JACIC
Japan Construction Information Center

buildingSMART SINGAPORE

updated on 29 May 2016

BIM IFC4 QTO, a practitioner's perspective

SEAH Kwee Yong FSISV MRICS, buildingSMART Singapore

JACIC's seminar 5 Jul 2016

At the Grand Arc Hanzomon, Tokyo

Last Visited Tokyo
in 2003 (SARS)

Quantity Take Off (QTO)

Basic QTO (from IFC)

Calibrated Quantities/
Customised Quantities

Schedule of Rates (SOR)

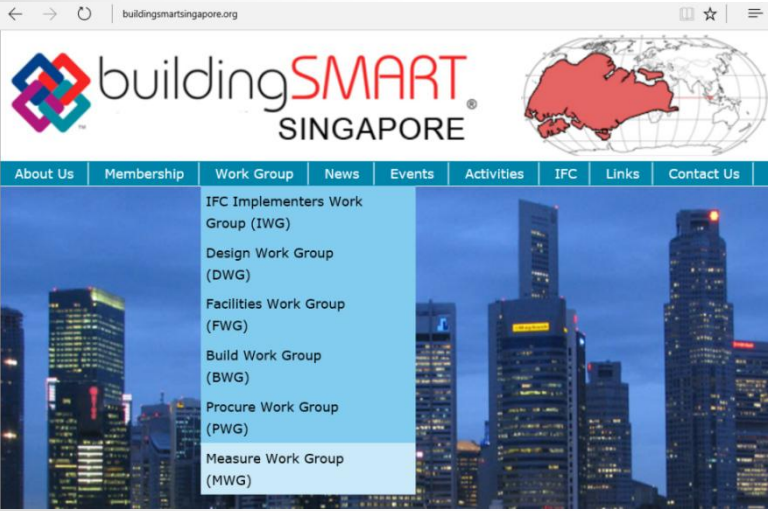
SEAH Kwee Yong,

Chartered Surveyor/ Cost Engineer

FSISV, ICECa, MRICS,

MSc Property & Maintenance Management (NUS),

BSc Building (NUS),



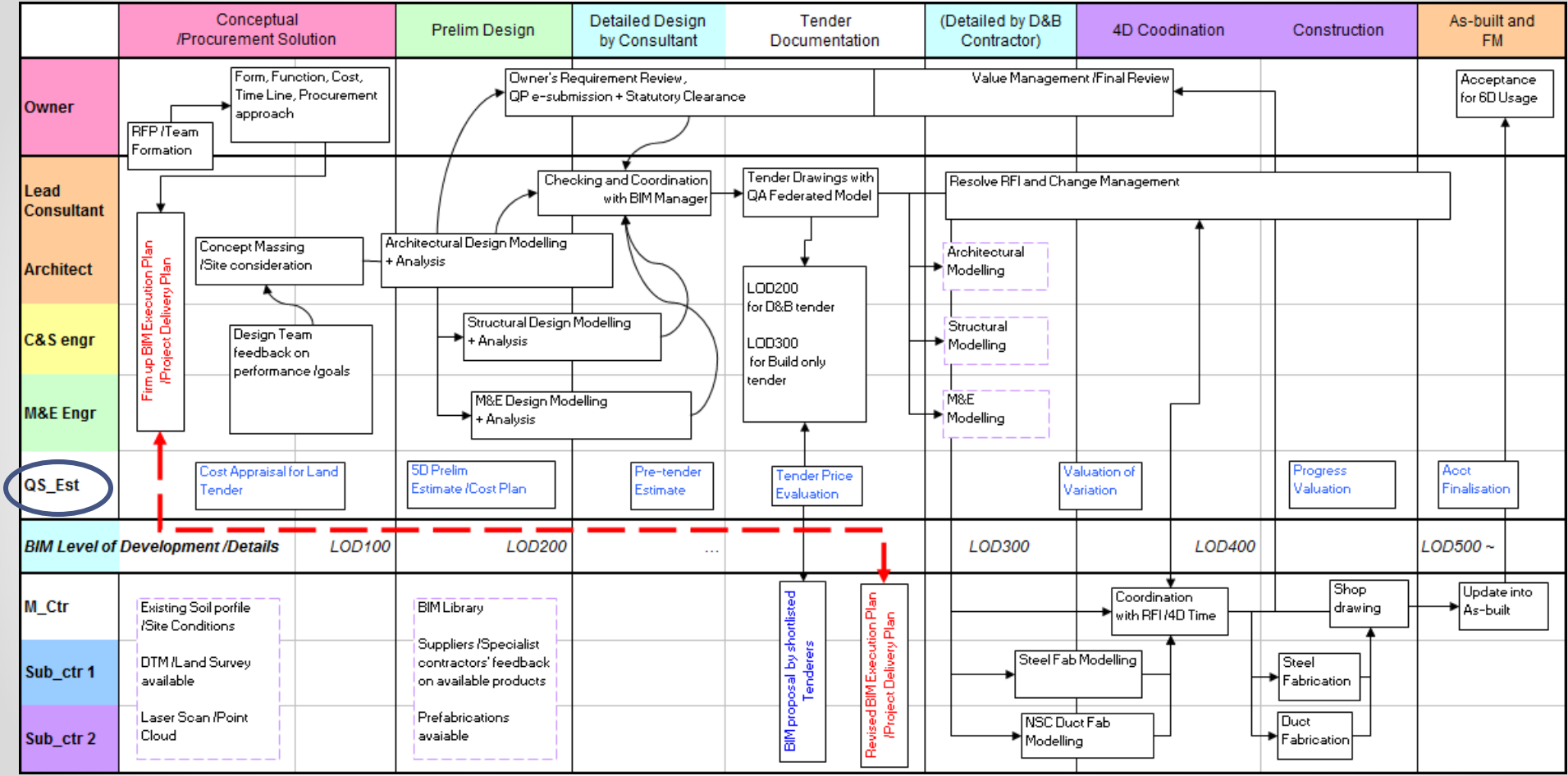
- Building and Construction Industry IT Standards Technical Committee (BCITC) Singapore
- Measure Work Group, buildingSMART Singapore (bSS)/ Singapore Institute of Surveyors and Valuers (SISV)
- International BIM Work Group, Royal Institution of Chartered Surveyors (RICS)
- BIM Manager/ Project Manager, Cyril K H Seah Architects
- Langdon & Seah (Retired 2013)
- Land Transport Authority Singapore (Retired 2008)

- Singapore Standard CP97 – Code of Practice for Construction Electronic Measurement Standard (CEMS):
  - SMM for Building Works (part 1) and
  - SMM for Mechanical and Electrical Works (part 2).
- Singapore Standard SS 527 – Code of Practice for Building Project Document Control System
- bSS Technical Guide on BIM Object Library and Collaboration
- Academic & Research Award for: "Excellence in International Quantity Surveying and Cost Engineering", by the Pacific Association of Quantity Surveyors (PAQS) 2007

History of IFC (open copyright)

- Begin as Industry Alliance for Interoperability
- 1997 International Alliance for Interoperability (IAI)
- 1997 IAI Singapore Chapter started
- **2003 IFC2x2** launched (**current standard IFC2x3**)
- 2006 Revit "IFC Export" certified
- Challenging AEC on
  - "Open BIM",
  - with "BIM Execution Plan (BEP)",
  - for "Integrated Project Delivery (IPD)" through vendors' **Navigator**
- 2009 IAI rebranded as buildingSMART International (bSI)
- **2013 IFC4** … yet to have vendors certified;
- Normative Reference: ISO 10303, *Industrial automation systems and integration*
- ???? ...For full implementation

- Implementation Phases suggested in country deadline
- Progressively working towards is termed "**BIM Maturity index**"
- AIA E202 Document "BIM Element Table" to monitor project progress



Integrated Project Delivery (IPD)

Typical Expectation on BIM Manager

Job Description:

The incumbent will be part of a BIM team working in the area of BIM for healthcare facility management. We are looking for candidates who have hands-on BIM industry project experience using Autodesk Revit and Navisworks. Job responsibilities include but are not limited to the following:

Responsibilities :

- Lead a team of BIM engineers/executives to develop the BIM capability of the organization
- Establish and maintain BIM systems/standards for both project and asset management in the healthcare industry
- Develop and enforce BIM documentation and workflow processes throughout the project and operations lifecycle
- Conduct training and assist team members through the use of 3D software
- Research and stay informed on BIM related software and technologies

Job Requirements:

