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):
  o SMM for Building Works (part 1) and
  o 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

- 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
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.
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.
SOR Databases according to SMM Basic or Composite/ Simplified

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

Cost Modelling

Brief stage
Sketch design
Detailed design
Working drawings

Space
Element
SMM items
Operations
Resources

Cost/m² of GFA
Cost/m² of functional area
Cost of functional element/m² of GFA
Bill of Quantities
Cost per operation
Cost of labour, plant, material, supervision

QS
CT

Figure 5 - Basis of 5D Costing at Different Phases

Lump sum
Elemental
Composite/ Simplified
BQ
Activities
Dayworks

capable of QTO
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?
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/html

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**: 建物に関する共通の基本数量情報の定義。

### 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。

### 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。

### 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; EavesHeight, GrossFloorArea, NetFloorArea, GrossVolume, NetVolume**

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

**GrossPerimeter, GrossArea**

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

---

**JACIC**
### Rooted entities

<table>
<thead>
<tr>
<th></th>
<th>IFC2X3 CV2.0</th>
<th>IFC4 RV</th>
<th>IFC4DTV</th>
</tr>
</thead>
<tbody>
<tr>
<td>IfcPropertySet</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IfcQuantitySet</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IfcElementQuantity</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### other Entities

| IfcPhysicalQuantity      | X            |         |         |
| IfcPhysicalComplexQuantity| X            |         |         |
| IfcPhysicalSimpleQuantity| X            |         |         |
| IfcQuantityArea          | X            |         |         |
| IfcQuantityCount         | X            |         |         |
| IfcQuantityLength        | X            |         |         |
| IfcQuantityTime          | X            |         |         |
| IfcQuantityVolume        | X            |         |         |
| IfcQuantityWeight        | X            |         |         |
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
Revit Export .dwf for 5D BIM CostX Estimate
CostX picking Revit’s .dwf by “Object”
Naviswork quantities Choose
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.
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
  - [http://www.designingbuildings.co.uk/wiki/NRM2](http://www.designingbuildings.co.uk/wiki/NRM2)

