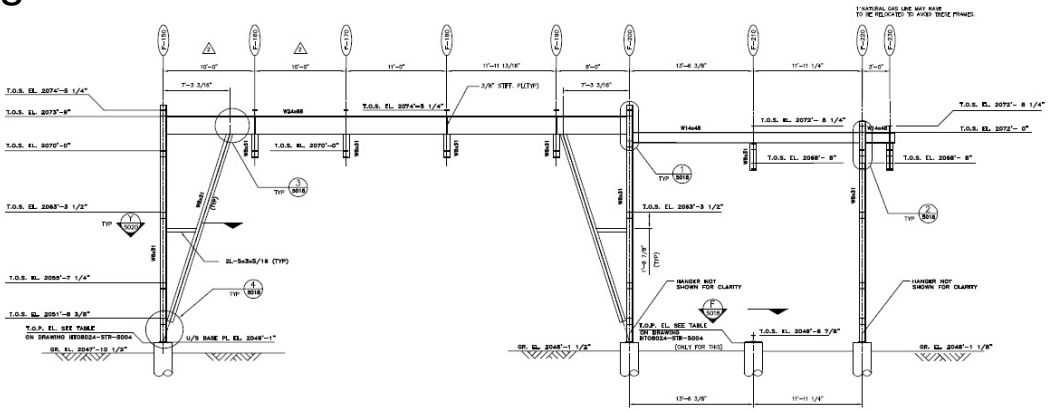
What is CAD?

- Computer Aided Design (CAD) transforms the labor intensive drafting to an efficient electronic documentation



- Lines
- Notations

Retrieved from http://cad-draftingservices.blogspot.co.uk/2013/04/drawings.html

- CAD can be used to produce 2 or 3 dimensional models of parts, materials or buildings.
- The lines, arcs, circles in CAD models are independent of one another.
- Notations are the only way to enrich the design context with very limited information

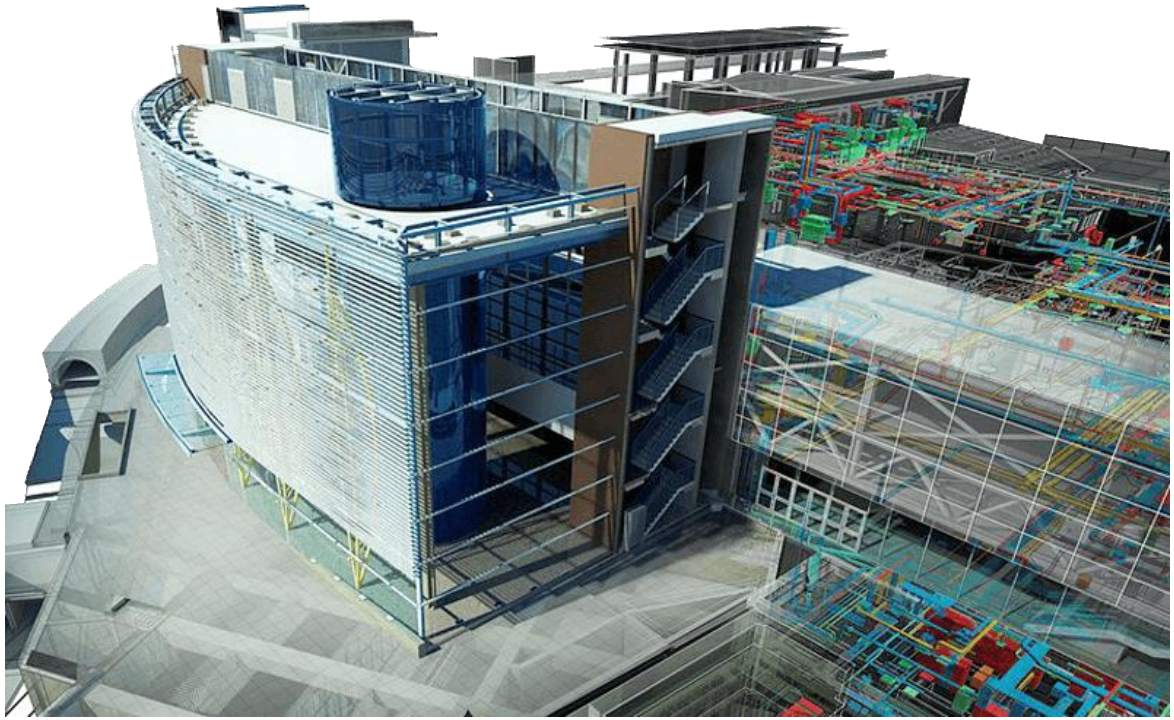
What is BIM?

Infravation
An Infrastructure Innovation Programme

SEEBRIDGE
SEMANTIC ENRICHMENT ENGINE FOR BRIDGES

Building Information Modeling is an intelligent model-based process

- A full digital prototype of a building
- A database to manage project information shared among all stakeholders



Retrieved from http://www.duttonelectric.com/custom-design-build/

What is BIM?

Infravation
An Infrastructure Innovation Programme

- A **Building Model** is a digital representation of a building, its function, design, construction and later its operation. A building model replaces building drawings.
- Unlike computerized drawings, building models can be processed by computer software.
- **Building Information Modeling** is the process of creating a building model. The term also describes the software and technologies for compiling and processing building models.

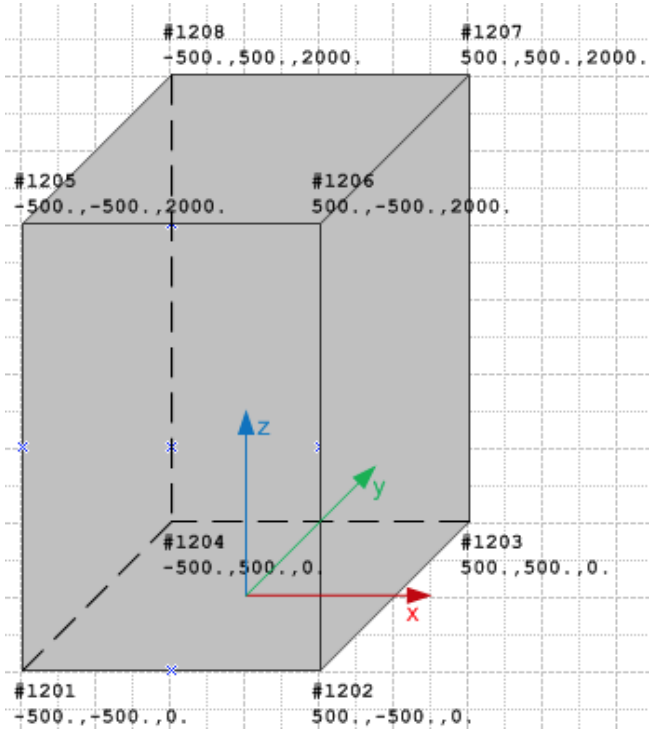
BIM Data Schema - IFC

Industry Foundation Classes (IFC)