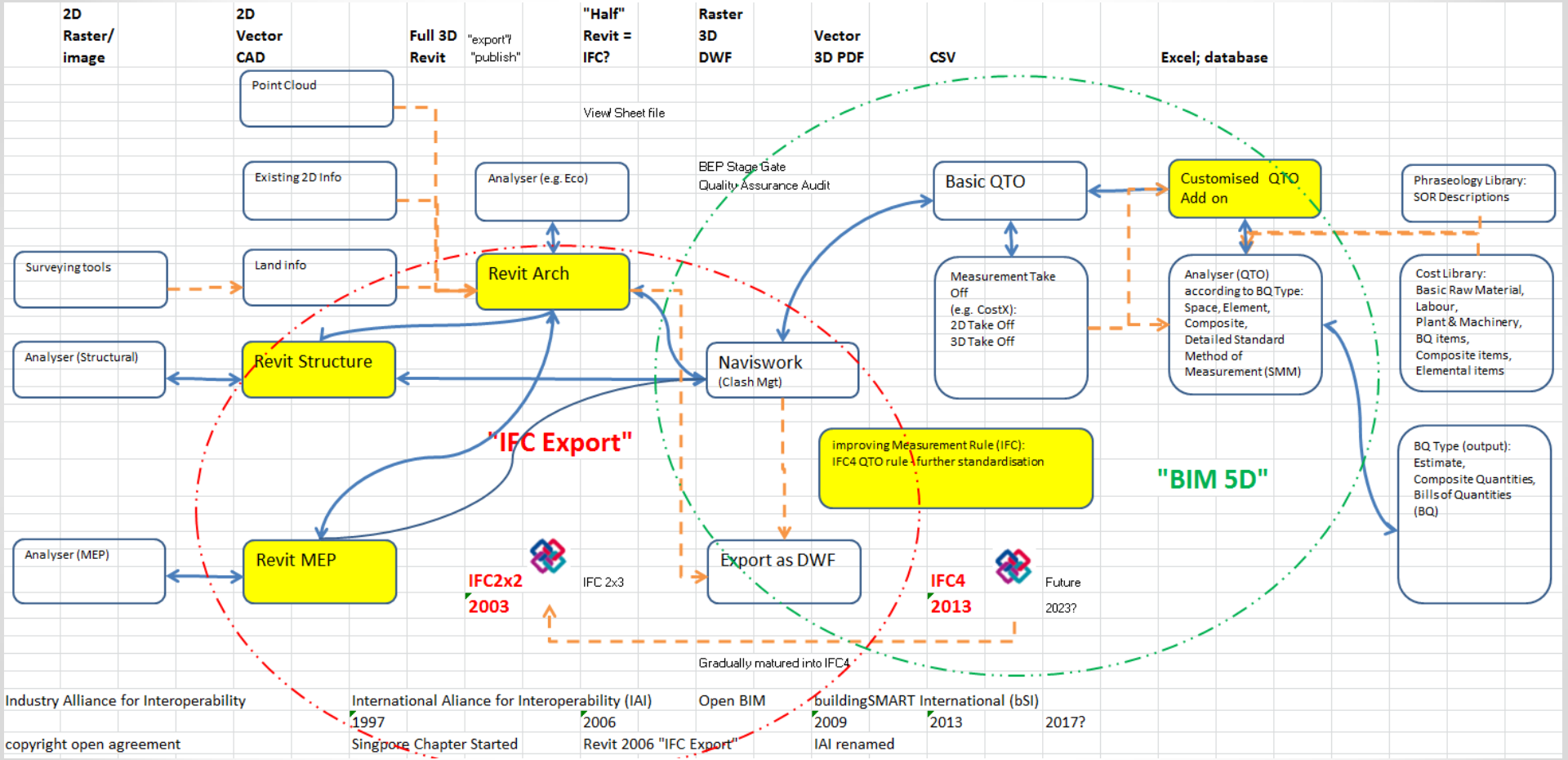
- Degree in Architecture, Interior Design, Structural Engineering, MEP Engineering or related field.
- 10 years of working experience in construction (preferably of healthcare infrastructure development projects)
- Ability to create written BIM process/standard is essential
- Active and proficient user of Autodesk Revit 2013/2014, as well as 2D CAD and other relevant BIM software such as Navisworks and Solibri Model Checker.
- Multi-discipline BIM Project experience using Revit collaboration tools
- Additional experience with at least one of the following: Revit Architecture, Revit Structure or AutoCAD MEP
- Background or industry experience in one of the MEP disciplines is a plus
- Work with the BIM team to review BIM models and relevant deliverables submitted by consultants/contractors.
- Work with both in-house and external team members to identify and resolve technical issues in BIM modelling, particularly for AM/FM applications.
- Work with the BIM team to archive and document good practices for developing BIM for AM/FM.

IFC Export

- E.g. Revit can export Data on IFC format. An **IFC certified vendor** would be able to support IFC (based on IFC2x2 to IFC2x3 currently).
- This export is not 100%, but for the basic essentials only.
- Properties of "Basic QTO" is one of them.
- Data beyond the basic, for example used by backend "Analyser" software to supplement Revit is not.
- Thus, it comprises the "Foundation Layer" only. Namely the basic 3D.

Basic QTO vs Add on calibrated Quantities

- IFC has a component on QTO, defining the parameters to be "snapped" on.
- During IFC2x2, it had not been fully developed nor in consensus.
- IFC4 (known as IFC2x4 then) had re-designed the "Relational Database", with QTO vendors and users.
- Basic QTO items would be expanded when vendors are certified for IFC4 compliance.
- IDM for whole new set of basic QTO is in progress; but only for the common ones.
- So localised items are not and has to be customised.


2D Raster/ image
2D Vector CAD
Full 3D Revit
"export"/ "publish"
"Half" Revit = IFC?
Raster 3D DWF
Vector 3D PDF
CSV
Excel; database
Point Cloud
View/ Sheet file
Existing 2D Info
Analyser (e.g. Eco)
BEP Stage Gate
Quality Assurance Audit
Basic QTO
Customised QTO
Add on
Phraseology Library:
SOR Descriptions
Surveying tools
Land info
Revit Arch
Measurement Take Off
(e.g. CostX):
2D Take Off
3D Take Off
Analyser (QTO)
according to BQ Type:
Space, Element, Composite,
Detailed Standard Method of Measurement (SMM)
Cost Library:
Basic Raw Material,
Labour,
Plant & Machinery,
BQ items,
Composite items,
Elemental items
Analyser (Structural)
Revit Structure
Naviswork
(Clash Mgt)
"IFC Export"
improving Measurement Rule (IFC):
IFC4 QTO rule - further standardisation
"BIM 5D"
BQ Type (output):
Estimate,
Composite Quantities,
Bills of Quantities
(BQ)
Analyser (MEP)
Revit MEP
Export as DWF
IFC2x2
2003
IFC 2x3
IFC4
2013
Future
2023?
Gradually matured into IFC4
Industry Alliance for Interoperability
International Aliance for Interoperability (IAI)
Open BIM
buildingSMART International (bSI)
1997
2006
2009
2013
2017?
copyright open agreement
Singpore Chapter Started
Revit 2006 "IFC Export"
IAI renamed

SOR Databases according to SMM Basic or Composite/ Simplified

The general rules on QTO and 5D costing is shown in the following figure:

