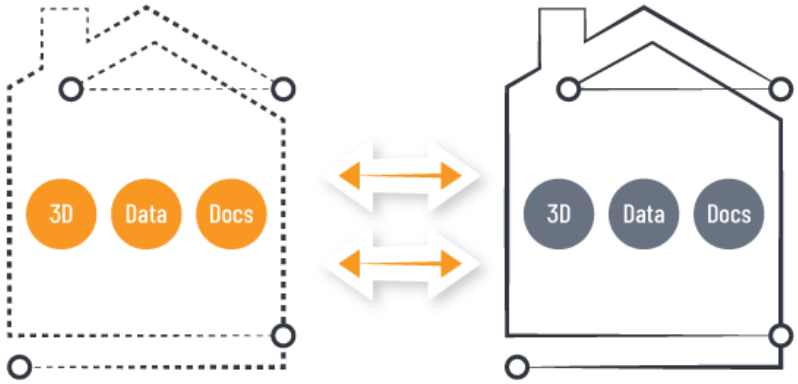
BIM

DIGITAL WORLD

DIGITAL TWIN

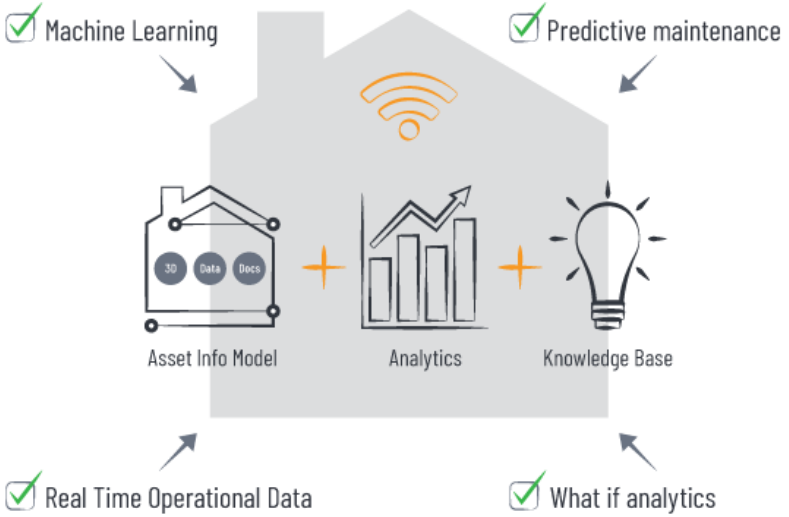
DIGITAL WORLD + PHYSICAL WORLD

STRUCTURED INTEROPERABLE DATA



as - DESIGNED model

as - BUILT model



CONCEPT DESIGN | DESIGN | CONSTRUCTION | OPERATION AND MAINTENANCE | END OF LIFE

Lean Principles

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• **Identify Value** - Identifying value and understanding the customer's point of views is a key component within Lean construction management. All stakeholders such as the client, architect, engineer, general contractor, suppliers, operators are expected to work collaboratively.

• **Define Value Stream** - Once we have a clear understanding of the value from the customer's point of view, we can design the processes necessary needed to deliver that value. For each activity, the necessary labor, information, equipment, and materials are defined and any unnecessary non-value adding steps or resources can be eliminated.

• **Elimination of Waste** - Lean construction targets each major types of waste which include defects, overproduction, waiting, underutilization of talent, transportation, inventory, motion, and over processing.

• **Work Process Flow** - The ideal state of lean construction management is continuous workflow that is considered reliable and predictable.

• **Pull Planning and Scheduling** - Creating reliable workflows depends on work being released based on downstream demand. Lean uses collaborative planning (Last Planner) to enable participants to communicate and collaborate close with each other to determine the schedule of tasks.

• **Continuous Improvement** - Continuously improve processes and eliminate waste is the overall goal of lean philosophy. Opportunities for improvement are then identified and acted upon during the project and applied to future projects.

