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IN GOD, WE TRUST ALMIGHTY, AND THE MOST MERCIFUL

SCHOOL OF CONSTRUCTION ECONOMICS AND MANAGEMENT

Digitalization for Dispute Resolution in Multifaceted Projects: Forensic BIM

Ehsan Saghatforoush, PhD

Claims in Multifaceted Projects

- It is probable that a multifaceted project anywhere in the world will encounter some form of delay as a consequence of change.
- It is likely to have a negative financial outcome.
- Compensation can be requested by an affected party in the form of a claim; however, issues of liability and quantum can be difficult given the ever increasing complexity of construction work involving numerous differing successive parallel tasks with varying levels of interrelated resources.

Claims in Multifaceted Projects - cont.

- To combat these problems, the courts are moving closer to e-disclosure and the use of screens as a method of communicating a case. Therefore, the potential to use DIGITALIZATION to represent delay as a response to change is possible.

DIGITALIZATION Opportunities

- Retrieval: A reason why disputes occur is due to a difference of information (Pickavance, 2010). A centralised, electronic hub ensures that the most up to date information is readily accessible to all parties involved on the project. In the event of a claim, all of the project information can be understood, accessed, sorted, filtered and reported at a faster rate than paper or unmanaged electronic information (CIOB, 2011).
- Visualisation: Extending the use of computerised presentation past construction schedules, the potential to use computer generated visualisations to assist with the communication of claims are discussed (Pickavance, 2010).

Forensic Modelling & Animation

- Visualise and orientate intricate construction sites
- Animate construction activities and plot their impact
- Illustrate complex situations graphically with timelines
- Communicate through persuasive 3-D and 4-D mediums

Forensic Modelling & Animation - Cont

- Produce persuasive videos and fly-throughs from 4-D models, which include the timing and sequence of events.
- link a relational database to the models and the animation, enabling visual scenario planning and 'what if' analysis of the case.
- Reduce the cost of producing these animations- they can be used far more widely, even to resolve variation claims and minor site disputes.

Forensic BIM

Through BIM forensic analysis we adhere to the principle that a good forensic engineering expert is a detective. Moreover, one who patiently searches for evidence and reconstructs events.

Background: DIGITALIZATION and IT for Construction

- **Traditionally construction process information is communicated with paper documents and 2D CAD drawings**
- **The need for web-based project information systems**
- **Information still uses document-based model**
- **Transition to model-based information accessible through web-based 3D user interface**

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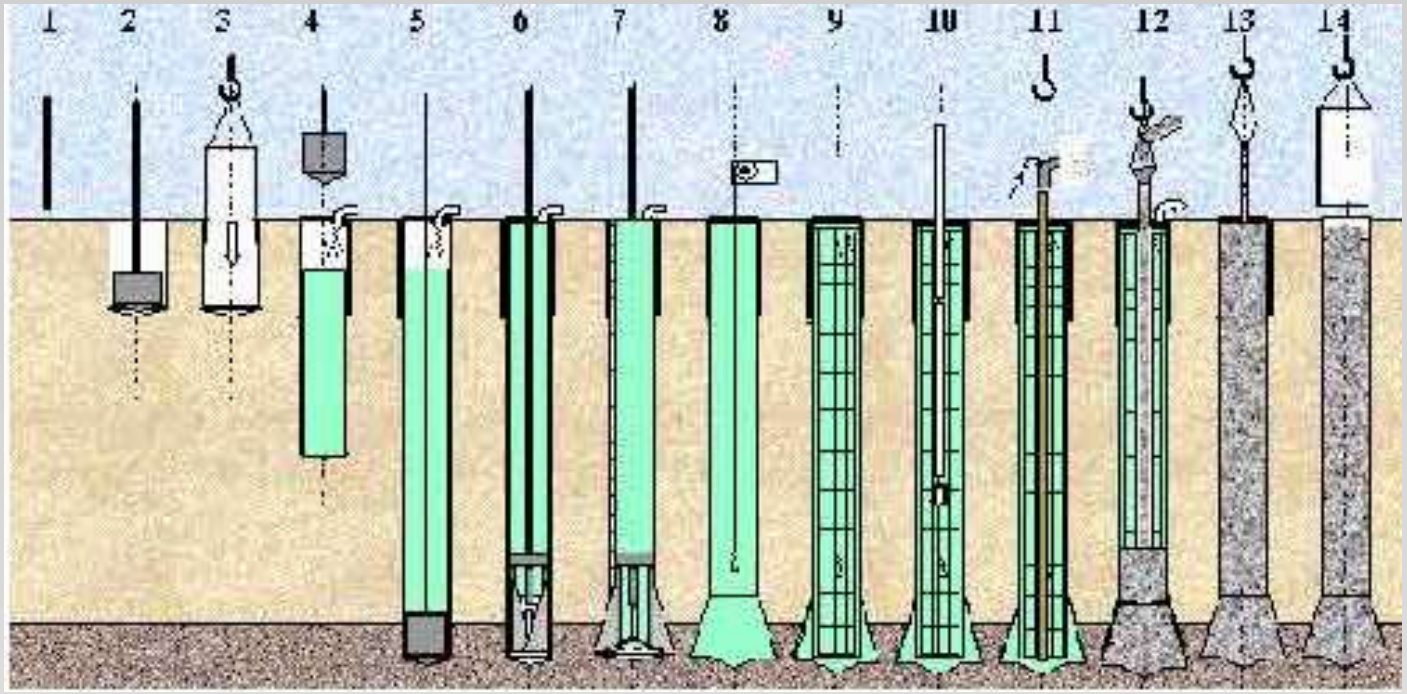
Conventional Construction Process Information



Isolated paper documents - Only to show the work procedure; not effective to assess, plan the site activities, and processes…

*** Source : National Institute of Standards and Technology**

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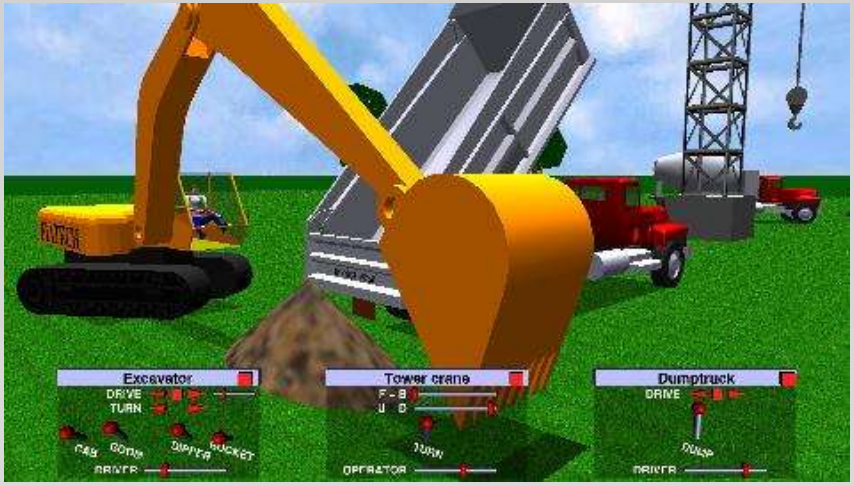
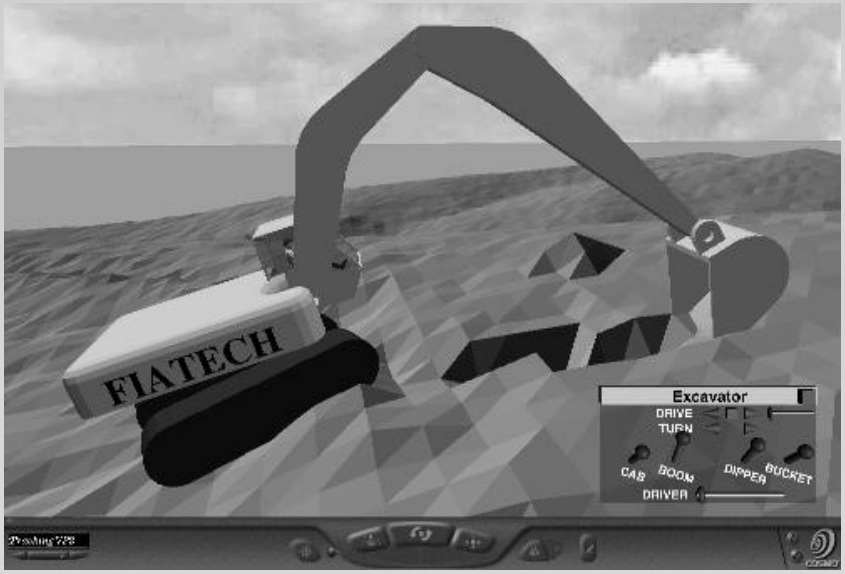
Virtual Reality Modelling