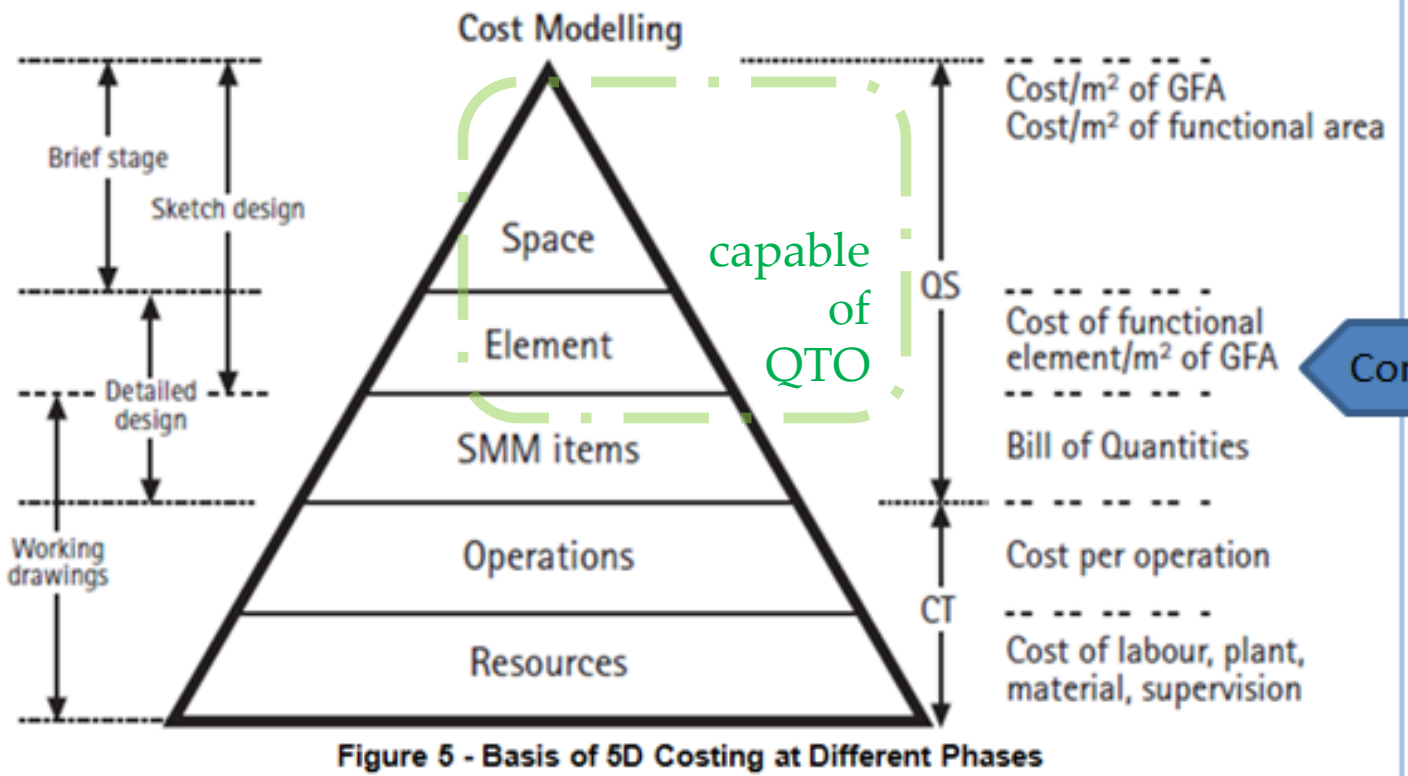


Figure 5 - Basis of 5D Costing at Different Phases

- Lump sum
- Elemental
- Composite/ Simplified
- BQ
- Activities
- Dayworks

Ad hoc or add on calibrated measurement

- Add formula as extension to basic QTO. Converting the basic quantity with one or more dimension. – e.g. Weight converter
- Some formula suggested in IDM are too complicated.
- Some are for “staging” or “range” or “intervals” constraints, such as “ceiling/ soffit height"; "excavation interval".
- A way to overcome is to simplify the “measuring rule” of the Standard Method of Measurement (SMM).
- In Singapore, this simplification is done by **SS CP97 CEMS - SMM**.

- Can **QTO stage-transformation** linked?

- Can past quantities be reused?:
  - From i. Space;
  - To ii. Element?;
  - To iii. Composite as item?;
  - To iv. BQ SMM items?

- Basic QTO for each stage? + customised Take Off?
- "Take off process" has to be "repeated" for each stage?

I. Conceptual Design Building "space" massing studies:

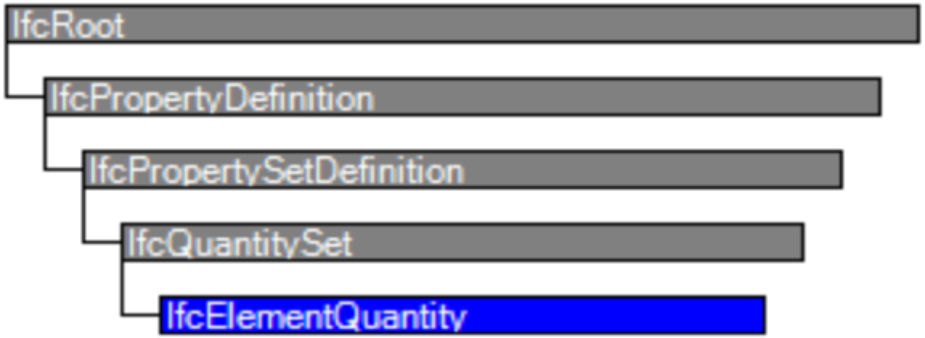
II. Schematic/ Preliminary Design "cost planning", Level of Detail 2A.:

III. Detailed Design, Level of Detail 2B (Level of Detail 3 is hardly achievable). Approximate Quantities

IV. Construction – Constructability and Fabrication, Level of Detail 3 on relevant Component only

IFC4

▼ **Entity inheritance**



5.2.5 Quantity Sets

5.2.5.1 Qto_BuildingBaseQuantities

5.2.5.2 Qto_BuildingStoreyBaseQuantities

5.2.5.3 Qto_SiteBaseQuantities

5.2.5.4 Qto_SpaceBaseQuantities

http://www.buildingsmart-tech.org/mvd/IFC4Add1/RV/1.0/htm

8.14 IfcQuantityResource

8.14.1 Schema Definition

8.14.2 Entities

8.14.2.1 IfcPhysicalComplexQuantity

8.14.2.2 IfcPhysicalQuantity

8.14.2.3 IfcPhysicalSimpleQuantity

8.14.2.4 IfcQuantityArea

8.14.2.5 IfcQuantityCount

8.14.2.6 IfcQuantityLength

8.14.2.7 IfcQuantityTime

8.14.2.8 IfcQuantityVolume

8.14.2.9 IfcQuantityWeight

8.14.3 Functions

8.14.3.1 IfcUniqueQuantityNames

5.2.5.1 Qto_BuildingBaseQuantities

QTO_TYPEDRIVENOVERRIDE / IfcBuilding

DE : Basismengen für Gebäude

EN **Building Base Quantities**: Base quantities that are common to the definition of all occurrences of building.

JP : 建物に関わる共通の基本数量情報の定義。

Height; EavesHeight, FootprintArea, GrossFloorArea, NetFloorArea, GrossVolume, NetVolume

5.2.5.2 Qto_BuildingStoreyBaseQuantities

QTO_TYPEDRIVENOVERRIDE / IfcBuildingStorey

DE : Basismengen für Stockwerke

EN **Building Storey Base Quantities**: Base quantities that are common to the definition of

JP : 建物階に関わる共通の基本数量情報の定義。

GrossHeight, NetHeight, GrossPerimeter, GrossFloorArea, NetFloorArea, GrossVolume, NetVolume

5.2.5.3 Qto_SiteBaseQuantities

QTO_TYPEDRIVENOVERRIDE / IfcSite

DE : Basismengen für das Grundstück

EN **Site Base Quantities**: Base quantities that are common to the de

JP : 敷地に関わる共通の基本数量情報の定義。

GrossPerimeter, GrossArea

5.2.5.4 Qto_SpaceBaseQuantities

QTO_TYPEDRIVENOVERRIDE / IfcSpace

DE : Basismengen für alle Räume

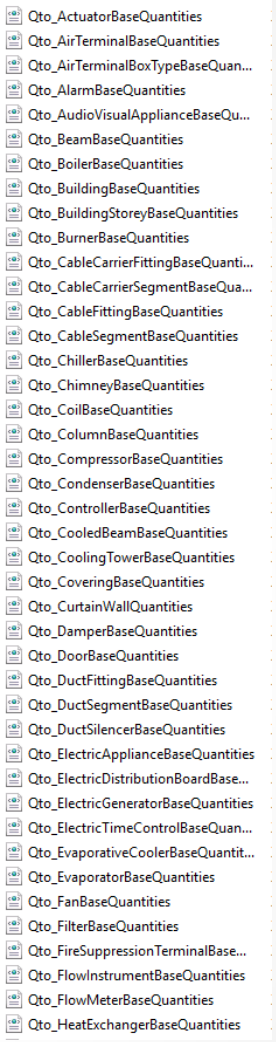
EN **Space Base Quantities**: Base quantities that are common to

JP : 部屋に関わる共通の基本数量情報の定義。

Height, FinishCeilingHeight, FinishFloorHeight, GrossPerimeter, NetPerimeter, GrossFloorArea, NetFloorArea, GrossWallArea, NetWallArea, GrossCeilingArea, NetCeilingArea, GrossVolume, NetVolume

Rooted entities	IFC2X3 CV2.0	IFC4 RV	IFC4DTV
IfcPropertySet	x	x	x
IfcQuantitySet		x	x
IfcElementQuantity		x	x

other Entities	IFC2X3 CV2.0	IFC4 RV	IFC4DTV
IfcPhysicalQuantity		x	x
IfcPhysicalComplexQuantity		x	x
IfcPhysicalSimpleQuantity		x	x
IfcQuantityArea		x	x
IfcQuantityCount		x	x
IfcQuantityLength		x	x
IfcQuantityTime		x	x
IfcQuantityVolume		x	x
IfcQuantityWeight		x	x



From Revit Guide

Referencing Elements in the IFC File

While linked IFC files are read-only in a Revit model, you can use them as references to do the following:

- Dimension to references of IFC elements. (These references apply to the faces of linked IFC geometry and not to center lines, reference planes, or other non-geometry elements.)
- Snap to IFC-based elements.
- Align Revit elements to IFC-based elements.
- Host some face-based families, such as conduit and some electrical devices. (This hosting does not include wall, roof, or floor-specific hosted families. For example, you cannot insert a door or a window into a linked IFC wall.)