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DOMAINS OF PROJECT DELIVERY

CPM-based; Activity-Centered;
Management by Exception

Individual
craft-contracts

2D/3D

Command & Control
Directives-Driven

(Abdelhamid 2014)

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DOMAINS OF PROJECT DELIVERY

CPM-based; Activity-Centered;
Management by Exception

Lean-based; Management by Means
(planning inclusive of execution party; fire prevention)

Individual craft-contracts

IPD/IFOA
Relational

(system optimization)

2D/3D

BIM/VDC

Command & Control
Directives-Driven

Dialogue & Collaboration
(planning is an ongoing conversations)

(Abdelhamid 2014)

BIM and Lean construction: MacLeamy curve

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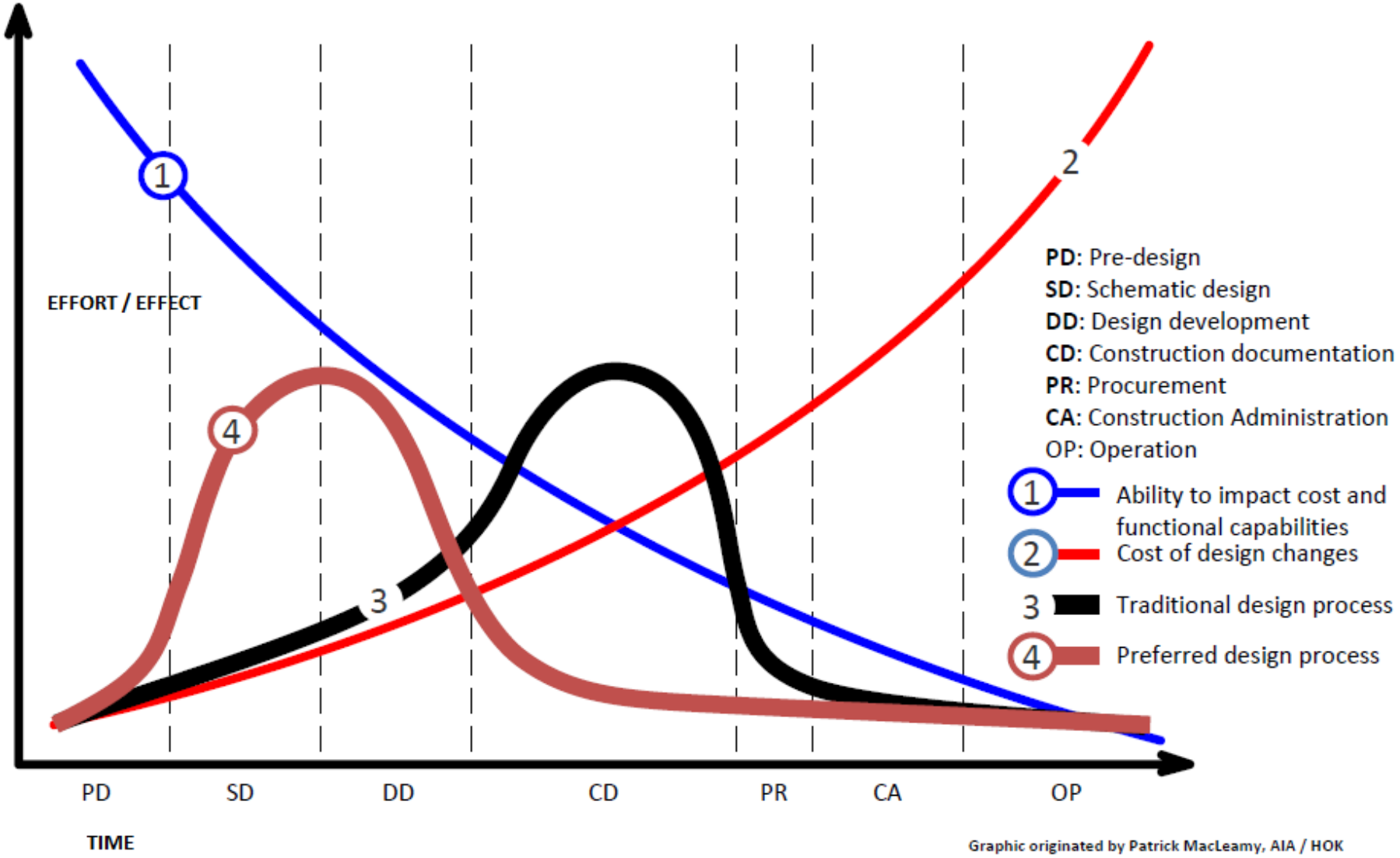