Provide the Visual representation and simulation of construction and building related models, activities, and processes – forecast the site condition exactly and prepare the possible problems…

*** Source : National Institute of Standards and Technology**

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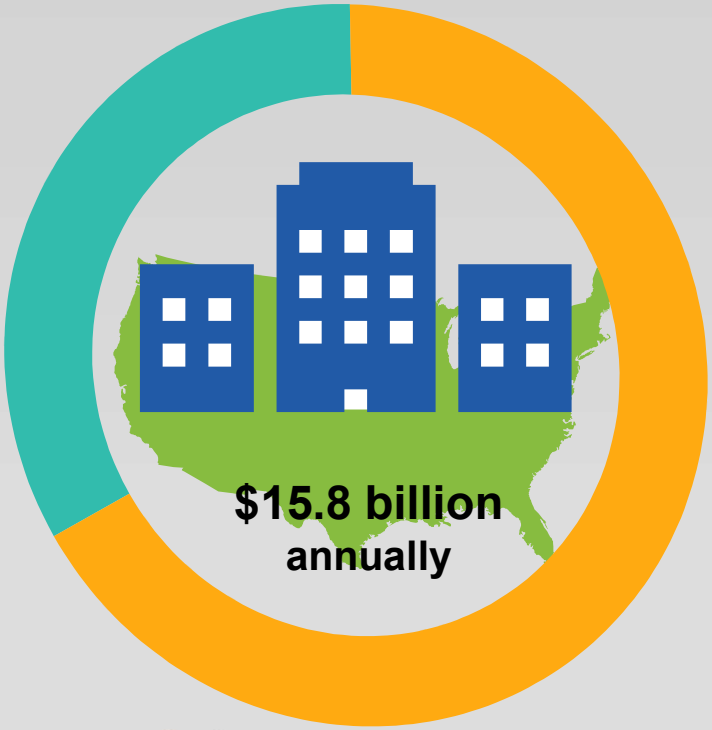
Expected Effects

- From mobilization to execution, it will be possible to plan and array the equipment / manpower in the right place timely as per the schedule
- Anticipate how well the execution plan can be applied for some of the issues related to construction site activities and procedure etc.
- Reduce / minimize the equipment idle times due to the unexpected problem
- Prevent the possible accidents beforehand due to the wrong operation of equipment
- Prevent fragmented teams

The Cost to Owners

- Poor use of data coupled with highly fragmented teams cost the US capital facilities industry $15.8 billion annually



Owner's weight is about 2/3 of those costs during ongoing operations.

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Problems owners face

Over **60%** of major capital programs fail to meet cost and schedule targets

30% of construction cost is rework

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Design Mistakes

Extra costs

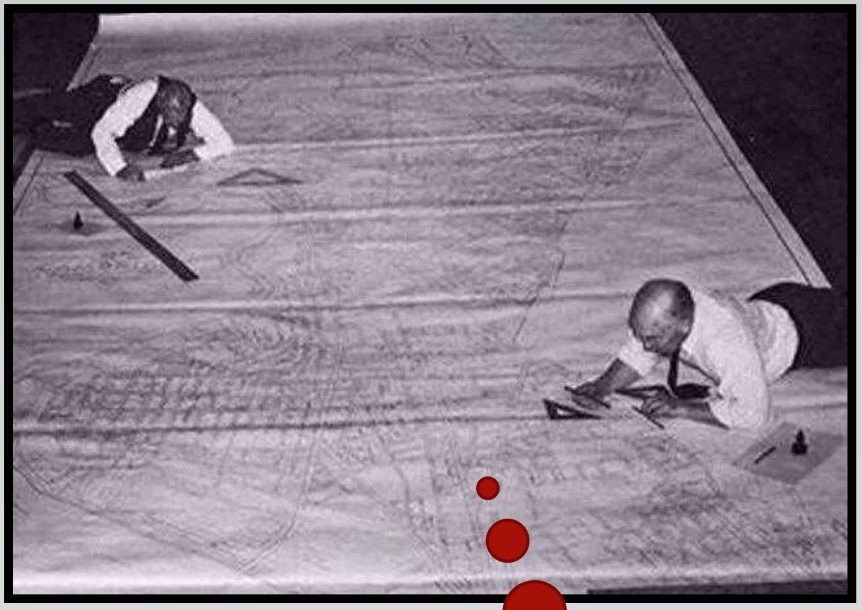
Delays

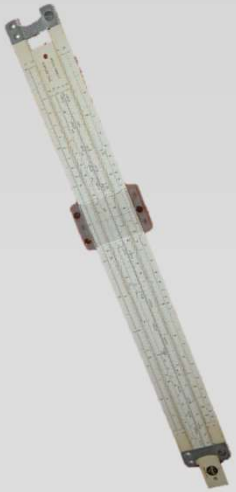
Lower quality

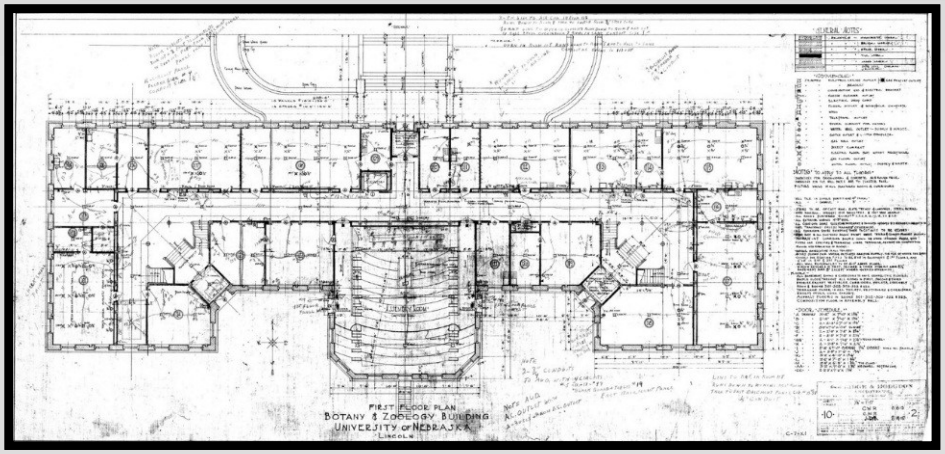
Owner's expectations not fulfilled

Design History

- Slow!
- Various mistakes!
- Hard to control!
- Hard to make changes!







Could they go over 2D?
3D,4D, 5D, …, nD?