- An official International Standard
- Describe building and construction industry data
- Facilitate the data interoperability in the architecture, engineering and construction (AEC) industry
- Open and platform neutral specification

BIM Data Schema

- BIM defines objects using parametric geometry, alphanumeric properties, and relationships



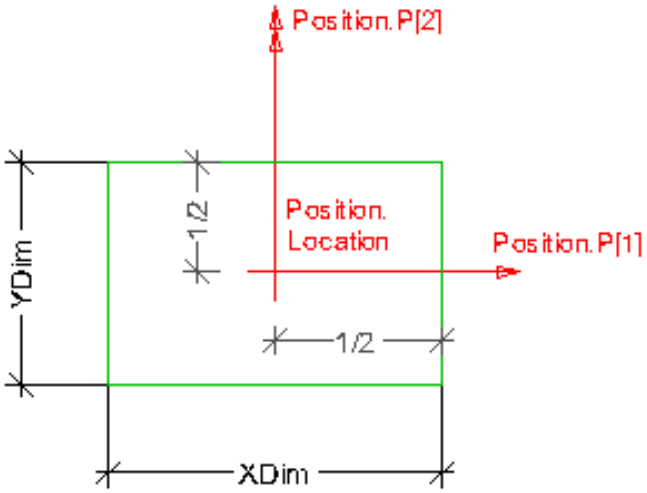
A point is defined using coordinates in 2D/3D space e.g., (500., 500., 2000)

Retrieved from http://www.buildingsmart-tech.org/ifc/IFC4//Add2/html/annex/annex-e/brep-model.htm

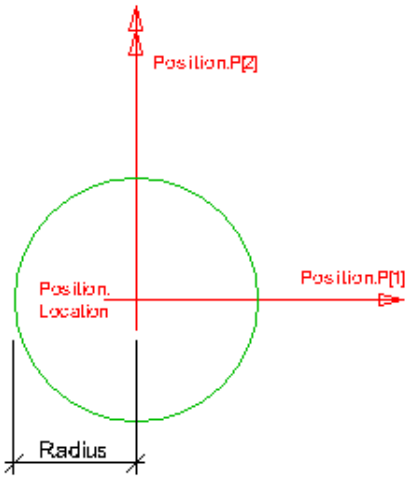
BIM Data Schema

- BIM defines objects using parametric geometry, alphanumeric properties, and relationships

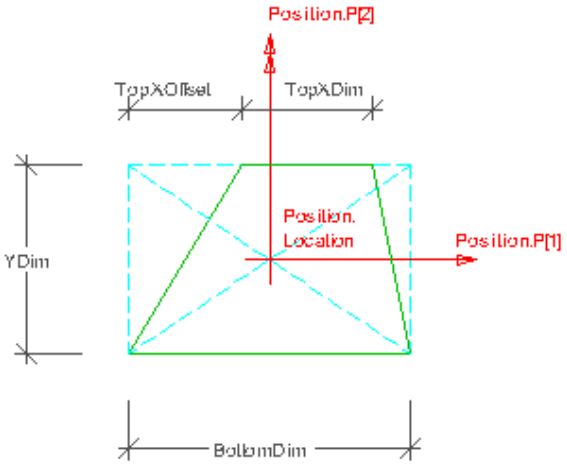
Different type of surfaces can be defined using different parameters
e.g., a rectangle can be defined by the length, width and the coordinates of its center



A rectangle



A circle



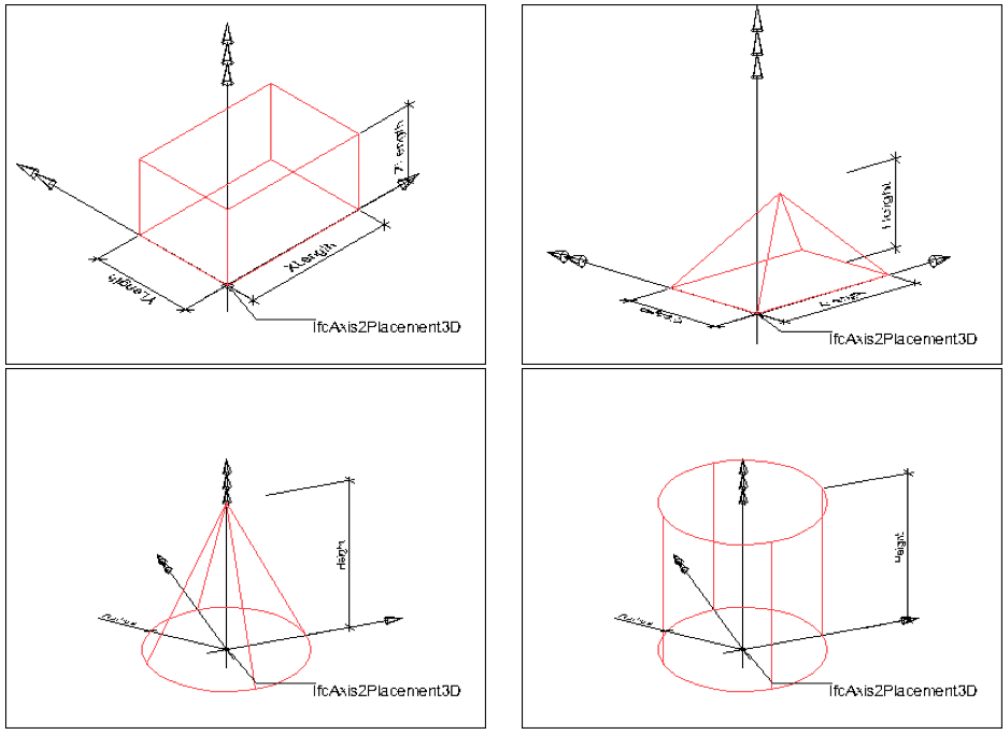
A trapezium

Retrieved from http://www.buildingsmart-tech.org/ifc/IFC4//Add2/html/schema/ifcprofileresource/lexical/ifcparameterizedprofiledef.htm

BIM Data Schema

- BIM defines objects using parametric geometry, alphanumeric properties, and relationships