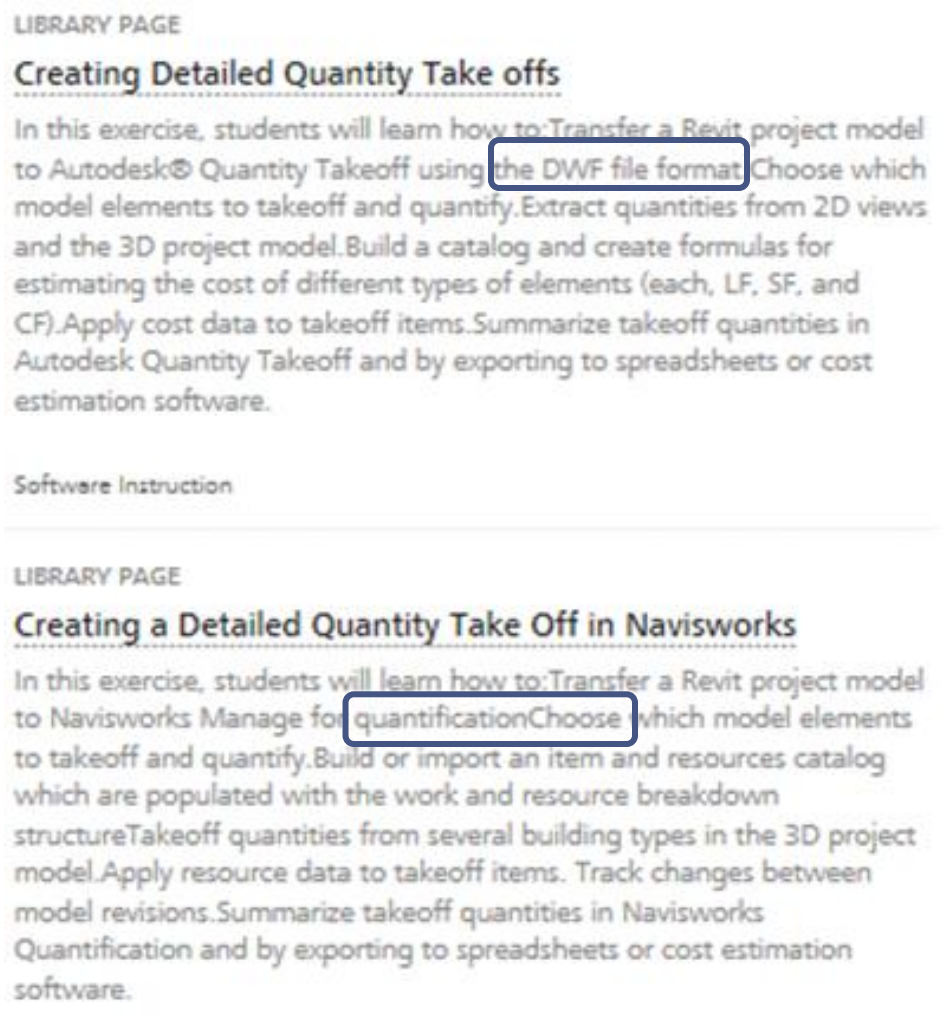
Export a Project to IFC

Save a project as an IFC file for use with an IFC-certified application that does not use the RVT file format.

Topics in this section

- **About Exporting to DWF**
  DWF™ is the Autodesk method of publishing design data. It offers an alternative to printing to PDF (Portable Document Format).
- **About Performance When Exporting Multiple Files to DWF**
  When you export multiple views and sheets to DWF, the software uses multiple processes to reduce the time required to complete the export operation.
- **About Exporting Object Data to DWF Files**
  Revit automatically includes object data for elements in 3D DWF files.
- **Export to DWF**
  Export one or more views and sheets to DWF or DWFx format.
- **Link DWF Markups**
  You can export sheet views as DWF files, mark up the files, and then link the markups back into the project.
- **Manage DWF Markup Links**

Estimate With just Basic QTO



LIBRARY PAGE

Creating Detailed Quantity Take offs

In this exercise, students will learn how to:Transfer a Revit project model to Autodesk® Quantity Takeoff using the DWF file format.Choose which model elements to takeoff and quantify.Extract quantities from 2D views and the 3D project model.Build a catalog and create formulas for estimating the cost of different types of elements (each, LF, SF, and CF).Apply cost data to takeoff items.Summarize takeoff quantities in Autodesk Quantity Takeoff and by exporting to spreadsheets or cost estimation software.