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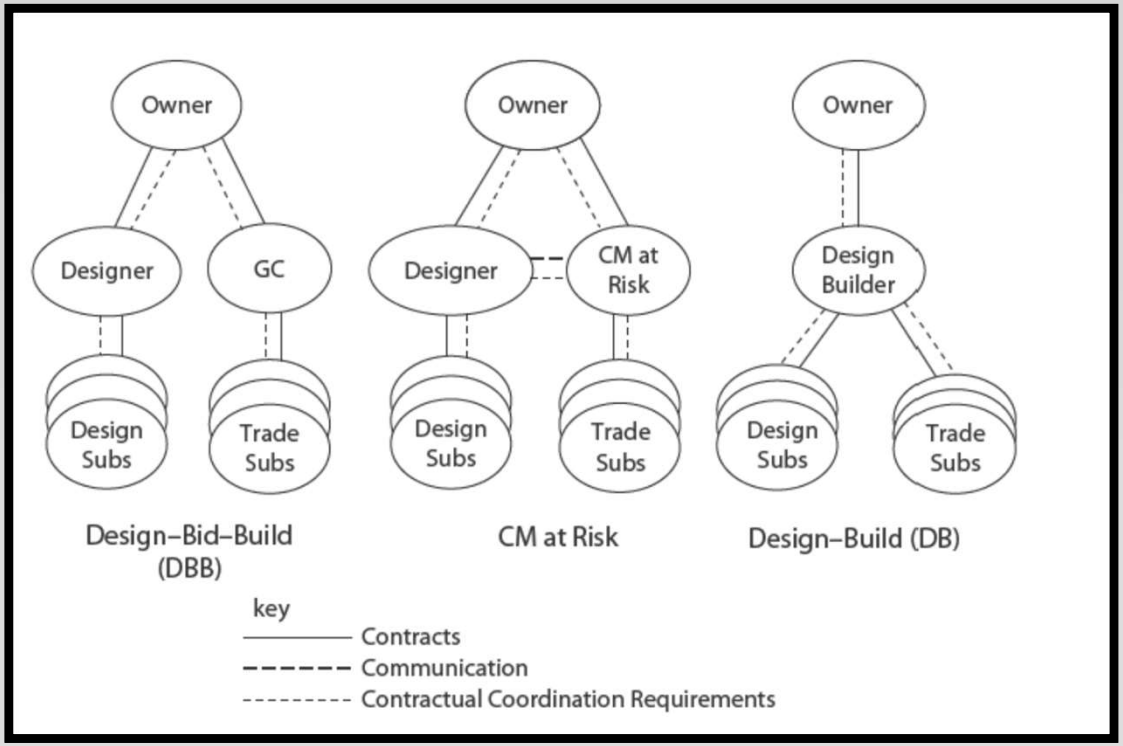
Traditional Solutions

- DB and CM instead of DBB
- 3D CAD
- Makets



Consequences:

- **Faster data transfer.**
- **The same mistakes!**
- **The same reworks!**

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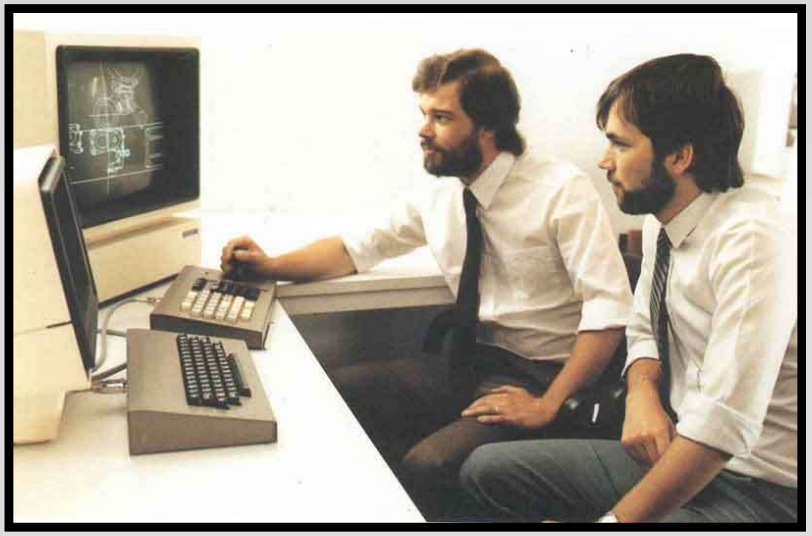
CAD

- Born on 1970th.
- Got popular very fast.
- Resulted in faster and more precise designs.



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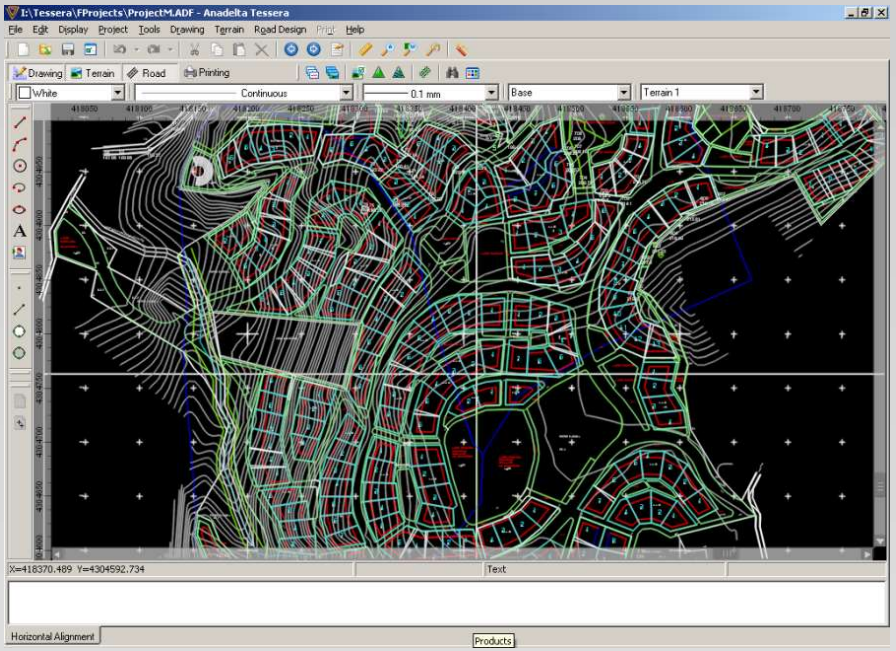
What was CAD for?

Use of computer to improve/enhance:

- creation
- modification
- analysis
- optimization



Nothing more than design!

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CAD Benefits

1. More efficient designs.
2. Fewer design mistakes.
3. Easier/improved collaboration.
4. Enhanced control over designs.
5. Better quality designs

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CAD Difficulties

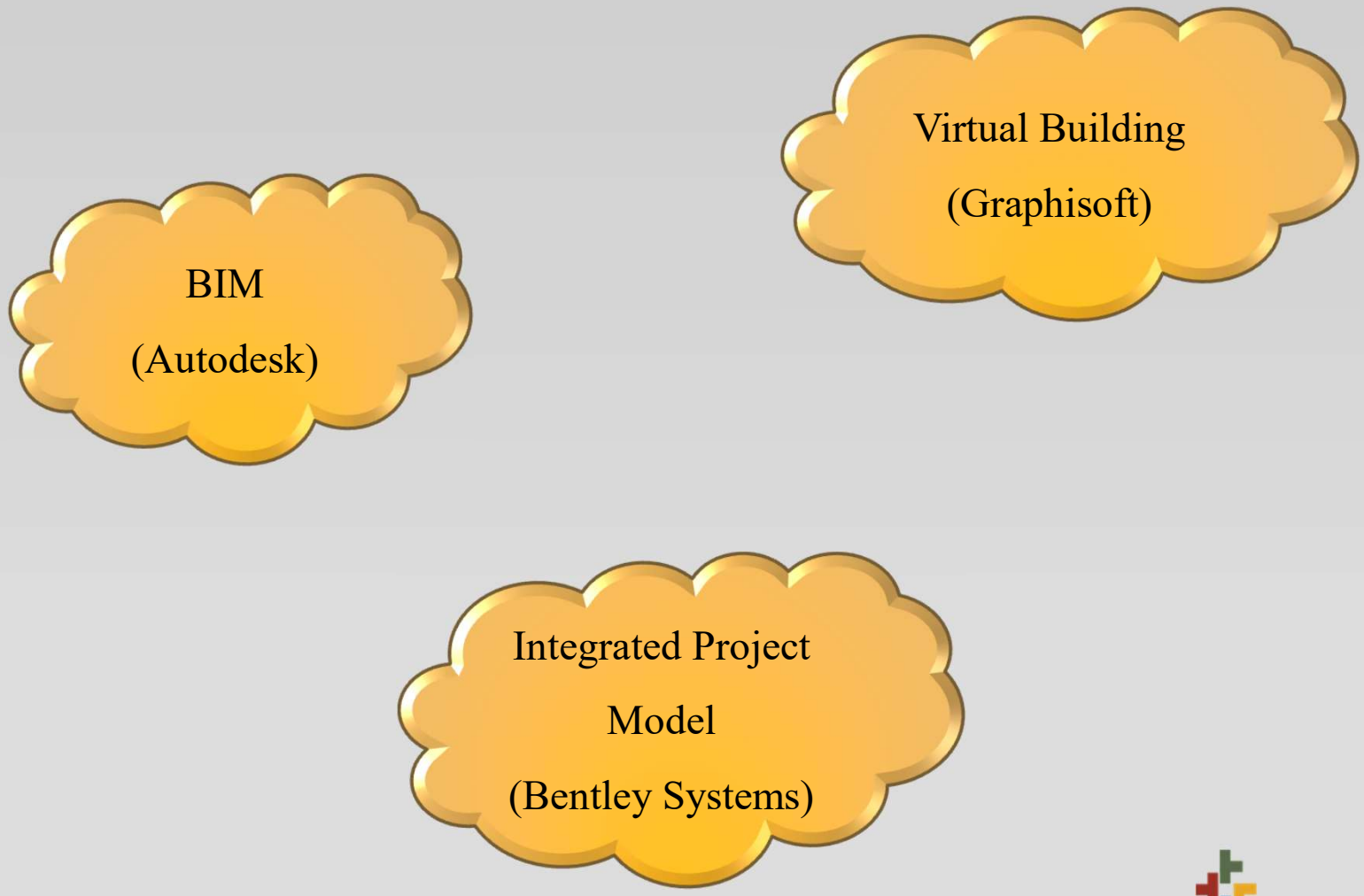
It was hard or sometimes impossible to:

1. make changes in designs.
2. do quantity surveying and estimation.
3. estimate energy consumptions.
4. draw details (like structural details)
5. find clashes, mistakes or incorrect information.