Different type of solids can be defined using different parameters
e.g., a cuboid can be defined by the length, width, height and the coordinates of a corner

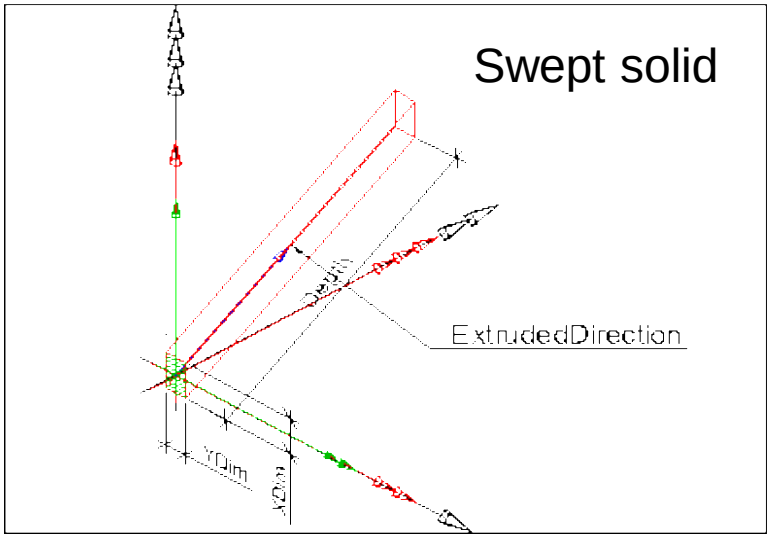


Retrieved from http://www.buildingsmart-tech.org/ifc/IFC4//Add2/html/schema/ifcgeometricmodelresource/lexical/ifccsgprimitive3d.htm

BIM Data Schema

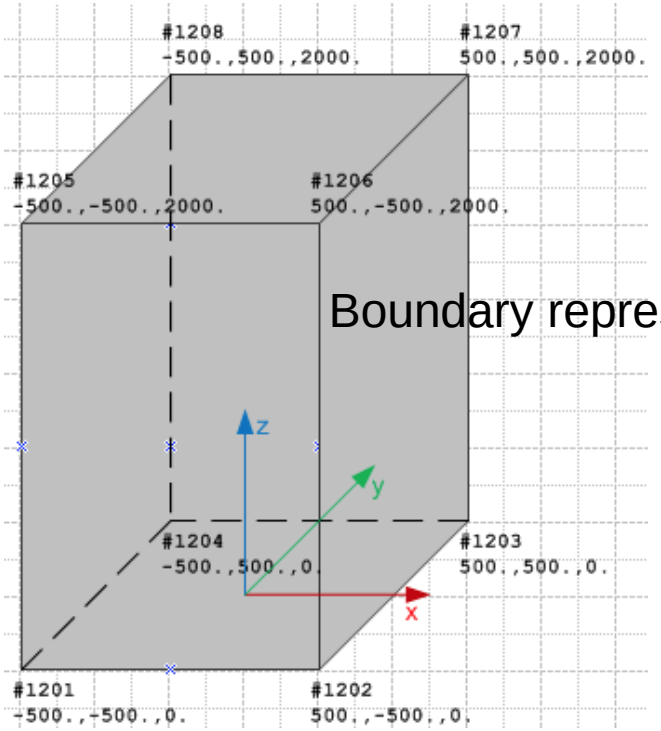
- BIM defines objects using parametric geometry, alphanumeric properties, and relationships

The same object can be modelled using different types of representation



A longitudinal object represented by its cross section and extruded direction

Retrieved from http://www.buildingsmart-tech.org/ifc/IFC2x3/TC1/html/ifcsharedbldgelements/lexical/ifcbeam.htm



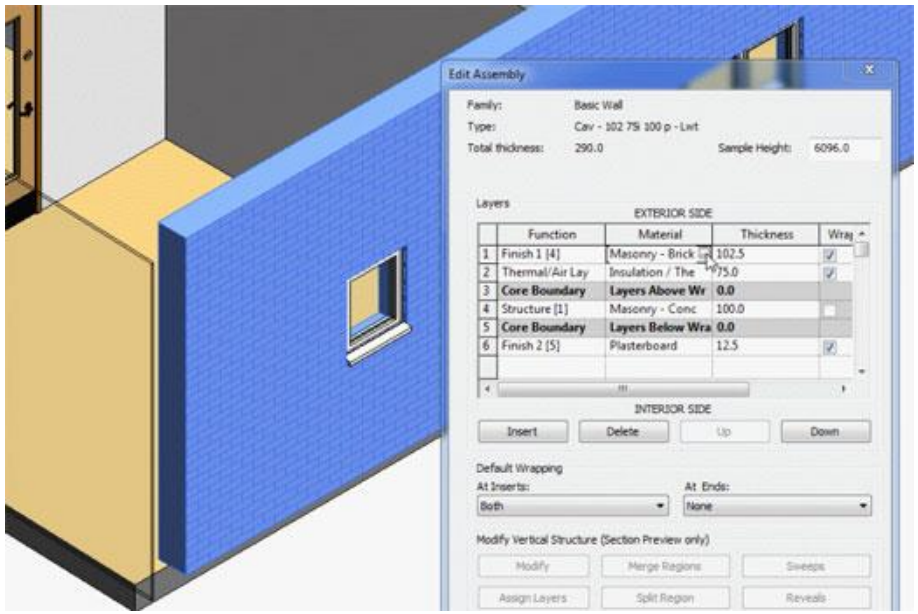
A 3D solid object defined by its six faces, each of which is defined by its four vertices

Retrieved from http://www.buildingsmart-tech.org/ifc/IFC4//Add2/html/annex/annex-e/brep-model.htm

BIM Data Schema

- BIM defines objects using parametric geometry, alphanumeric properties, and relationships

A BIM model serves like a database for storing useful information in certain data structures



Definition of the materials (the type and thickness of layers) of the wall in a BIM model