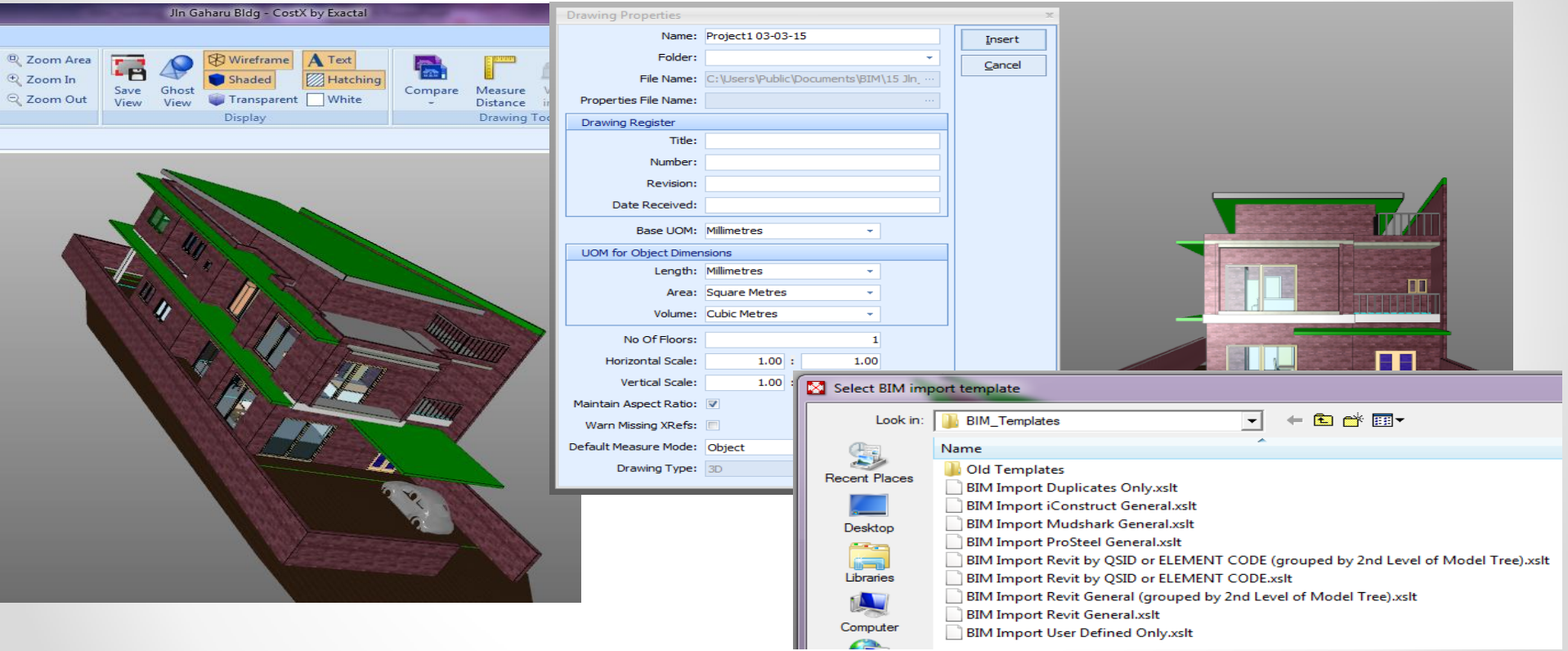
Software Instruction

LIBRARY PAGE

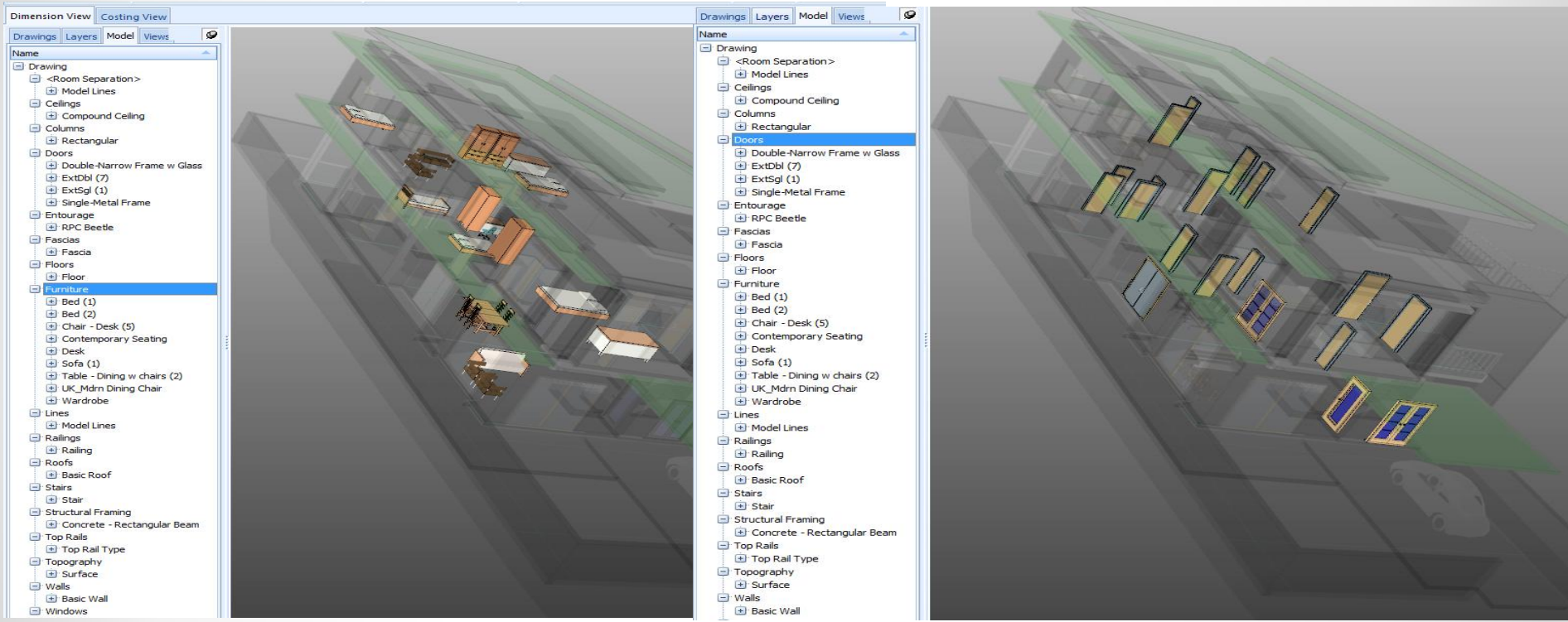
Creating a Detailed Quantity Take Off in Navisworks

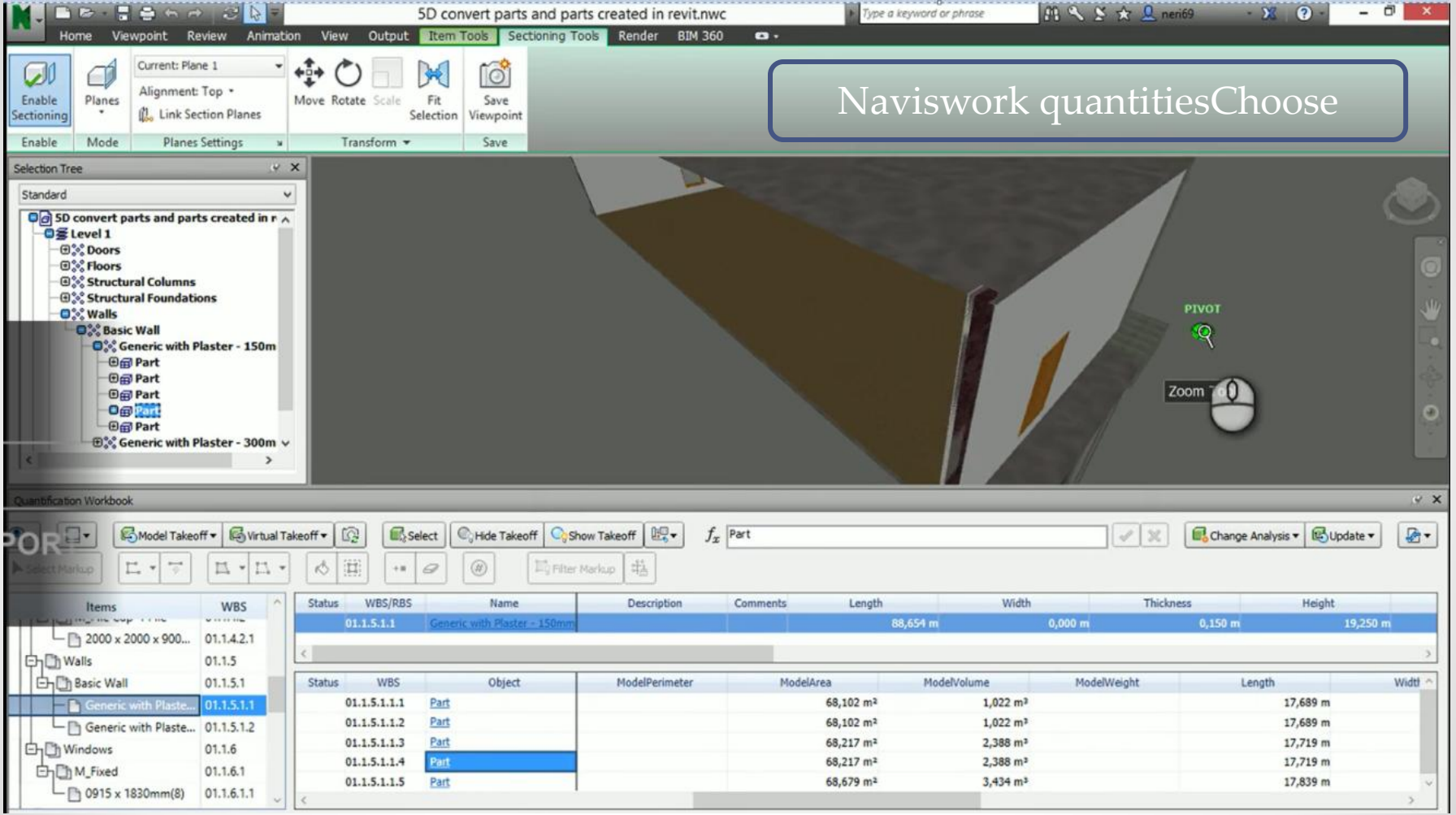
In this exercise, students will learn how to:Transfer a Revit project model to Navisworks Manage for quantificationChoose which model elements to takeoff and quantify.Build or import an item and resources catalog which are populated with the work and resource breakdown structureTakeoff quantities from several building types in the 3D project model.Apply resource data to takeoff items. Track changes between model revisions.Summarize takeoff quantities in Navisworks Quantification and by exporting to spreadsheets or cost estimation software.

Revit Export .dwf for 5D BIM CostX Estimate



CostX picking Revit's .dwf by "Object"




5D convert parts and parts created in revit.nwc
Home
Viewpoint
Review
Animation
View
Output
Item Tools
Sectioning Tools
Render
BIM 360
Enable Sectioning
Planes
Current: Plane 1
Alignment: Top
Link Section Planes
Move
Rotate
Scale
Fit Selection
Save Viewpoint
Enable
Mode
Planes Settings
Transform
Save
Naviswork quantitiesChoose
Selection Tree
Standard
5D convert parts and parts created in r
Level 1
Doors
Floors
Structural Columns
Structural Foundations
Walls
Basic Wall
Generic with Plaster - 150m
Part
Part
Part
Part
Part
Generic with Plaster - 300m
PIVOT
Zoom
Quantification Workbook
Model Takeoff
Virtual Takeoff
Select
Hide Takeoff
Show Takeoff
Part
Change Analysis
Update
Filter Markup
Items
WBS
2000 x 2000 x 900...
01.1.4.2.1
Walls
01.1.5
Basic Wall
01.1.5.1
Generic with Plaste...
01.1.5.1.1
Generic with Plaste...
01.1.5.1.2
Windows
01.1.6
M_Fixed
01.1.6.1
0915 x 1830mm(8)
01.1.6.1.1
Status
WBS/RBS
Name
Description
Comments
Length
Width
Thickness
Height
01.1.5.1.1
Generic with Plaster - 150mm
88,654 m
0,000 m
0,150 m
19,250 m
Status
WBS
Object
ModelPerimeter
ModelArea
ModelVolume
ModelWeight
Length
Width
01.1.5.1.1.1
Part
68,102 m²
1,022 m³
17,689 m
01.1.5.1.1.2
Part
68,102 m²
1,022 m³
17,689 m
01.1.5.1.1.3
Part
68,217 m²
2,388 m³
17,719 m
01.1.5.1.1.4
Part
68,217 m²
2,388 m³
17,719 m
01.1.5.1.1.5
Part
68,679 m²
3,434 m³
17,839 m