The new iron triangle: IPD, Lean, BIM

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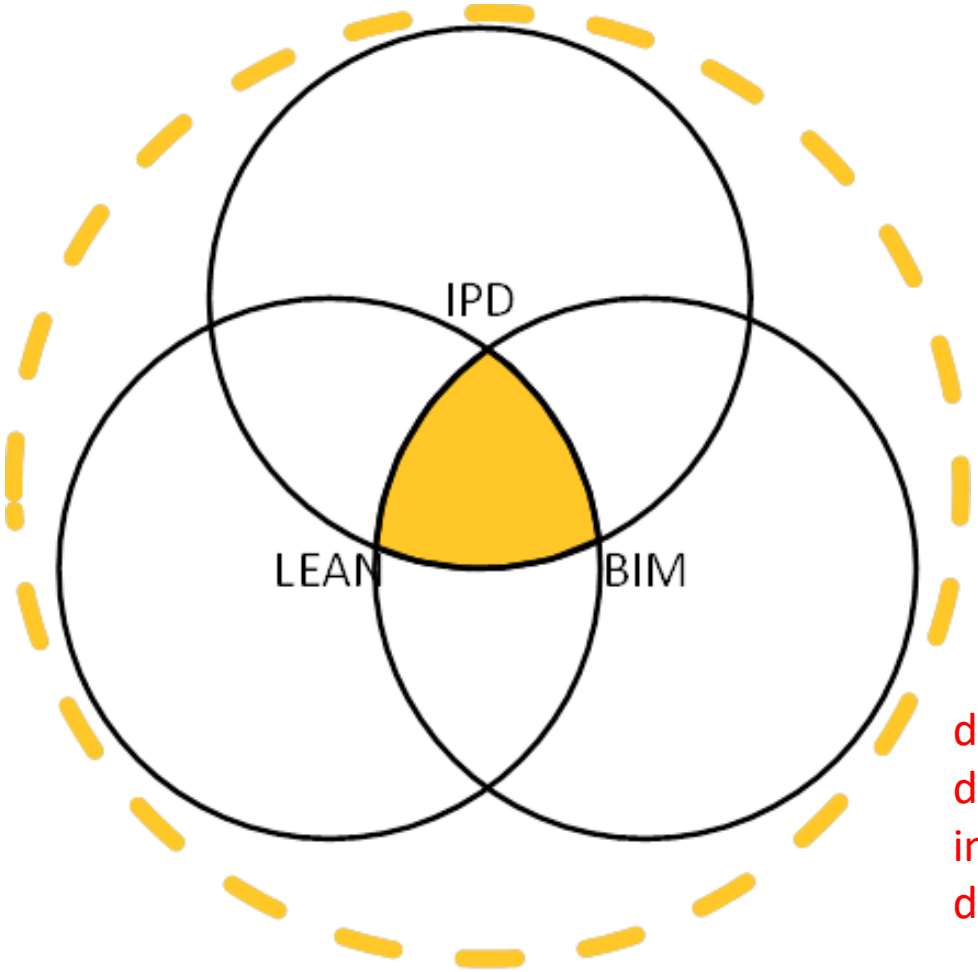
system optimization



processes and workflows optimization

digitalization of design construction information, data-driven processes

BIM & Lean construction management

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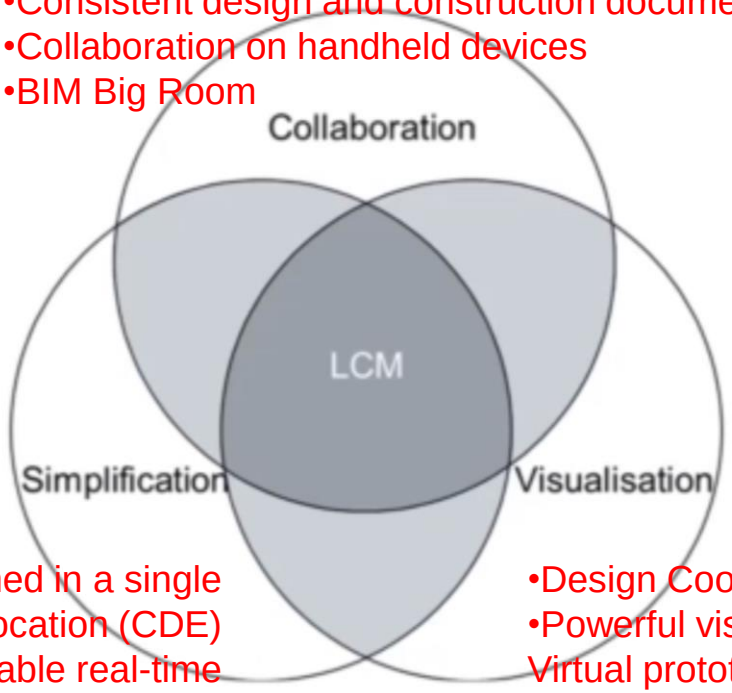
•Real time-collaboration between stakeholders
•Transparency, better scope management
•Identification of constrains
•Consistent design and construction documentation
•Collaboration on handheld devices
•BIM Big Room