Forensic BIM

BIM Initiation

+ First white paper on BIM by Autodesk on 2002



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Building Information Modelling (BIM) – Cont.

The US National Building Information Model Standard Project Committee has the following definition:

- *Building Information Modelling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is 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.*

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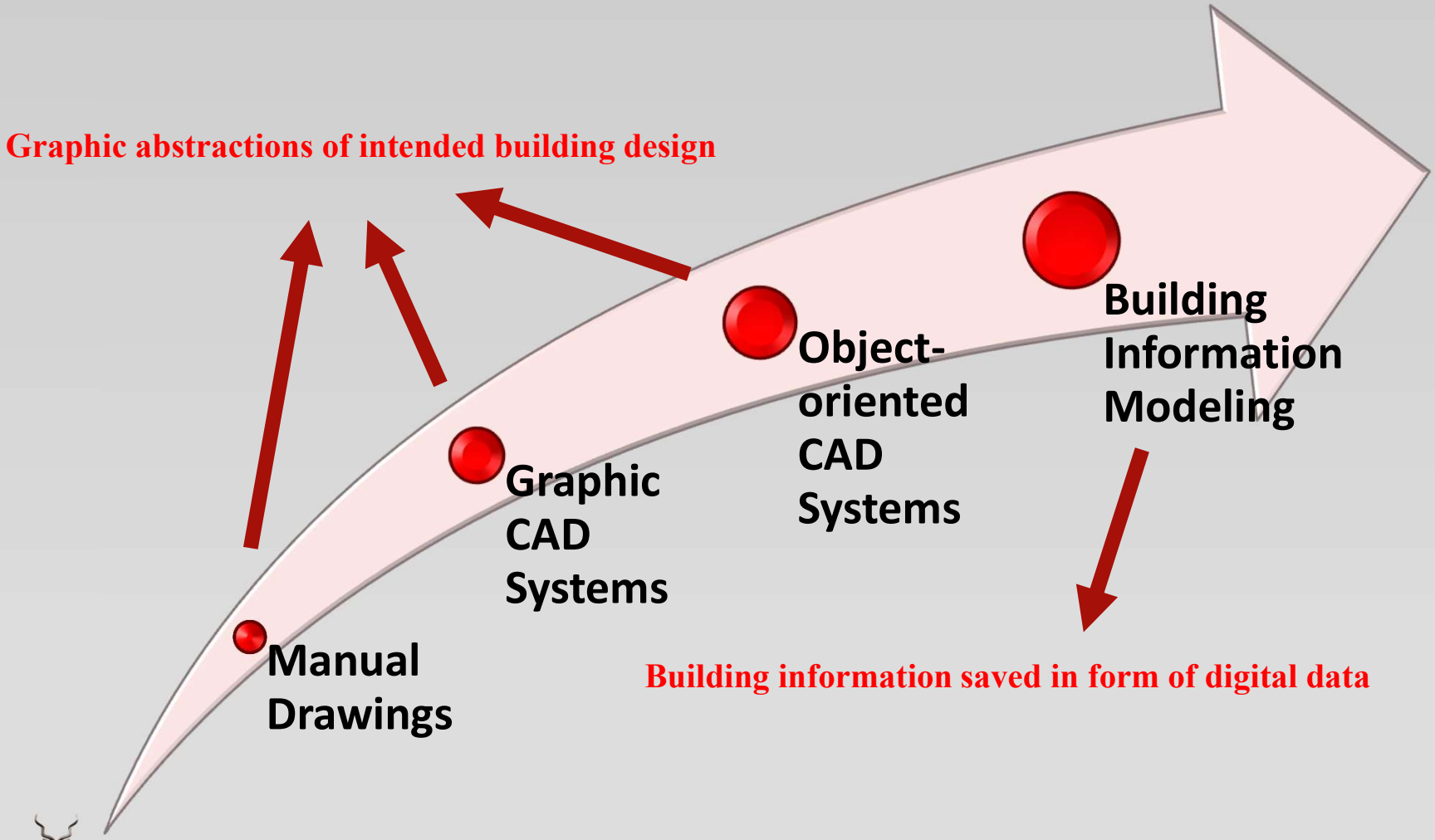
BIM vs. CAD



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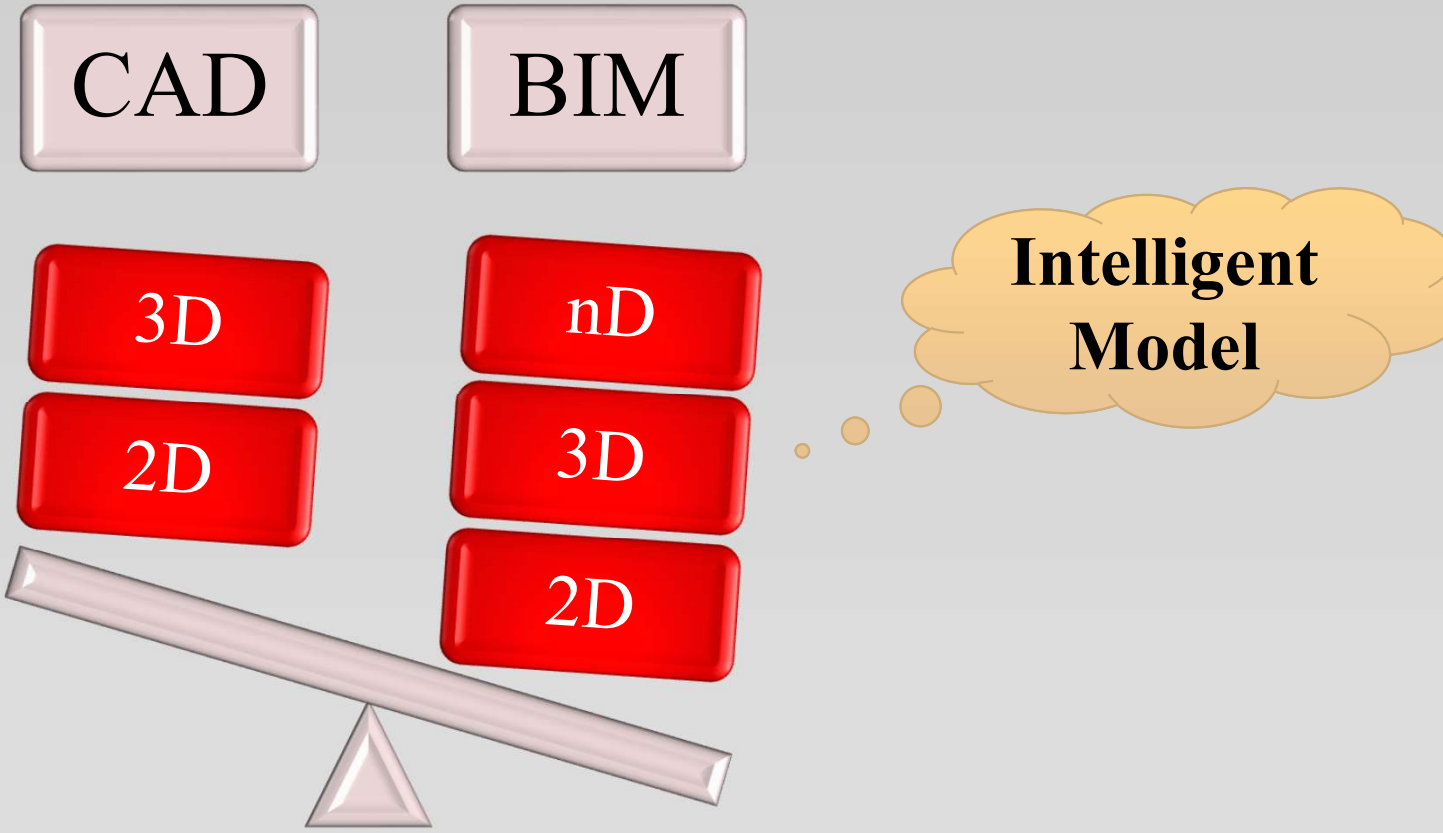
BIM vs. CAD