REVIT® 2017

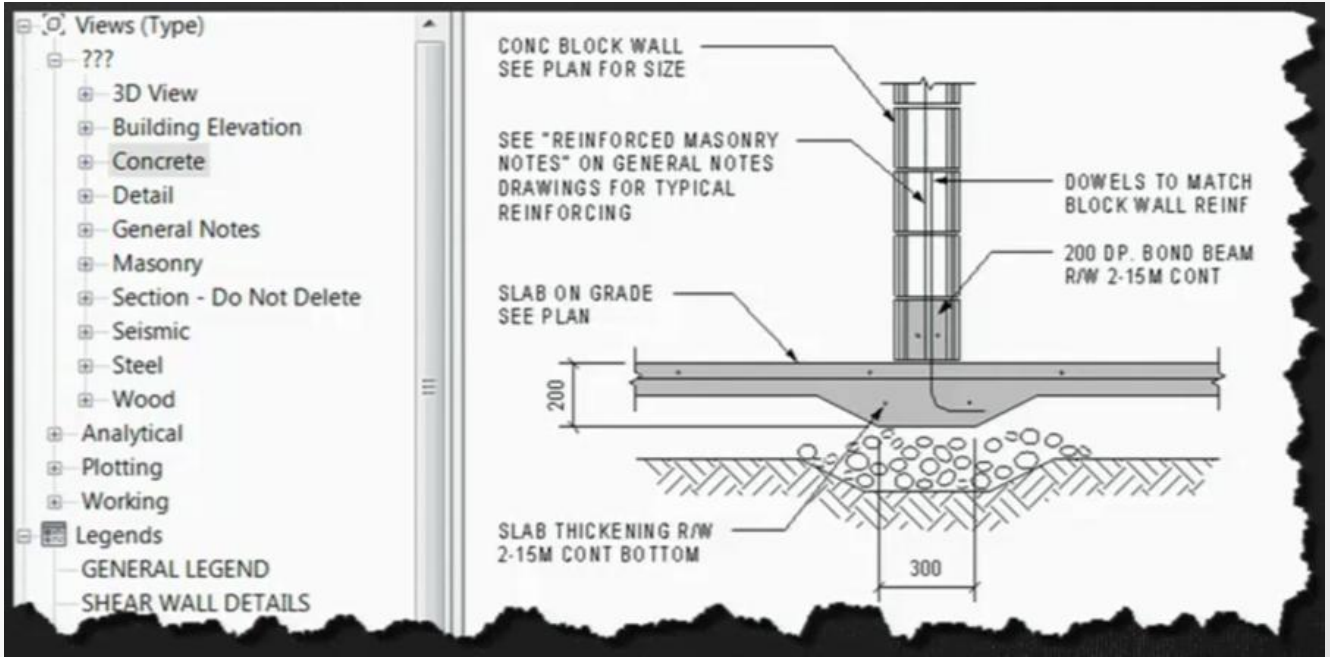
Create a Schedule or Quantity

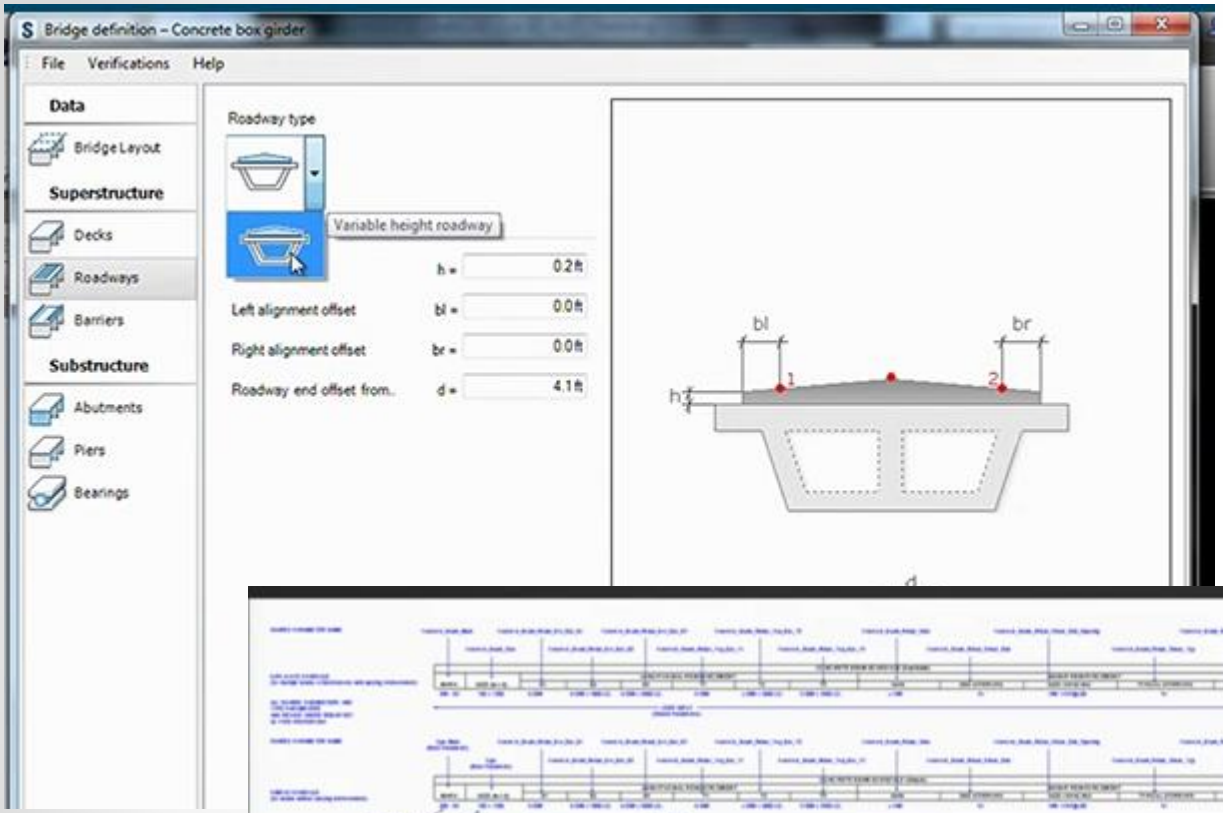
When needed, add a list of building element components to your project.

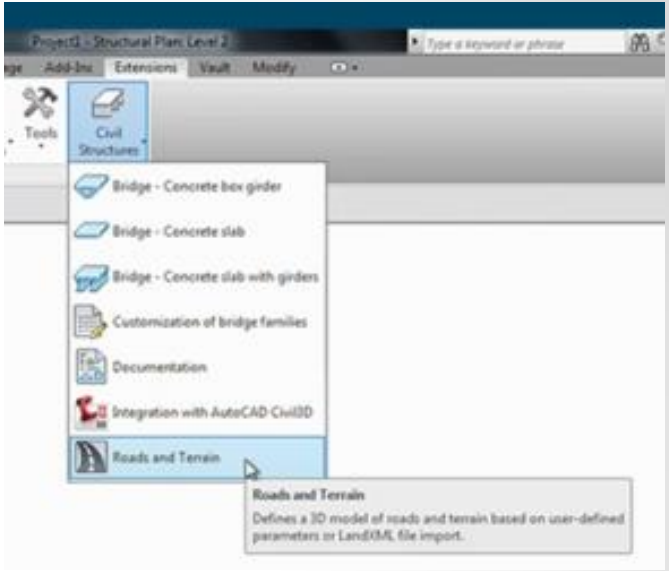
1. Click View tab ➤ Create panel ➤ Schedules drop-down ➤ Schedule/Quantities.

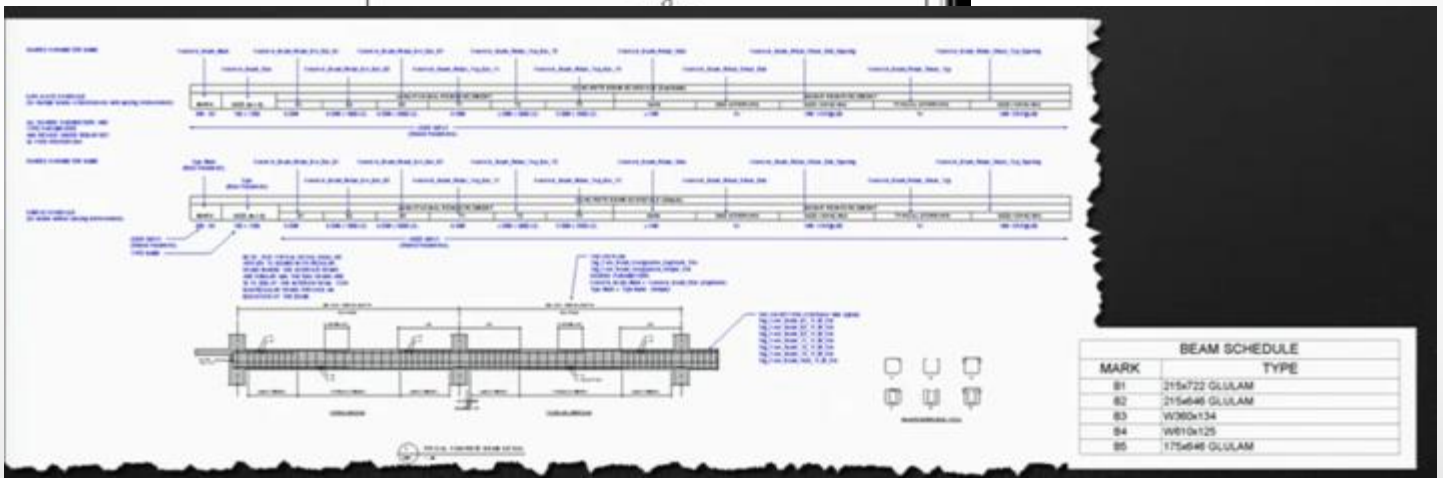
Structural Specific Schedules

- Foundation Schedules
- Column Schedules
- Beam Schedules
- Base Plate Schedules
- Shear Walls