A wall

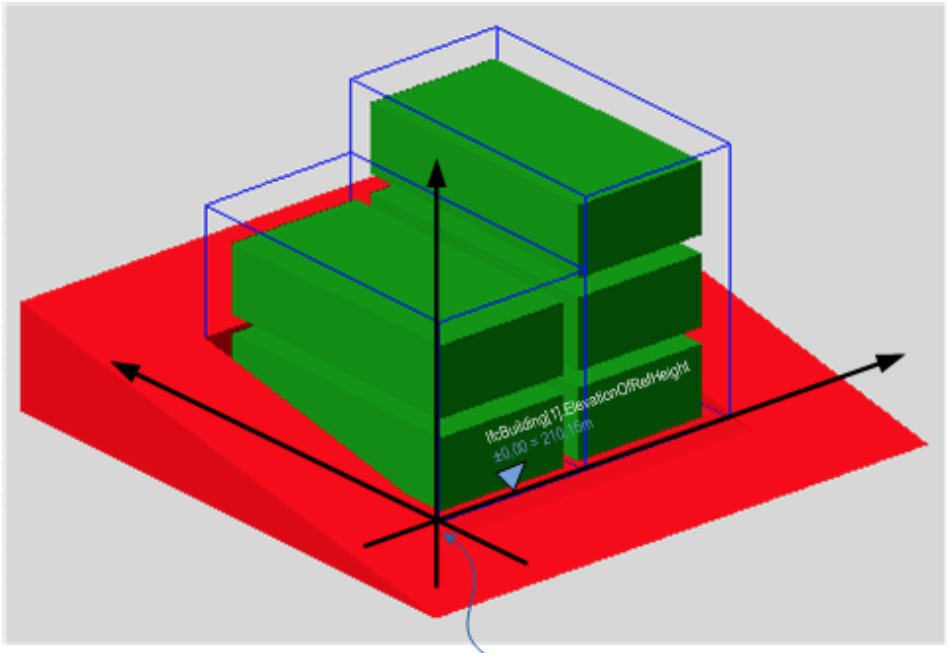
Example alphanumeric properties of a wall

Retrieved from https://www.thenbs.com/knowledge/isnt-bim-just-3d-cad

BIM Data Schema

- BIM defines objects using parametric geometry, alphanumeric properties, and relationships

In addition to the physical objects, virtual objects can also be defined in a BIM model



e.g., the virtual object "project site" has properties:

- Longitude
- Latitude
- Height

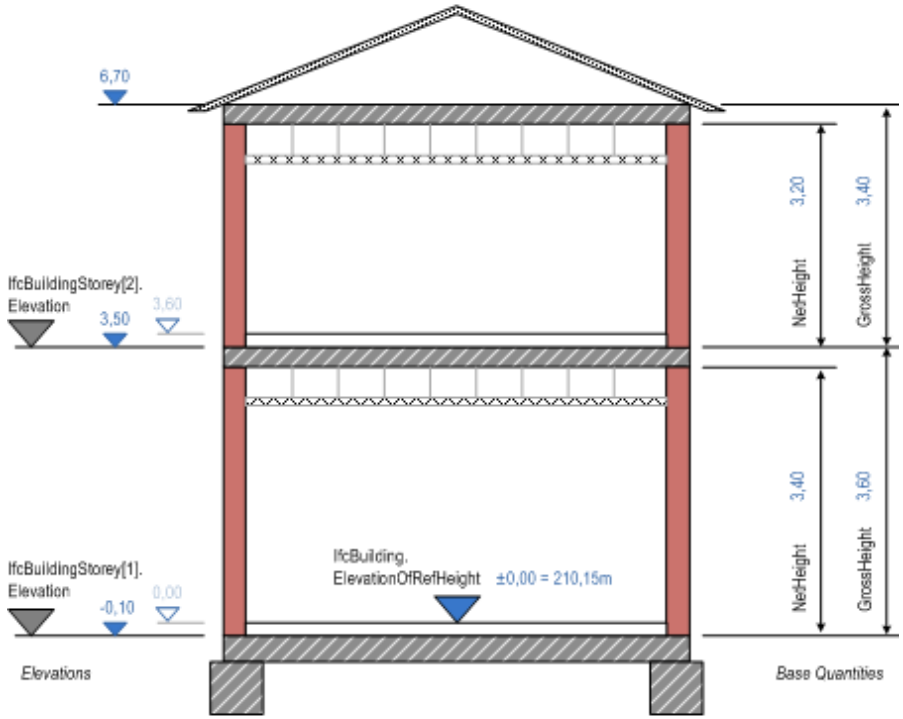
etc.

Retrieved from http://www.buildingsmart-tech.org/ifc/IFC4//Add2/html/schema/ifcproductextension/lexical/ifcsite.htm

BIM Data Schema

- BIM defines objects using parametric geometry, alphanumeric properties, and relationships

In addition to the tangible objects, virtual objects can also be defined in a BIM model



e.g., the virtual object “building storey” has properties:

- Elevation
- Height
- Gross height

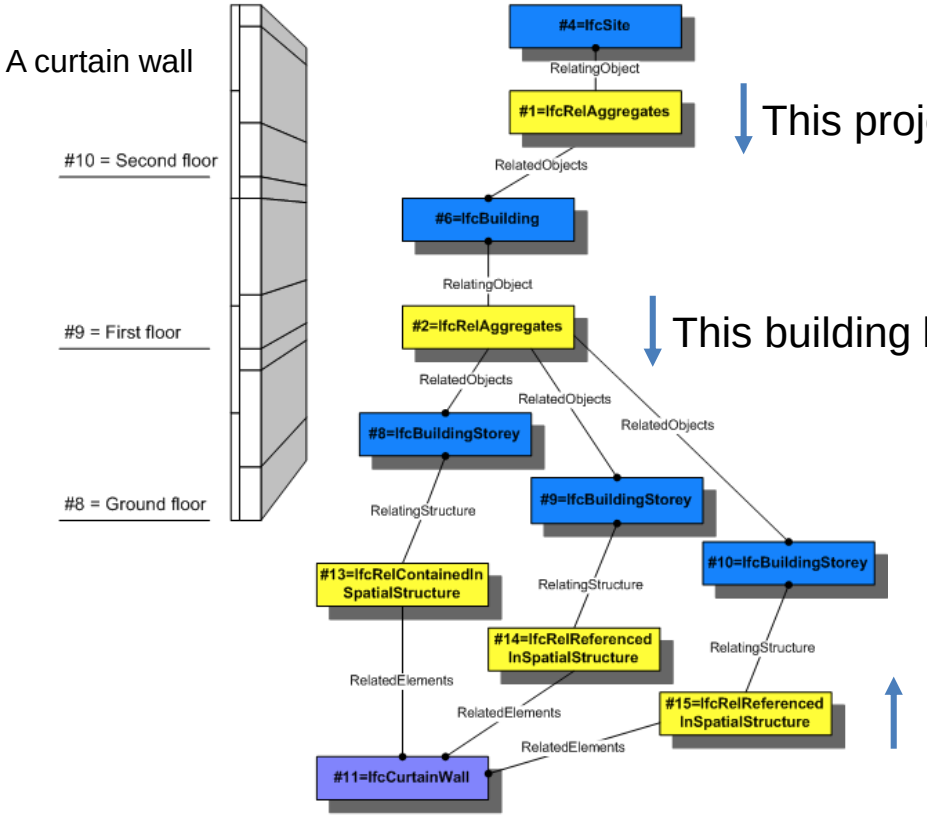
etc.