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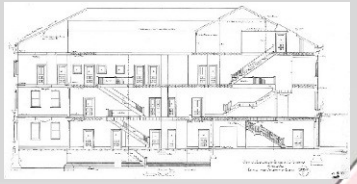
nD



2D

X
Y

3D

X
Y
Z

4D

X
Y
Z
Time

5D

X
Y
Z
Time
Cost

nD

X
Y
Z
Time
Cost
Contractor
Warranty
Maintenance
...

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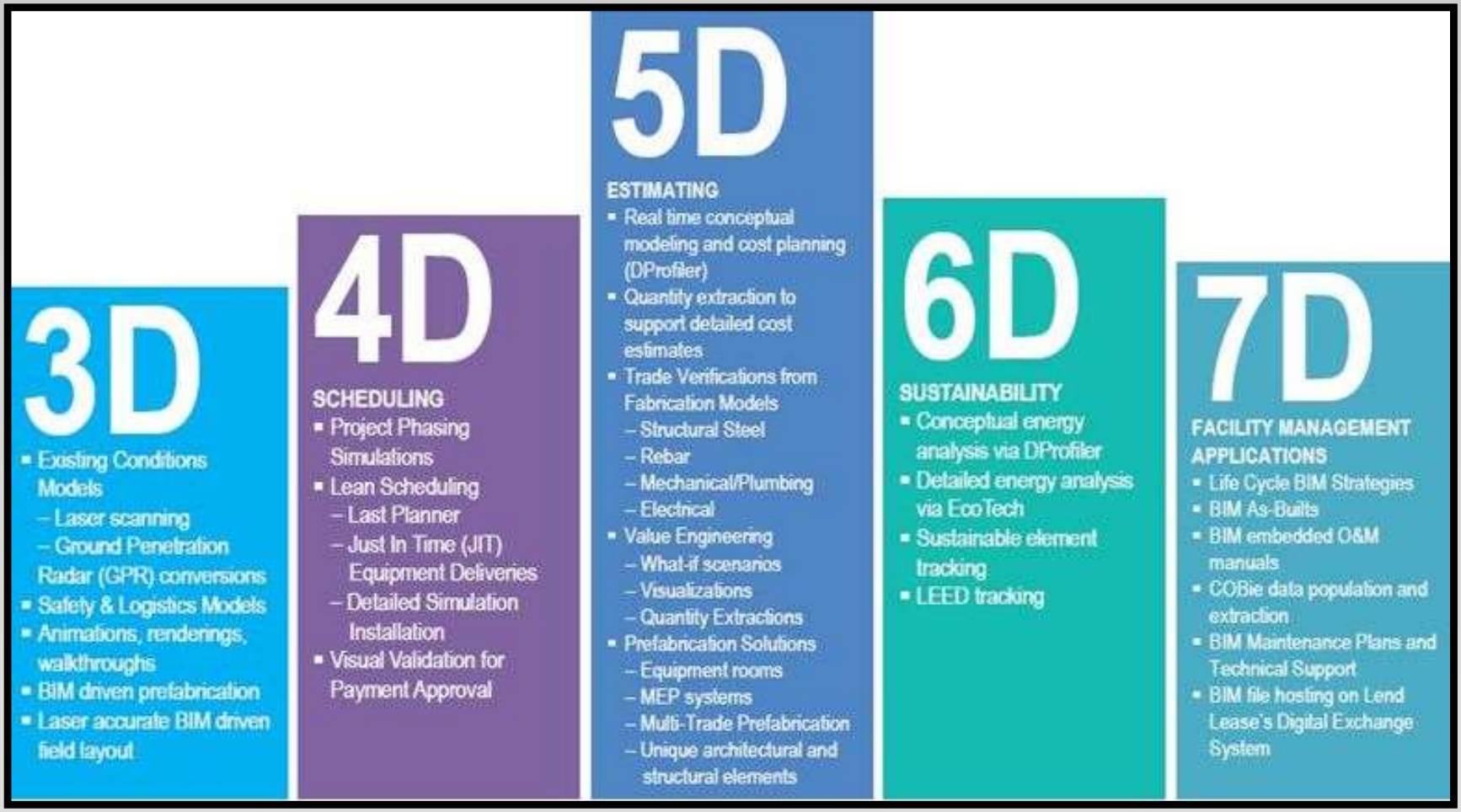

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BIM Characteristics

Clash controls	Integration of building information models of different disciplines Check geometrical design Detection and correction of errors and overlap Points of models of different disciplines each other during integration
Analyzes	Energy analyses Environmental analysis
Time estimation (4D)	Linkage of objects to time plan Graphical visualization of projects schedule Early detection of planning errors.
	Optimization of logistical aspects.
Cost estimation (5D)	Connection of objects with price lists for different materials.
	Easy value engineering analysis
	accurate cost estimation at any point in the design phase
	Creates understanding regarding financial implications of design decisions.

Fazli, A. et al (2014)

BIM vs. CAD

BIM	CAD
The building information is stored in a database.	The building information is stored in a format.
Architects work on the building information through a drawing rather than working directly on a drawing	Architects work directly on a drawing

BIM Benefits

- Coordination

• Like real buildings, virtual models are comprised of virtual components and elements.

• Relationships between elements are updated as the modeler modifies the model.

- Communication

• 3D models/images can be grasped immediately by most people.

• BIM improves communication between designers and anyone else.

• BIM provides an opportunity to engage clients, contractors and other stakeholders much earlier in the design process.

- Data management

• Generates graphical representations of building elements.

• Modelling software manages data associated with each element of the building.

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BIM Benefits – Cont.

- **Analysis and simulation**

• Simulation of various aspects of the proposed building's behavior such as structural, thermal, acoustic, etc.

- **Improved productivity during construction**

• Better planning of site activities and optimization of the construction sequence

• More prefabrication off site as building elements can be modelled and manufactured with greater precision.

- **Better information for Facilities Management**

. Data generated during design and construction can be readily passed on to Facility Managers to assist the min operating and maintaining buildings more effectively.

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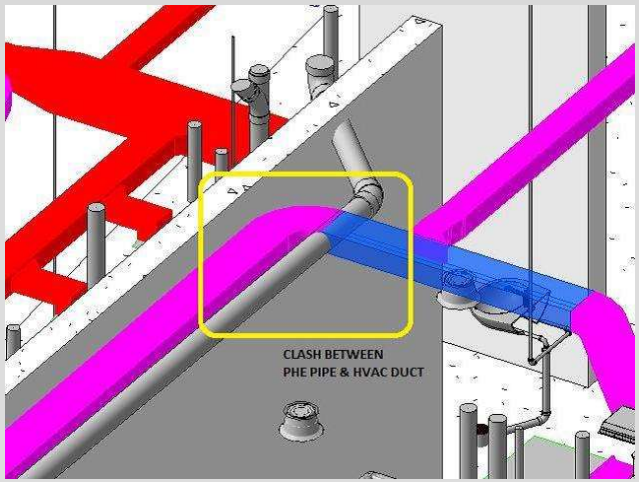
Clash Detection

What is a clash?

A clash occurs when elements of different models occupy the same space. A clash may be geometric (for example, pipes passing through walls), schedule based (when different aspects of work that are supposed to be sequential are scheduled to occur together or in reverse), or changes/updates not made to drawings.