•All information maintained in a single common location (CDE)
•Latest information available real-time
•All Drawings and Documentation extracted from a single source (of truth): the models

•Design Coordination
•Powerful visualization, VR, Rendering and Virtual prototypes
•Client early engagement and sign-off
•Visual Management
•Construction Sequence and Methodology

BIM uses and outputs

BIM & Lean construction

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- **Faster project delivery.**

- **Better quality.**

- **Cost saving due to reduced waste and less rework.**

- **Better value for all Stakeholders.**

- **Lower risk.**

BIM ROI

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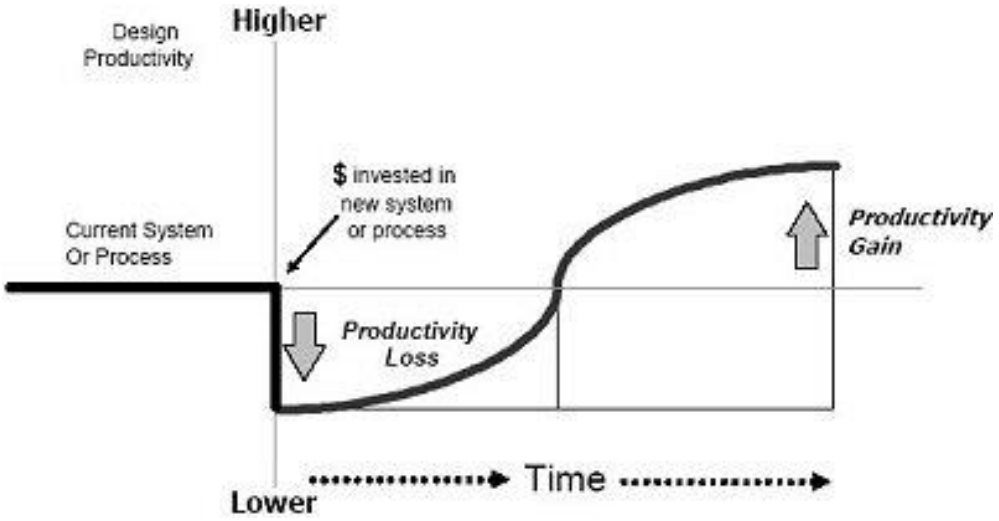

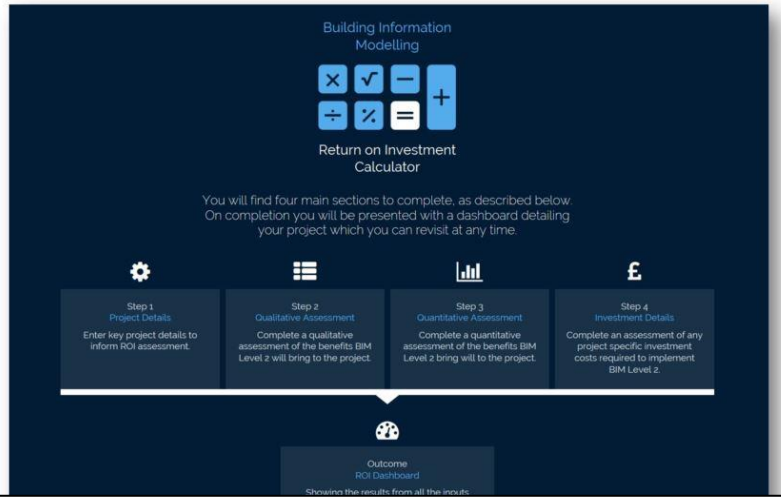

Questions