Retrieved from http://www.buildingsmart-tech.org/ifc/IFC4//Add2/html/schema/ifcproductextension/lexical/ifcbuildingstorey.htm

BIM Data Schema

- BIM defines objects using parametric geometry, alphanumeric properties, and relationships

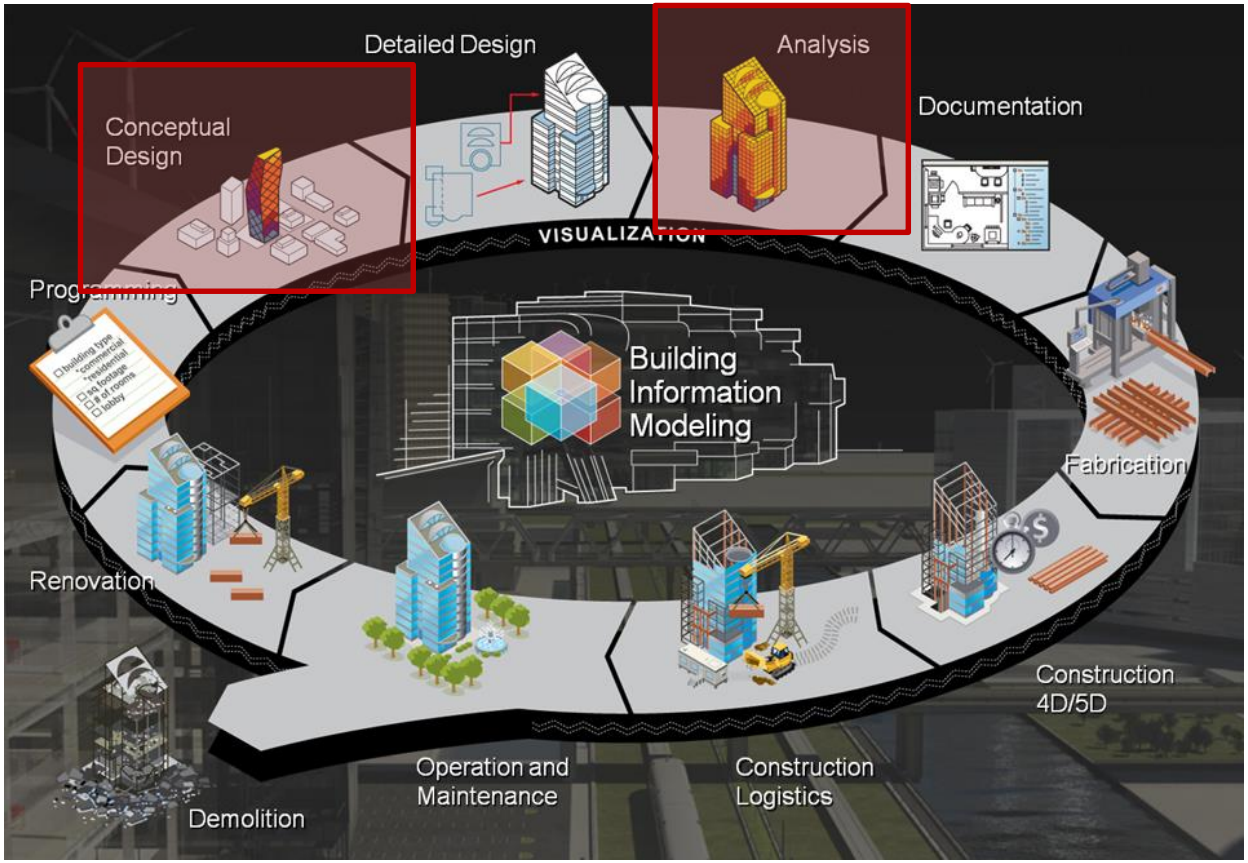
The relationships between physical objects and virtual objects (e.g. spaces) are explicitly defined in a BIM model



Retrieved from http://www.buildingsmart-tech.org/ifc/IFC4//Add2/html/schema/ifcproductextension/lexical/ifcrelreferencedinspatialstructure.htm

BIM Application

- BIM is more advanced than CAD because it can automate domain applications when information required are defined



A BIM model can incorporate related information for automated energy analysis

- weather information
- heat transfer coefficients of the objects
- thermal resistance of the objects
- ...

A BIM model can incorporate related information for automated structural analysis