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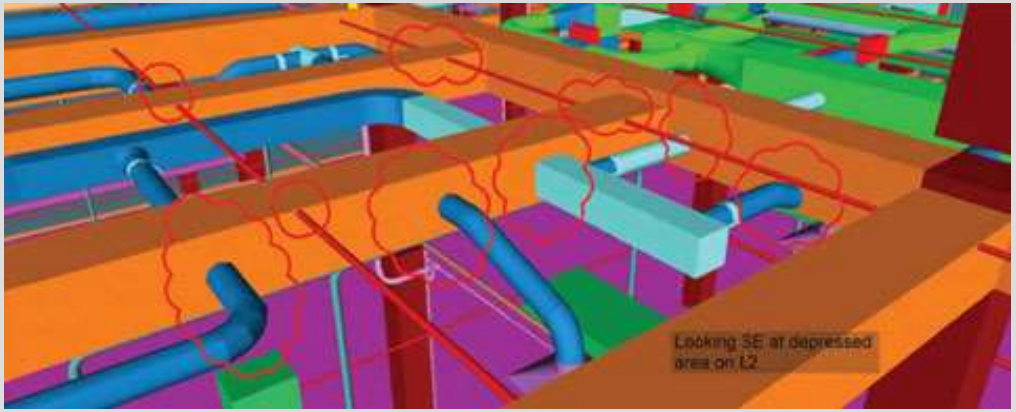
Clash Detection – Cont.

Is there no way to check for clashes without BIM?

There is... but it is very tedious. It involves overlaying of drawing to see if there are any conflicts. With BIM though, this process is vastly improved as BIM brings automation to clash detection.



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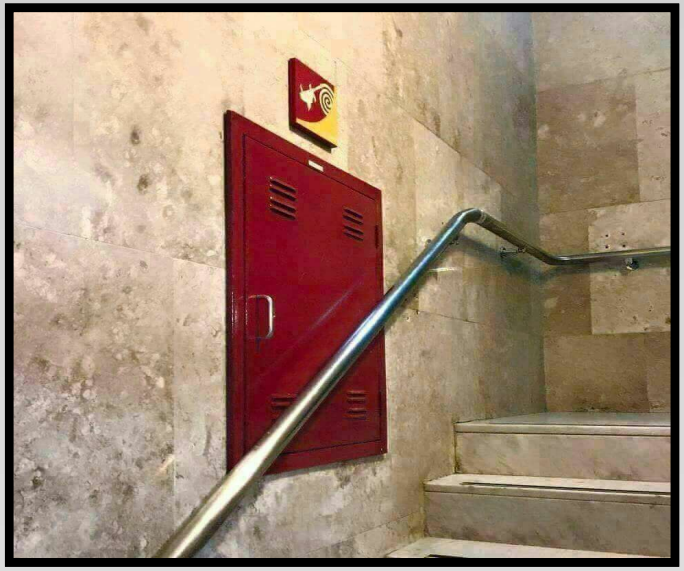
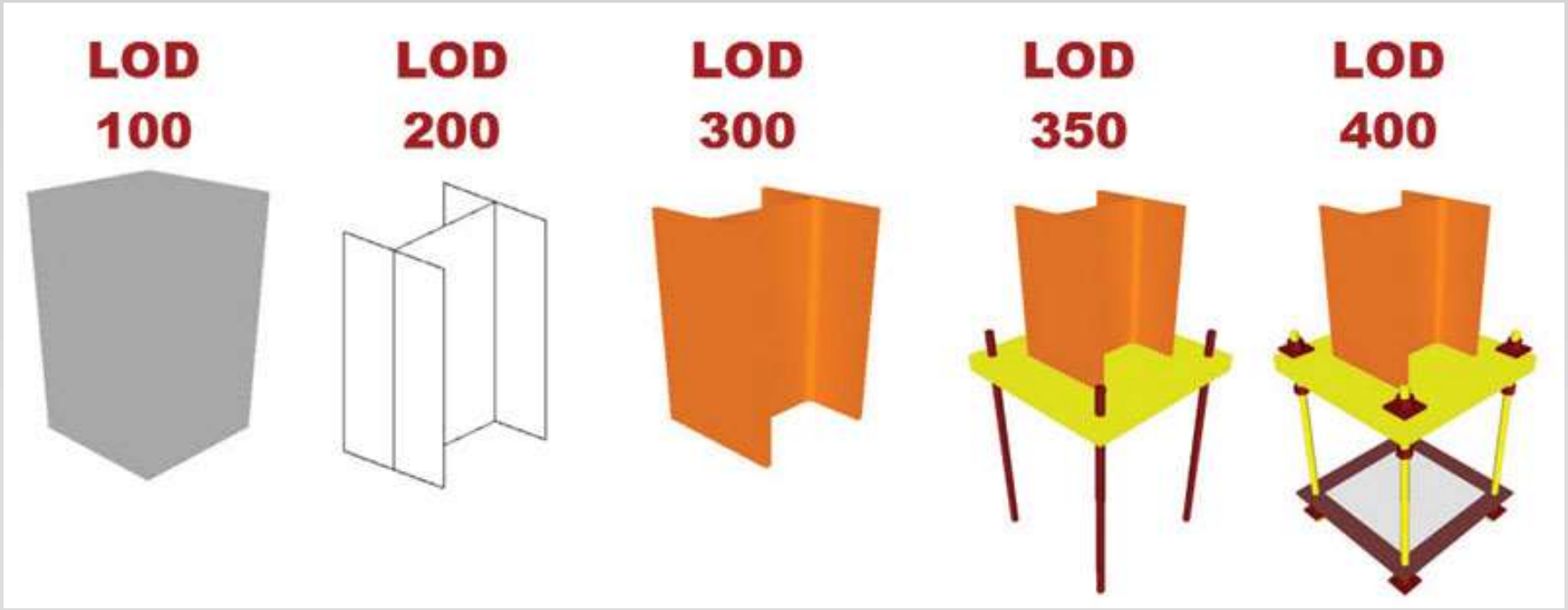
Clash Detection – Cont.



Clash Examples!!!

LOD

Level of Development - Level of Detail - Level of Design



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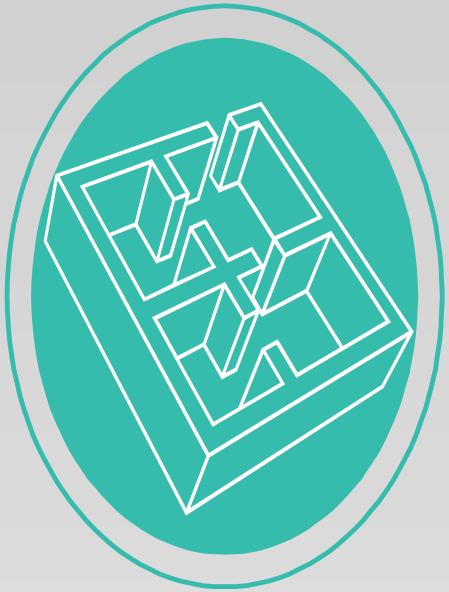
How BIM saves owners' time and money throughout the building lifecycle



Design

Construction

Management

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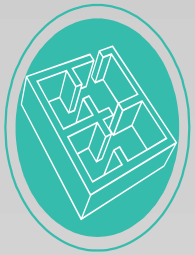
BIM saves time and money in the design phase

Area	Description	Example
Conceptual design 	Quickly iterate on design elements including building form, sustainability, client requests, municipal regulations, budget, and more. Conduct analyses and simulation	The Beck Group created 100 visualizations for a church in Seoul and adjusted the shape of the building to appear curved, but with flat glass, saving over $1 million on glazing, and 1,000 hours of design time
Sustainable building design 	Complete energy analysis early in the design stage to reduce ongoing energy consumption	Using BIM to evaluate design scenarios for energy savings, NASA's 50,000' building in Silicon Valley yielded features such as a steel-frame exoskeleton, geothermal walls, natural ventilation, wastewater treatment, and a photovoltaic roof that will provide 30% of the building's power
Design Documentation 	Create a building model and complete set of designs documents in an integrated database, where everything is interconnected and there is real-time self-coordination of information	

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BIM saves time and money in the construction phase