- 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
  o Gross Floor Area (usage x) is not the same as GFA (usage Y) and is affecting input to Assets Information Model
  o 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”
  o 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
  o An associated customised QTO (i.e. formula extension) can be developed for “reused” or lookup as reference. (e.g. plug in in HELIOS)
<table>
<thead>
<tr>
<th>Company</th>
<th>Product</th>
<th>Category</th>
<th>Import &amp; Export</th>
<th>Export Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autodesk</td>
<td>AutoCAD Architecture</td>
<td>Architecture</td>
<td>Import &amp; Export</td>
<td>Export: certified</td>
</tr>
<tr>
<td>Autodesk</td>
<td>AutoCAD MEP</td>
<td>Building Services</td>
<td>Export</td>
<td>Import: in progress</td>
</tr>
<tr>
<td>Autodesk</td>
<td>Revit Architecture</td>
<td>Architecture</td>
<td>Import &amp; Export</td>
<td>Export: certified</td>
</tr>
<tr>
<td>Autodesk</td>
<td>Revit MEP</td>
<td>Building Service</td>
<td>Import &amp; Export</td>
<td>Export: certified</td>
</tr>
<tr>
<td>Autodesk</td>
<td>Revit Structure</td>
<td>Structural</td>
<td>Import &amp; Export</td>
<td>Export: certified</td>
</tr>
<tr>
<td>Autodesk</td>
<td>Revit LT</td>
<td>Architecture</td>
<td>Import &amp; Export</td>
<td>Export: certified</td>
</tr>
<tr>
<td>Bentley Systems</td>
<td>AECOsim Building</td>
<td>Architecture</td>
<td>Import &amp; Export</td>
<td>Export: certified</td>
</tr>
<tr>
<td></td>
<td>Designer</td>
<td>Building Service</td>
<td>Import &amp; Export</td>
<td>Export: certified</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Structural</td>
<td>Import &amp; Export</td>
<td>Export: certified</td>
</tr>
<tr>
<td>CadLine Ltd</td>
<td>ARCHLine.XP</td>
<td>Architecture</td>
<td>Import &amp; Export</td>
<td>Export: certified</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Import: in progress</td>
<td>in progress</td>
</tr>
<tr>
<td>DICAD Systeme GmbH</td>
<td>STRAKON</td>
<td>- (*)</td>
<td>Import</td>
<td>Export: certified</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Import: in progress</td>
<td>in progress</td>
</tr>
<tr>
<td>Data Design System</td>
<td>DDS-CAD MEP</td>
<td>Building Service</td>
<td>Export</td>
<td>Export: certified</td>
</tr>
<tr>
<td>Design Data</td>
<td>SDS/2</td>
<td>Structural</td>
<td>Import &amp; Export</td>
<td>Export: certified</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Import: in progress</td>
<td>in progress</td>
</tr>
<tr>
<td>Dlubal Software GmbH</td>
<td>RFEM/RSTAB</td>
<td>- (*)</td>
<td>Import</td>
<td>Export: certified</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Import: in progress</td>
<td>in progress</td>
</tr>
<tr>
<td>ETU Software GmbH</td>
<td>HottCAD 4</td>
<td>- (*)</td>
<td>Import</td>
<td>in progress</td>
</tr>
<tr>
<td>FirstInVision</td>
<td>CasCADos / P3cad</td>
<td>Architecture</td>
<td>Import &amp; Export</td>
<td>in progress</td>
</tr>
<tr>
<td>Company</td>
<td>Software/Application</td>
<td>Category</td>
<td>Function</td>
<td>Status</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------------------------------------</td>
<td>--------------------</td>
<td>---------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Glodon Software</td>
<td>Glodon Takeoff for Architecture and Structure</td>
<td>Architecture, Structural</td>
<td>Import &amp; Export</td>
<td>Import: certified Export: in progress</td>
</tr>
<tr>
<td>Graphisoft</td>
<td>ArchiCAD</td>
<td>Architecture</td>
<td>Import &amp; Export</td>
<td>Export: certified</td>
</tr>
<tr>
<td>Kymdata Oy</td>
<td>CADS Planner</td>
<td>BuildingService</td>
<td>Export</td>
<td>Import: certified in progress</td>
</tr>
<tr>
<td>NEMETSCHEK Allplan</td>
<td>Allplan</td>
<td>Architecture</td>
<td>Import &amp; Export</td>
<td>Export: certified</td>
</tr>
<tr>
<td>NEMETSCHEK BIM+</td>
<td>BIM+ (*</td>
<td></td>
<td>Import</td>
<td>Import: certified in progress</td>
</tr>
<tr>
<td>NEMETSCHEK Vectorworks, Inc.</td>
<td>Vectorworks</td>
<td>Architecture</td>
<td>Import &amp; Export</td>
<td>Export: certified</td>
</tr>
<tr>
<td>NEMETSCHEK Scia</td>
<td>Scia Engineer</td>
<td>Structural</td>
<td>Import &amp; Export</td>
<td>Export: certified</td>
</tr>
<tr>
<td>Progman</td>
<td>MagiCad</td>
<td>BuildingService</td>
<td>Export</td>
<td>Import: certified</td>
</tr>
<tr>
<td>RIB</td>
<td>iTWO  (*</td>
<td></td>
<td>Import</td>
<td>Import: certified</td>
</tr>
<tr>
<td>Seokyoung Systems</td>
<td>NaviTouch  (*</td>
<td></td>
<td>Import</td>
<td>Import: certified</td>
</tr>
<tr>
<td>Solibri</td>
<td>Solibri Model Checker  (*)</td>
<td></td>
<td>Import</td>
<td>Import: certified</td>
</tr>
<tr>
<td>Solideo Systems</td>
<td>ArchiBIM Server  (*)</td>
<td></td>
<td>Import</td>
<td>Import: certified</td>
</tr>
<tr>
<td><strong>Tekla</strong></td>
<td><strong>Tekla Structures</strong></td>
<td>Structural</td>
<td>Import &amp; Export</td>
<td>Export: certified</td>
</tr>
<tr>
<td>think project!</td>
<td>think project! Collaboration cloud (*)</td>
<td></td>
<td>Import</td>
<td>in progress</td>
</tr>
<tr>
<td>Trimble Germany</td>
<td>Plancal nova</td>
<td>BuildingService</td>
<td>Import &amp; Export</td>
<td>Export: certified</td>
</tr>
<tr>
<td>VIZELIA</td>
<td>Facility on line (*)</td>
<td></td>
<td>Import</td>
<td>in progress</td>
</tr>
</tbody>
</table>
BIM Maturity; Index?
How much can practitioner influence?

CAD Vendor + Intermediate 5D Vendor + Practitioner

Object library detail + Cost library detail link


Architectural Objects, Structural Objects, MEP Services Objects
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 | - Width
         | - Length
         | - Height
         | - GrossFootprintArea
         | - NetFootprintArea
         | - GrossSideArea
         | - NetSideArea
         | - GrossVolume
         | - NetVolume

StandardCase
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;