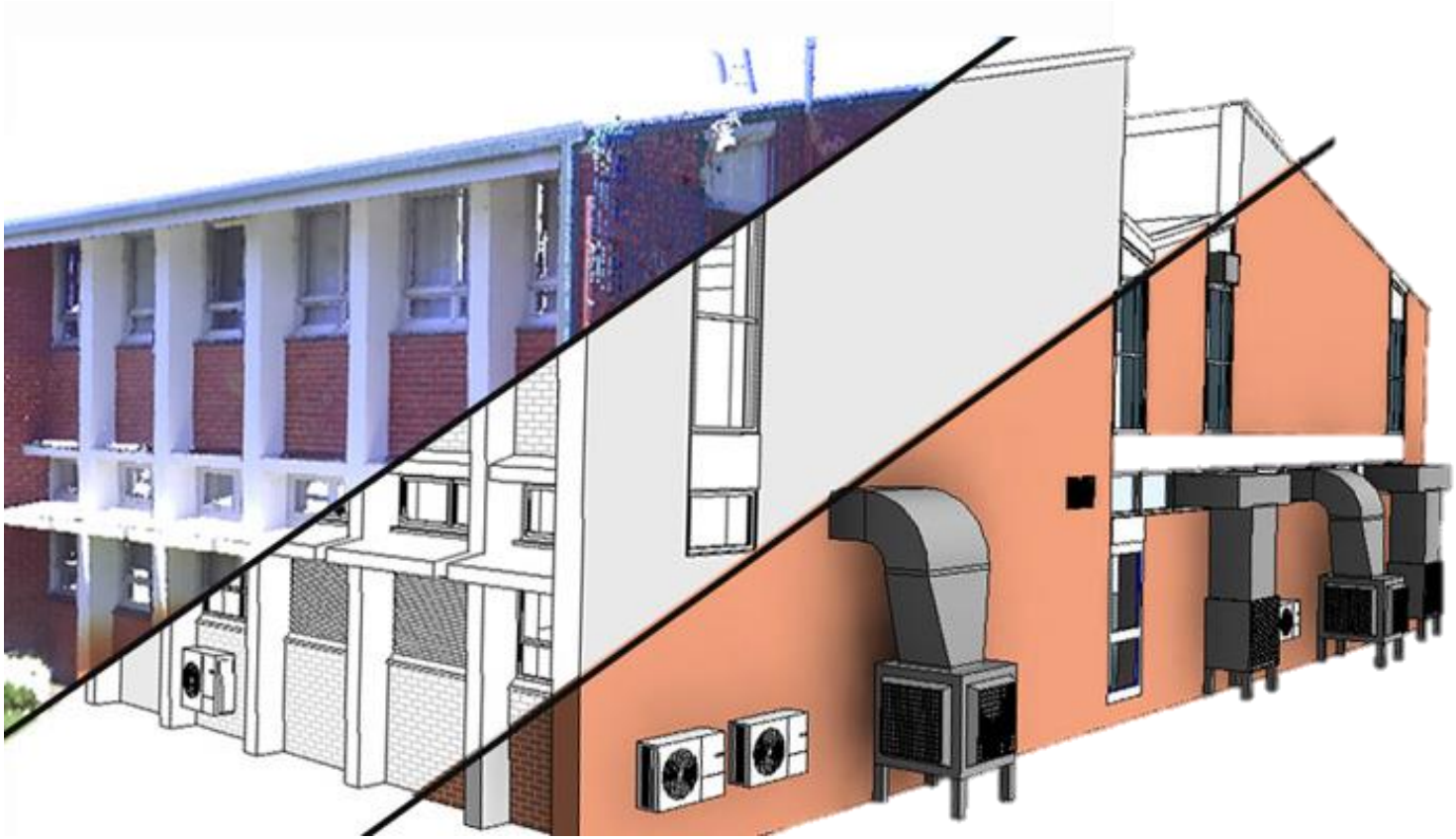
- Young's modulus of the objects
- Shear modulus of the objects
- ...

Retrieved from https://www.directionsmag.com/article/1486

‘As-is’ BIM model

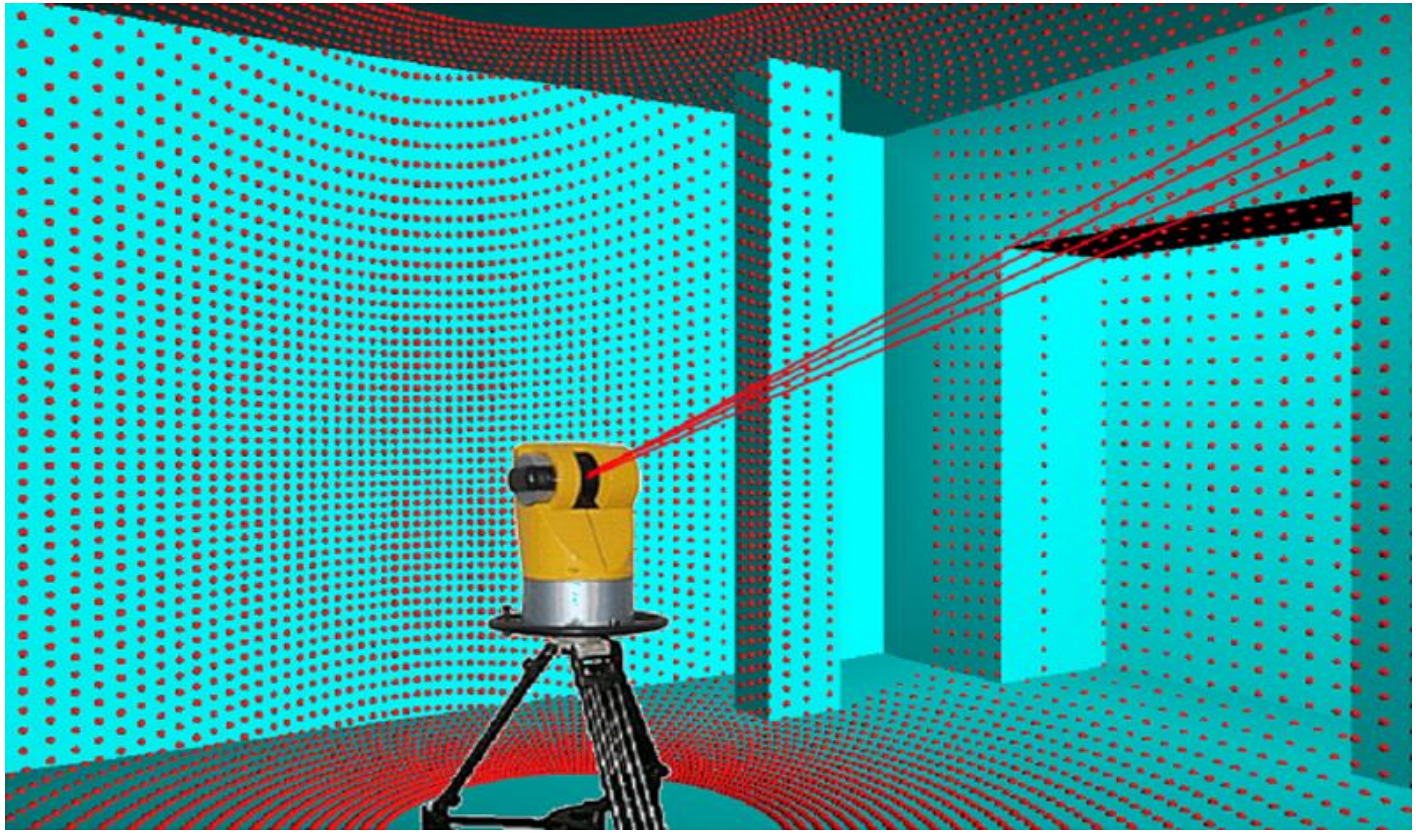
Infravation
An Infrastructure Innovation Programme