Area	Description	Example
General construction 	▪ Links project planning to construction planning and simulation, as well as visualization during construction and digital fabrication ▪ Enhances project communication and collaboration among teams ▪ Create more accurate cost estimates ▪ Deliver more projects on time and within budget	Contractor Robins and Morton used BIM to design and construct an Augusta, Maine hospital. Due to greater collaboration, the project was completed ten months ahead of schedule and returned approximately US$20 million in value-added savings.
Pre-fabrication, modular construction 	▪ Extract information from BIM to pre-fabricate building components to improve project schedule, reduce cost, improve site safety, and produce greener construction practices by reducing material waste	J.C. Cannistraro used BIM and pre-fabrication to upgrade the central utility plant for University of Massachusetts's Boston campus helping to minimize installation time of a new HVAC system and hangers

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BIM saves time and money in the management phase

Area	Description	Examples
Lifecycle costs 	▪ Reuse building models and data to better manage facility operations ▪ Analyze data-rich models to optimize resources and reduce waste and lower lifetime maintenance and operation costs ▪ Use intelligent 3D models to help manage space and perform spatial validation for tenant chargebacks	▪ Shanghai Tower Construction & Development Co. Ltd. used BIM not only to design and build, but also to inform operations of their super high-rise tower. STC&D plans to use BIM for emergency and property management going forward. ▪ The Government Services Administration (GSA) is creating a database of its 3D models to inform O&M and future projects. Additional software leveraging the 3D models will use its data for security, updates, analysis, and reporting.

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Is BIM a Software?

NO!

Construction Simulation	MEP	Structure	Architecture
• Autodesk Navisworks • Bentley ConstrucSim • Tekla BIMSight	• Autodesk Revit MEP • Bentley Hevacomp Mechanical Designer • Gehry Technologies - Digital Project MEP Systems Routing	• Autodesk Revit Structure • Tekla Structures • Bentley Structural Modeler	• Autodesk Revit Architecture • Graphisoft ArchiCAD • Bentley Architecture

Case Studies

Wellington City Council Bracken Road Flats

Kathleen Kilgour Centre

North Shore Hospital's Elective Surgery Centre

University of Auckland Undergraduate Laboratories

UNITEC's integrated information system

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Wellington City Council Bracken Road Flats

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"On average, approximately 29 components in a built asset comprise 80% of its value. If you can manage these electronically you can manage the asset long-term with minimum intervention. The value of a BIM model is far greater if you view it over the whole life of an asset."

Haydn Read, Manager Strategic Asset Planning,
Wellington City Council

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Duration

March 2014 - ongoing

This is part of an ongoing WCC data management project run by its Strategic Asset Management Planning team.

Project partners

Wellington City Council
Archaus Architects
Caduceus Architects

BIM Uses

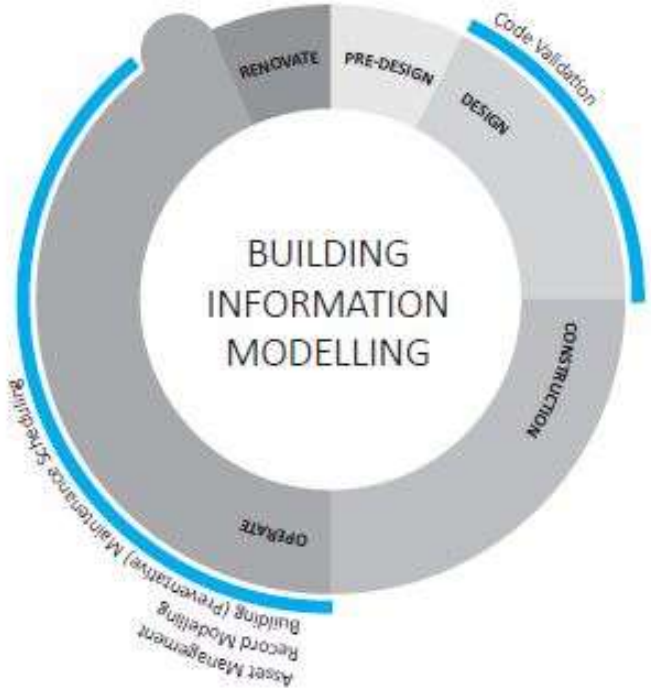
The New Zealand BIM Handbook Appendix D defines 21 distinct BIM Uses.

For this project the primary BIM Use is:

- Asset management – electronic data transfer to an asset management database, for strategic planning and long-term asset budgeting.

It also supports other BIM Uses including:

- Record modelling for future refurbishments
- Building (preventative) maintenance scheduling
- Code validation.



This case study highlights the value of using BIM in the design and operate stages of the project life cycle

North Shore Hospital's Elective Surgery Centre

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"I have been involved in three recent hospital design/ implementation projects now and this facility is by far the best of the lot. It is a striking looking facility, simple, yet effective in its flow and certainly a real jewel in the DBH's crown."

Mark Watson,
Group Manager, Elective Surgery Centre- North Shore Hospital.

Duration

The project commenced in 2008 and was completed in 2013.

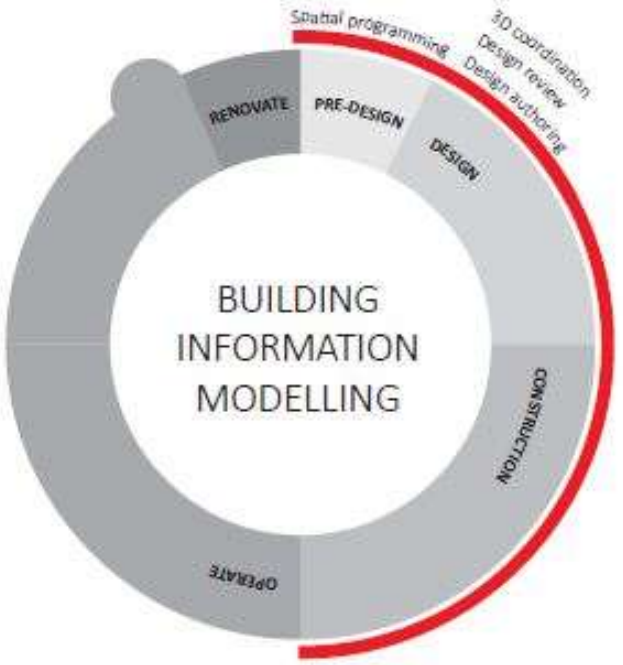
Project partners

Owner and developer:	Waitemata District Health Board
Construction company:	Argon Construction
Architect:	Jasmax, MSJ
Structural engineer:	BGT Structures
Mechanical engineer:	Aurecon
Quantity surveyor:	Rider Levett Bucknall
Project manager:	Ncounter Group, RCP

BIM Uses

The New Zealand BIM Handbook Appendix D defines 21 distinct BIM Uses. On this project BIM was used for:

- Spatial programming – room data sheets
- Design review
- Design authoring
- 3D coordination.



This case study highlights the value of using BIM in the pre-design, design and construction stages of the project life cycle.

Kathleen Kilgour Centre

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"The Kathleen Kilgour Centre is an innovative centre of excellence. Its planning, construction, form and services all contribute to the better treatment of cancer patients at their most vulnerable time."

Mark Fraundorfer,
Kathleen Kilgour Centre General Manager

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Duration

The project has taken approximately two years and is due for completion in December 2014.

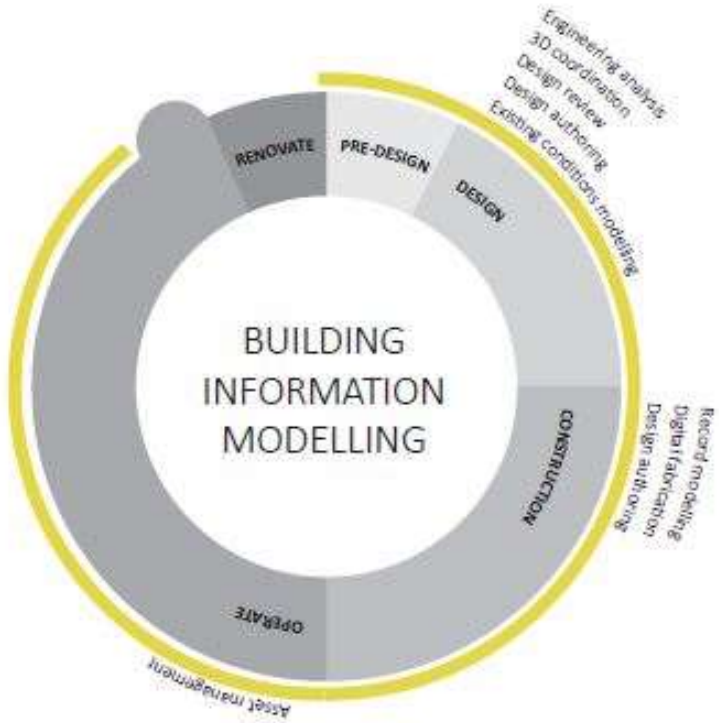
Project partners

Project manager:	The Building Intelligence Group
Architecture and interior design:	Wingate + Farquhar, Assemble
Structural engineering:	Redco
Services engineering:	Innerscape

BIM Uses

The New Zealand BIM Handbook Appendix D defines 21 distinct BIM Uses. On this project BIM was used for:

- Existing conditions modelling
- Design authoring
- Design review
- Engineering analysis
- 3D co-ordination
- Digital fabrication
- Record modelling
- Facilities/asset management.



