STRICT AND AUTOMATIC MAPPING OF IFC-BIM MODELS INTO SEMANTICALLY ENRICHED 3D CITYGML BUILDING MODELS (EXTERIOR AND INTERIOR)

1ST INTERNATIONAL IAG WORKSHOP ON BIM AND GIS INTEGRATION

25 OCTOBER 2017

Rudi Stouffs
IFC TO CITYGML

• Challenges
• Approach
• Scope
• Use cases
CONVERSION PROCESS

B Native BIM

C IFC

D CityGML

A Virtual Singapore

revit
ArchicAD
AecosIM
Tekla
A: **Virtual Singapore CityGML Model**

- Virtual Singapore is a dynamic 3D city model and collaborative data platform. The model and platform will be unveiled during the World Cities Summit in July 2018.

**Challenge 1:** *Ensure the research is driven by user needs*
A’: POTENTIAL USE CASES

- Housing & Development Board (Centre of Building Research)
  - energy
  - urban greening
  - living environment
  - waste & water
  - building technology

- Urban Redevelopment Authority
  - housing
  - transport
  - economy
  - recreation
  - identity
  - public space

- Singapore Land Authority
  - 3D cadastre & strata
  - planning
  - operations
  - risk management
A’: Potential use cases

- Simulations
  - thermal comfort (cool walls)
  - energy consumption (common lighting, elevators)
  - safeguarding wind corridors
  - limiting noise
  - solar photovoltaics
  - greening
  - rainwater harvesting and recycling
  - urban mobility

- Code compliance
  - privacy
  - view

- Visualisation
  - operations (e.g., refuse disposal)

Challenge 1: Ensure the research is driven by user needs
B: Native BIM Building Models

- Singapore’s Building and Construction Authority (BCA) will mandate e-submissions in native BIM format for new developments with GFA more than 5,000 m². Native BIM e-submissions must be prepared in accordance with the prevailing CoP.

<table>
<thead>
<tr>
<th>Types</th>
<th>Voluntary</th>
<th>Mandatory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture</td>
<td>19 October 2016</td>
<td>Second half of 2017</td>
</tr>
<tr>
<td>C&amp;S Engineering</td>
<td>1 October 2017</td>
<td>Second half of 2018</td>
</tr>
<tr>
<td>MEP Engineering</td>
<td>1 October 2017</td>
<td>Second half of 2018</td>
</tr>
</tbody>
</table>

Challenge 2: Work with real-world native BIM models
C: IFC4

- IFC4 Addendum 2 published on 15\textsuperscript{th} July 2016

- Selection of IFC4 as state-of-the-art IFC standard
  - native BIM models as input
  - focus on architectural building data – including foundation (piling)

\textbf{Challenge 3:} Demonstrate the conversion of more information than has been previously achieved – to enable automatic creation of semantically enriched data models
CityGML v3.0 is an ongoing development
  - Core Model
  - Level of Detail (LOD) concept
  - improved interoperability with other relevant standards (IndoorGML, IFC, LADM)

Application Domain Extension (ADE)
  - GeoBIM (IFC) ADE for integrating semantic IFC data in CityGML is insufficient for our purpose

Challenge 4: Transition from CityGML v2.0 to CityGML v3.0 at some time during the project
CONVERSION PROCESS

Native BIM → IFC → CityGML → Virtual Singapore

1

2

Software:
- revit
- ArchiCAD
- AecoSIM
- Tekla

Smart Nation Singapore
1: FROM NATIVE BIM TO IFC4

• Model consistency
  – no initial weeding of unfavourable BIM models – aim to determine workarounds for modelling inconsistencies
  – use of and tweaking of existing *export facilities* to ensure inclusion of all required information

• Model checking
  – can a *Model View Definition* (MVD) be used to ensure consistency?

• Model guidelines
  – suggestions for amendments to BIM e-submission *Code of Practice*, based on enhanced practical understanding of BIM-IFC-CityGML interoperability levels
2A: FROM IFC TO CITYGML — SCOPE

• Starting points
  – IFC4
  – buildings – architectural information (including foundation)
  – CityGML LOD3
  – exterior and interior (LOD4)

• Specification range
  – min: conversion of geometric model content
  – max: complete and lossless
  – use cases based
  – configurable?
2B: FROM IFC TO CITYGML

• Kernel
• Core layer
  – product extension
• Interop layer
  – shared bldg elements
    (wall, column, slab, stair etc.)
• Domain layer
  – architecture domain (windows and doors)
  – structural elements (piles and footings)
• Resource layer
  – to be derived from core and domain layer
    what is needed to support

Image adapted from “Industry Foundation Classes Version 4 - Addendum 2”, buildingSMART International Limited.
2B: FROM IFC TO CITYGML

• Conversion of geometric content
  – SweptSolid, Brep, CSG, ...

• Type propagation from building elements to surfaces
  – walls, roofs, slabs, columns, beams, doors, windows

• Conceptual objects supporting informational use cases
  – spaces (physical and logical)

• Semantic relations supporting simulation use cases
  – window in a wall, ...
  – relationship between spaces and boundaries (CityGML v3.0)

• Relevant properties to support use cases
  – material properties: shader, reflectivity, transmittance, roughness
  – intended usage of spaces
  – ...

REMAINING POINTS

• From IFC to CityGML

• Theoretical framework
**PROJECT DETAILS**

- **Project duration:** May 2017 – April 2019
- **Funding:** NRF2015VSG-AA3DCM001-008
  NRF and GovTech
- **Research collaboration:** OSI
- **Collaborating agencies:** HDB, BCA, URA
- **Collaborating vendors:** Bentley, Graphisoft, Trimble, Autodesk
RESEARCH TEAM

• Principal investigators:
  – Rudi Stouffs
    (NUS – Dept. of Architecture)
  – Patrick Janssen (co-PI)
    (NUS – Dept. of Architecture)

• Research fellows:
  – Helga Tauscher (NUS)
  – Filip Biljecki (NUS)
  – James Crawford (OSI)

• Research assistants:
  – Chen Kok Kiong
  – Amol Konde
THANK YOU

1ST INTERNATIONAL IAG WORKSHOP ON BIM AND GIS INTEGRATION
25 OCTOBER 2017

Rudi Stouffs