SeeBridge
Semantic Enrichment Engine for Bridges



Retrieved from http://www.caddwest.com.au/services/printing-scanning/3d-scanning

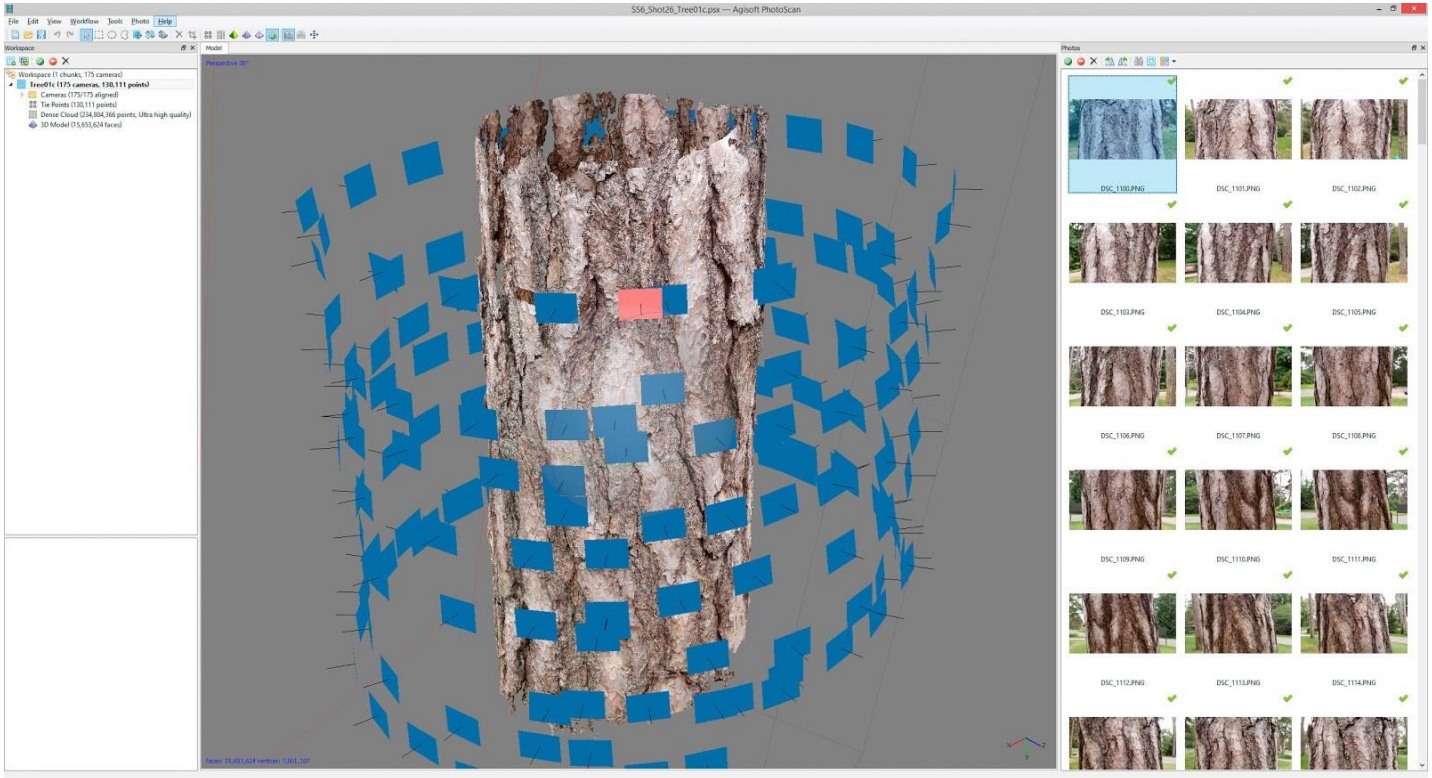
TLS and photogrammetry



Terrestrial laser scanning (TLS) is an automated measurement technology.

Retrieved from http://www.spatialhumanities.de/en/ibr/technology/terrestrial-laserscanning.html

TLS and photogrammetry



Photogrammetry

Retrieved from https://www.allegorithmic.com/blog/go-scan-world-photogrammetry-smartphone

PCD, 3D models, and BIM models

Infravation
An Infrastructure Innovation Programme

SEEBRIDGE
SEMANTIC ENRICHMENT ENGINE FOR BRIDGES

Point Cloud Data

Adapted from http://www.cansel.ca/

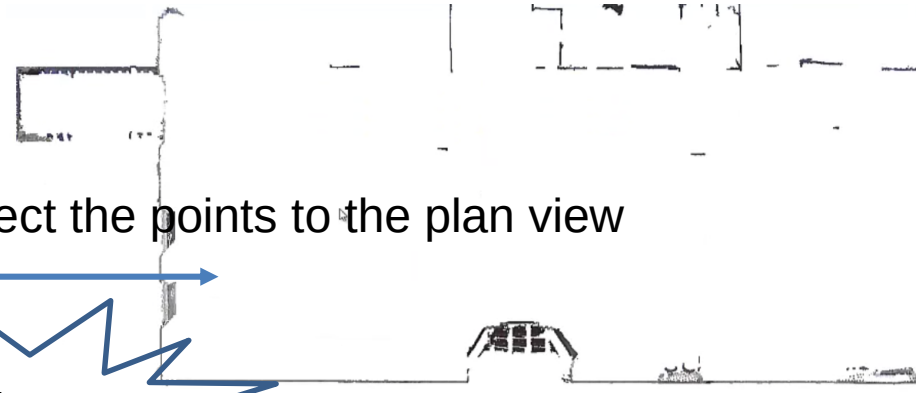
PCD, 3D models, and BIM models

Infravation
An Infrastructure Innovation Programme

SEEBRIDGE
SEMANTIC ENRICHMENT ENGINE FOR BRIDGES

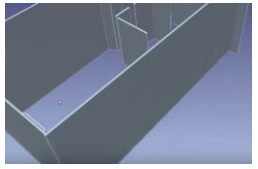
Traditional workflow of creating a 3D model using point cloud data