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University of Auckland Undergraduate Laboratories

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"The complicated nature of this project plus the tight timeframe required intensive collaboration between the project partners and client. BIM was hugely beneficial in this regard."

Jon Williams,
Beca

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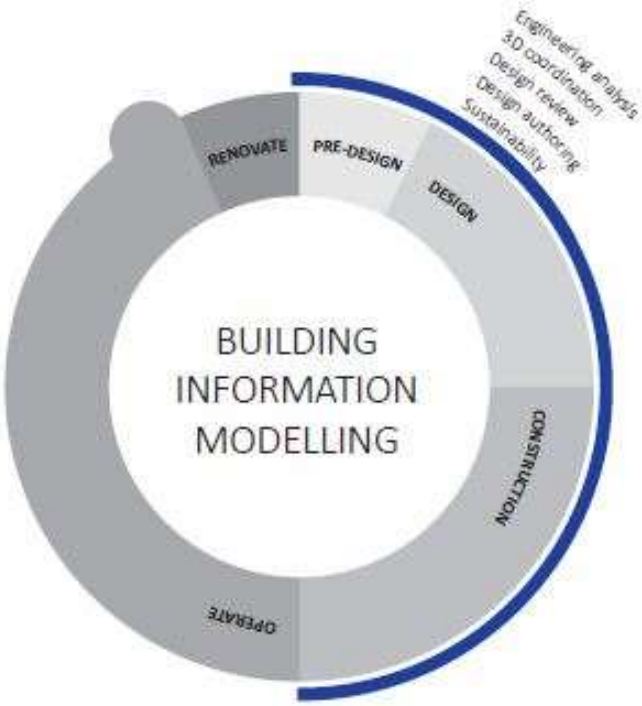
Project partners

Client:	University of Auckland
Services, structure:	Beca
Architect:	Architectus
Specialist lab design:	Labworks
Main contractor:	Fletcher Construction
Mechanical subcontractor:	Hasties
Project manager:	RCP

BIM Uses

The New Zealand BIM Handbook Appendix D defines 21 distinct BIM Uses. On this project BIM was used for:

- Design authoring
- Design review
- Engineering analysis
- Sustainability
- 3D co-ordination



This case study highlights the value of using BIM in the pre-design, design and construction stages of the project life cycle.

UNITEC's integrated information system

"BIM indicates a future where detailed information on buildings is available to consultants and clients alike, which will lead to greater accuracy of documentation and productivity gains, allowing higher levels of service."

Graeme Scott
Director, ASC Architects

Duration

The project took about four and a half years to complete:

- development of Unitec's FM system – May 2007 to January 2009
- building information modelling of Unitec campus – March 2008 to September 2011
- BIM integration with FM system – October 2011 to January 2012.

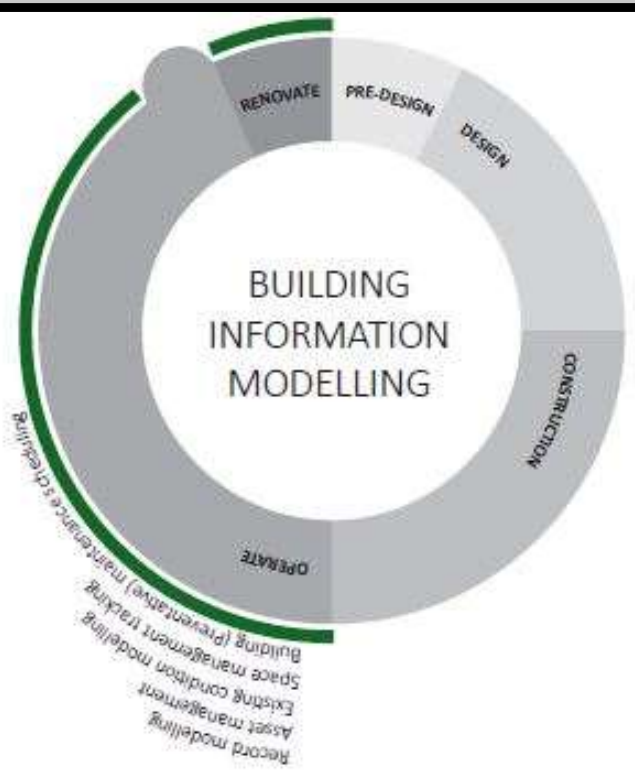
Project partners

The project was undertaken by Unitec in-house by a team of mainly part-time staff and contractors.

BIM Uses

The New Zealand BIM Handbook Appendix D defines 21 distinct BIM Uses. On this project BIM was used for:

- Existing condition modelling
- Record modelling
- Asset management
- Building (preventative) maintenance scheduling
- Space management tracking.



This case study highlights the value of using BIM in the operate and renovate stages of the project life cycle.

WITS UNIVERSITY

SCHOOL OF CONSTRUCTION ECONOMICS AND MANAGEMENT

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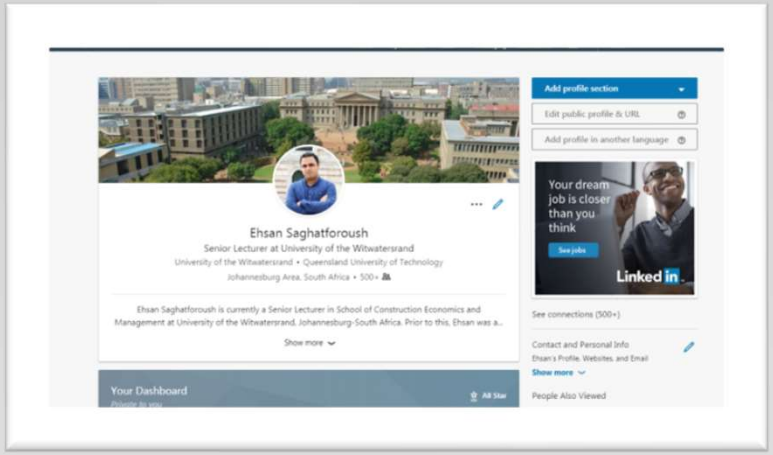

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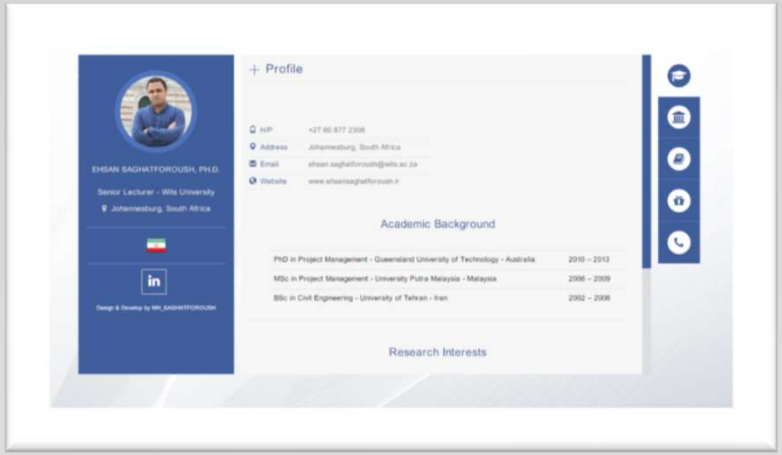

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