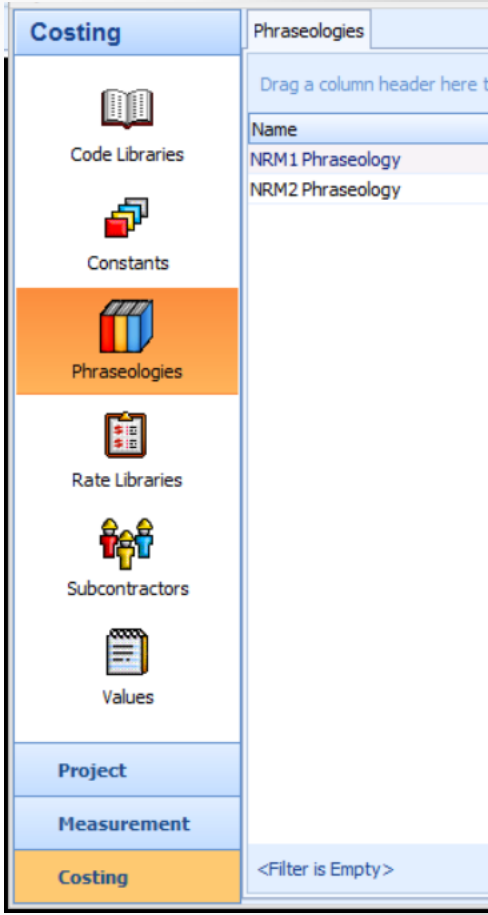

Bridge definition – Concrete box girder
File
Verifications
Help
Data
Bridge Layout
Superstructure
Decks
Roadways
Barriers
Substructure
Abutments
Piers
Bearings
Roadway type
Variable height roadway
h =
0.2 ft
Left alignment offset
bl =
0.0 ft
Right alignment offset
br =
0.0 ft
Roadway end offset from..
d =
4.1 ft
bl
br
h
1
2
d


Project1 - Structural Plan: Level 2
Add-Ins
Extensions
Vault
Modify
Tools
Civil Structures
Bridge - Concrete box girder
Bridge - Concrete slab
Bridge - Concrete slab with girders
Customization of bridge families
Documentation
Integration with AutoCAD Civil3D
Roads and Terrain
Roads and Terrain
Defines a 3D model of roads and terrain based on user-defined parameters or LandXML file import.


BEAM SCHEDULE
MARK
TYPE
B1
215x722 GLULAM
B2
215x646 GLULAM
B3
W360x134
B4
W610x125
B5
175x646 GLULAM

Other practice initiatives

- RICS New rules of measurement for building works (NRM)
  - NRM 1 - *Order of cost estimating and cost planning for building works*. Elements, systems, sub systems and components.
  - NRM 2 – *Detailed rules for measurement and description of building works*. Trade based classification system
  - NRM 3 – *Order of cost estimating and cost planning for building maintenance works*. Extension of NRM1.
  - http://www.designingbuildings.co.uk/wiki/NRM2
  - http://www.isurv.com/site/scripts/download.aspx?type=downloads&fileID=6531
- COBie (BS 1192-4:2014) *Collaborative production of information Part 4: Fulfilling employer's information exchange*
- *4D, 5D integration – From "objects"*
  → Properties (IFC QTO)
  → Formula → calibrated Quantities

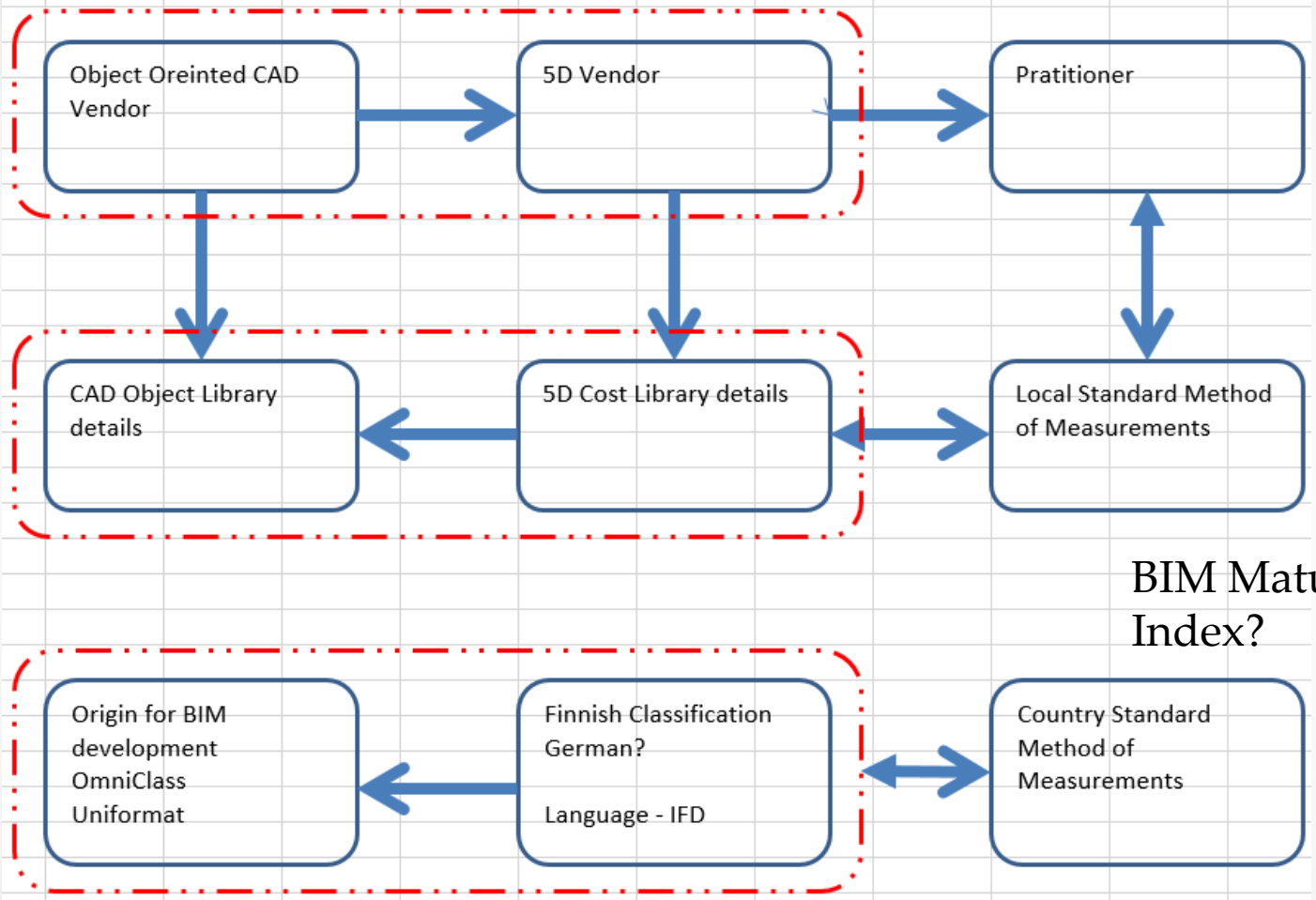


Hurdles

- Need to synchronise meaning of terms e.g. GFA
  - Gross Floor Area (usage x) is not the same as GFA (usage Y) and is affecting input to Assets Information Model
  - RICS introduces International Property Measurement Standards (IPMS) to address and understand the country differences in the definition of GFA (usages)
- Need to synchronise "Digital Building Block"
  - A structured common Library of BIM Object for commonly used items "in a shared context" – e.g. Country Based; and therefore a possible Object related Cost Library
  - An associated customised QTO (i.e. formula extension) can be developed for "reused" or lookup as reference. (e.g. plug in in HELIOS)

Autodesk	AutoCAD Architecture	Architecture	Import & Export	**Export: certified** Import: in progress
Autodesk	AutoCAD MEP	BuildingServices	Export	in progress
Autodesk	Revit Architecture	Architecture	Import & Export	**Export: certified** **Import: certified**
Autodesk	Revit MEP	BuildingService	Import & Export	**Export: certified** **Import: certified**
Autodesk	Revit Structure	Structural	Import & Export	**Export: certified** **Import: certified**
Autodesk	Revit LT	Architecture	Import & Export	**Export certified** Import: in progress
Bentley Systems	AECOsim Building Designer	Architecture, BuildingService, Structural	Import & Export	**Export: certified** **Import: certified**
CadLine Ltd	ARCHLine.XP	Architecture	Import & Export	**Export: certified** Import: in progress
DICAD Systeme GmbH	STRAKON	- (*)	Import	in progress
Data Design System	DDS-CAD MEP	BuildingService	Export	**Export: certified**
Design Data	SDS/2	Structural	Import & Export	**Export: certified** Import: in progress
Dlubal Software GmbH	RFEM/RSTAB	- (*)	Import	**Import: certified**
ETU Software GmbH	HottCAD 4	- (*)	Import	in progress
FirstInVision	CasCADos / P3cad	Architecture	Import & Export	in progress