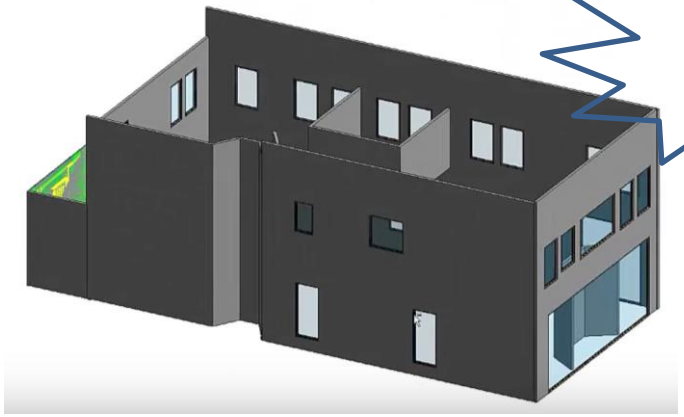
1. Project the points to the plan view



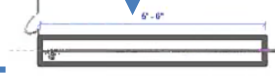
Manual
Time consuming
Costly

2. Create façade by tracing the points





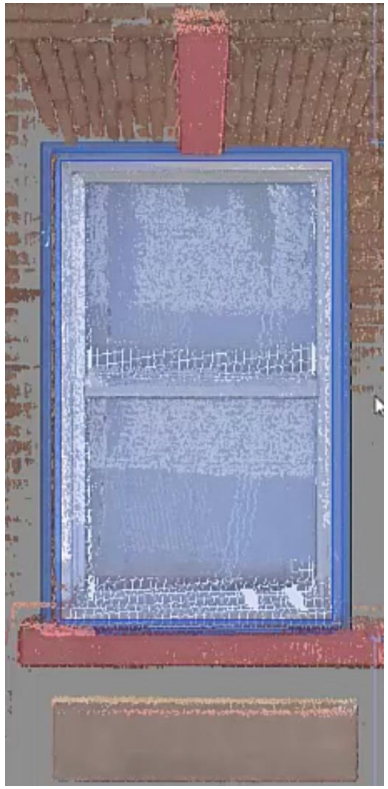
3. Add openings



Adapted from http://www.cansel.ca/

PCD, 3D models, and BIM models

3D objects to BIM objects



A timber window
Timber type?
Frame type?
Fenestration Options?
Glazing?
Hinge Options?
Reference to a space?

Information needs to be supplemented to the BIM model according to specific needs

Create a window by examining the point cloud data

Adapted from http://www.cansel.ca/

Facility management

Visualize the 3D objects

Retrieve the information of the objects

Bridge defect detection

Infravation
An Infrastructure Innovation Programme

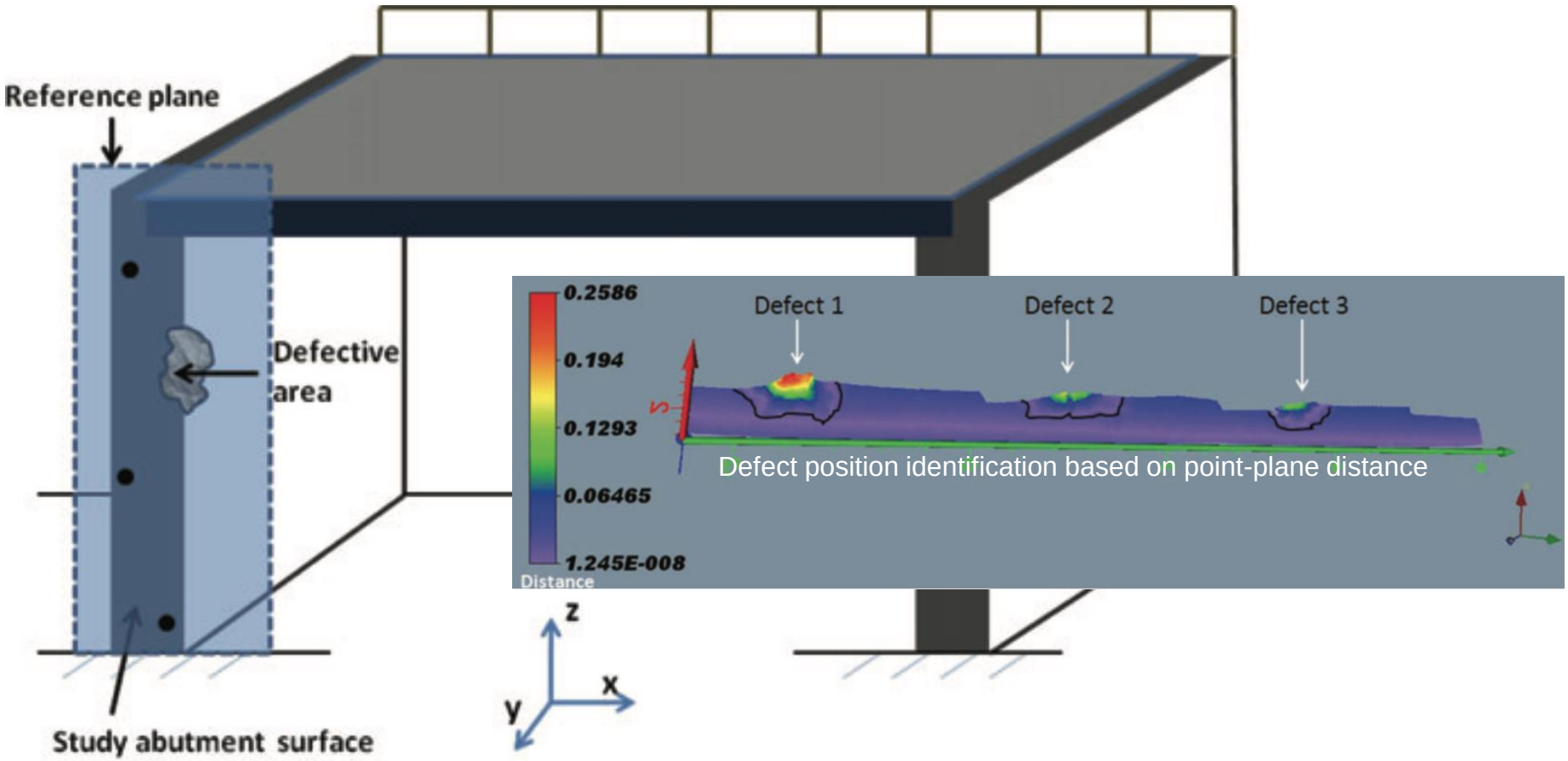
SeeBridge
Semantic Enrichment Engine for Bridges

Retrieved from https://www.fhwa.dot.gov/publications/publicroads/07may/02.cfm

Remote sensing for defect detection

Infravation
An Infrastructure Innovation Programme

SEEBRIDGE
SEMANTIC ENRICHMENT ENGINE FOR BRIDGES



Liu, W., et al. (2011). "LiDAR-BASED BRIDGE STRUCTURE DEFECT DETECTION." Experimental Techniques 35(6): 27-34.

Summary

Infravation
An Infrastructure Innovation Programme

SEEBRIDGE
SEMANTIC ENRICHMENT ENGINE FOR BRIDGES

- BIM is a process for creating parametric and semantically rich building models.
- IFC is the data schema that specifies how computers represent a BIM model
- TLS and photogrammetry are contactless survey technologies for rapid collection of spatial data
- The data need to be progressively converted to 3D geometries and BIM models which can then be used in asset management systems
- The structural defects need to be detected in the spatial data and incorporated in the system