Glodon Software	Glodon Takeoff for Architecture and Structure	Architecture, Structural	Import & Export	**Import: certified** Export: in progress
Graphisoft	ArchiCAD	Architecture	Import & Export	**Export: certified** **Import: certified**
Kymdata Oy	CADS Planner	BuildingService	Export	in progress
NEMETSCHEK Allplan	Allplan	Architecture	Import & Export	**Export: certified** **Import: certified**
NEMETSCHEK BIM+	BIM+	- (*)	Import	in progress
NEMETSCHEK Vectorworks, Inc.	Vectorworks	Architecture	Import & Export	**Export: certified** **Import: certified**
NEMETSCHEK Scia	Scia Engineer	Structural	Import & Export	**Export: certified** **Import: certified**
Progman	MagiCad	BuildingService	Export	in progress
RIB	iTWO	- (*)	Import	**Import: certified**
Seokyoung Systems	NaviTouch	- (*)	Import	**Import: certified**
Solibri	Solibri Model Checker	- (*)	Import	**Import: certified**
Solideo Systems	ArchiBIM Server	- (*)	Import	**Import: certified**
Tekla	Tekla Structures	Structural	Import & Export	**Export: certified** **Import: certified**
think project!	think project! Collaboration cloud	- (*)	Import	in progress
Trimble Germany	Plancal nova	BuildingService	Import & Export	**Export: certified** Import: in progress
VIZELIA	Facility on line	- (*)	Import	in progress



BIM Maturity; Index?

How much can practitioner influence?

CAD Vendor + Intermediate 5D Vendor + Practitioner

Object library detail + Cost library detail link

• • •

e.g. http://www.vicosoftware.com/products/Vico-Office/tabid/85286/Default.aspx

Architectural Objects,
Structural Objects,
MEP Services Objects

SINGAPORE STANDARDS COUNCIL

CP 97 : Part 1 : 2002 (2015)
(ICS 91.200)

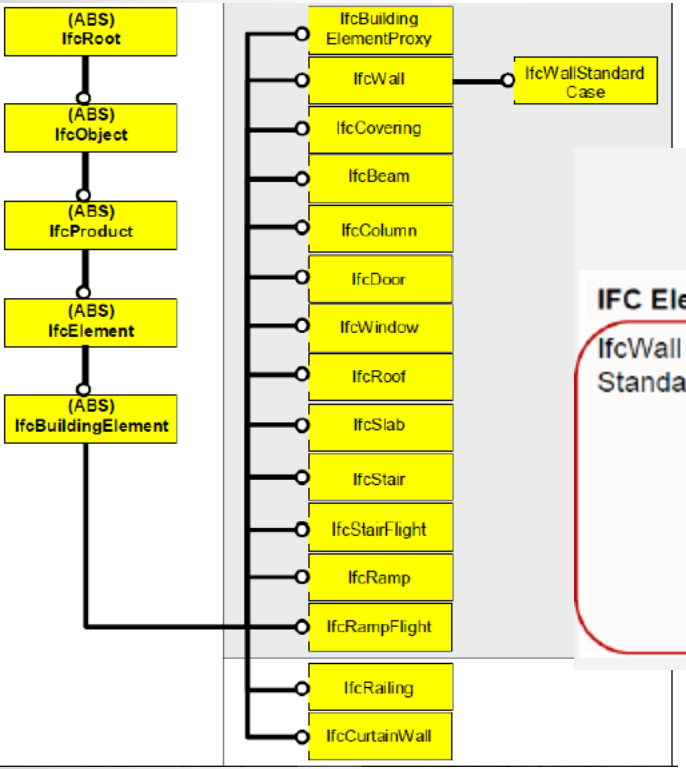
Thank You

SINGAPORE STANDARD

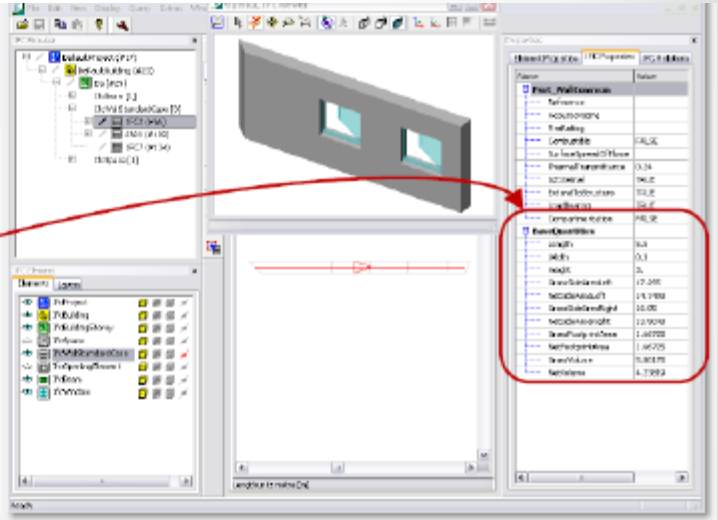
Code of practice for construction electronic measurement standards (CEMS)

– Part 1 : Standard method of measurement (SMM) for building works

– Part 2 : Standard method of measurement (SMM) for mechanical and electrical works



IFC Element	Base quantities supported
IfcWall StandardCase	- Width - Length - Height - GrossFootprintArea - NetFootprintArea - GrossSideArea - NetSideArea - GrossVolume - NetVolume



http://au.autodesk.com/au-online/classes-on-demand/class-catalog/2014/revit-for-architects/sd6060#chapter=1

IFC top level format to Revit comparison

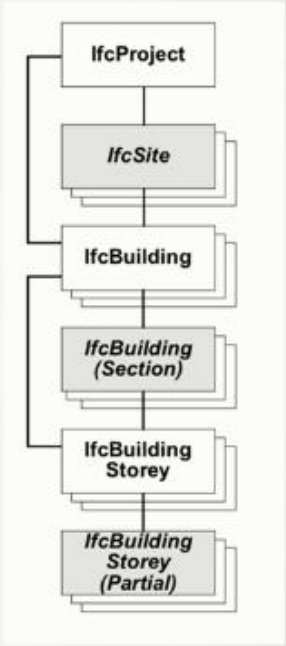
IfcProject = Revit Document

IfcSite = Revit Site (if it has any geometry)

IfcBuilding = Revit parameters in Project Information

IfcBuildingStorey = Revit Levels

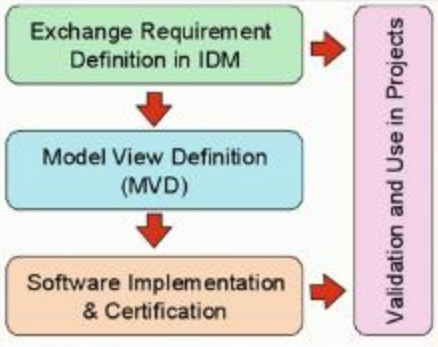
IfcBuildingElements = Revit Elements



ABCs of IFC (MVD)

MVD = Model View Definition

- An MVD is the subset of IFC suited for a particular workflow. Examples are:
  - Coordination View
  - Structural Analysis View
  - FM (Facilities Handover) View (a.k.a. COBie)
- An IFC file must be generated based on some MVD, perhaps with compatible "Add-ons" such as:
  - QTO (Quantity Take-off)
  - 1st or 2nd level space boundaries



IfcElement hierarchy


```
ENTITY IfcWall;
  ENTITY IfcRoot;
    GlobalId            : IfcGloballyUniqueId;
    OwnerHistory        : IfcOwnerHistory;
    Name                : OPTIONAL IfcLabel;
    Description         : OPTIONAL IfcText;
  ENTITY IfcObjectDefinition;
  INVERSE
    HasAssignments      : SET OF IfcRelAssigns FOR RelatedObjects;
    IsDecomposedBy      : SET OF IfcRelDecomposes FOR RelatingObject;
    Decomposes          : SET [0:1] OF IfcRelDecomposes FOR RelatedObjects;
    HasAssociations     : SET OF IfcRelAssociates FOR RelatedObjects;
  ENTITY IfcObject;
    ObjectType          : OPTIONAL IfcLabel;
  INVERSE
    IsDefinedBy         : SET OF IfcRelDefines FOR RelatedObjects;
  ENTITY IfcProduct;
    ObjectPlacement     : OPTIONAL IfcObjectPlacement;
    Representation      : OPTIONAL IfcProductRepresentation;
  INVERSE
    ReferencedBy        : SET OF IfcRelAssignsToProduct FOR RelatingProduct;
  ENTITY IfcElement;
    Tag                 : OPTIONAL IfcIdentifier;
```