



# The national CityGML standard in The Netherlands: explanation, experiences and requests for stronger harmonisation with 2D models

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# 3D community NL organised in 3D Pilot

- Since 2010
- Initiative of Kadaster, Geonovum, Ministry of Infrastructure and Environment
- Community with ambition to push 3D developments
  - government, industry, universities
  - By: collaboration, knowledge exchange and agreements at (inter)national level



# Phase I 3D Pilot: Jan 2010-June 2011

- Established a national vision for 3D developments by collaboration with many stakeholders in a test area and on use cases





# Main result 3D Pilot Phase I: National 3D standard

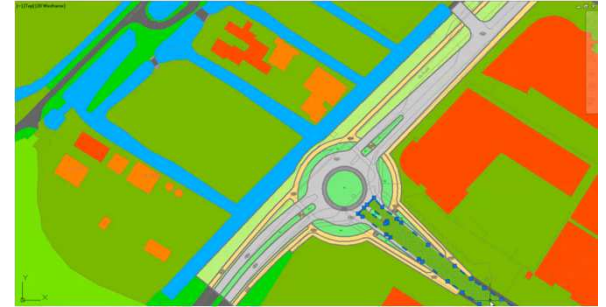
Integration of:

## 1. 2D Information Model Geography (IMGeo)

- roads, water, land use/land cover, bridges, tunnels

## 2. CityGML:

- Not limited to cities!
- Not only an exchange format



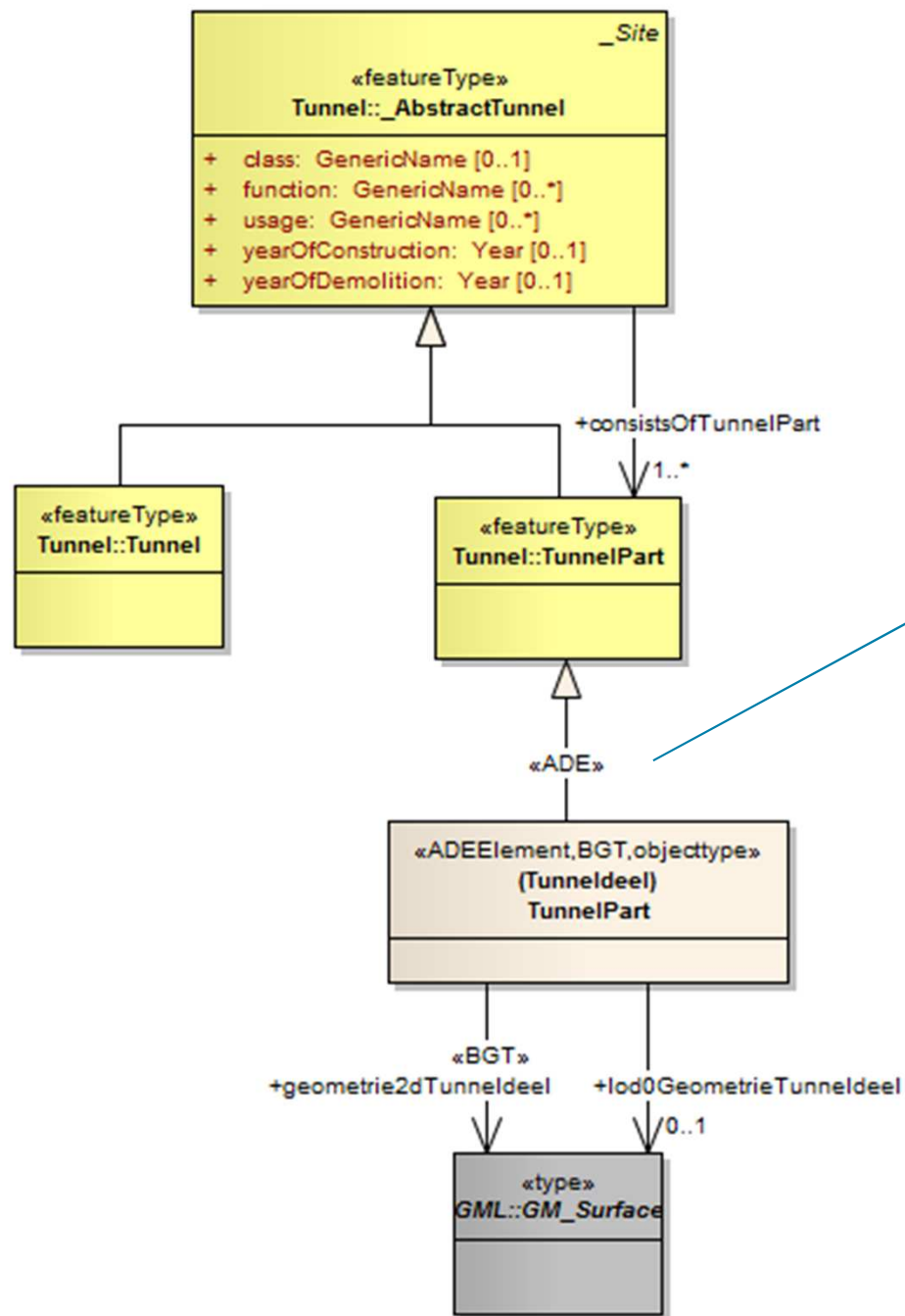
# IMGeo ADE for CityGML

- Every IMGeo class is modelled as a CityGML class, with extra attributes if needed
- Required remodelling of IMGeo
- Not for all classes an equivalent CityGML class could be found: Other constructions



- 2D geometry added for all classes; LOD0 geometry when missing (CR)

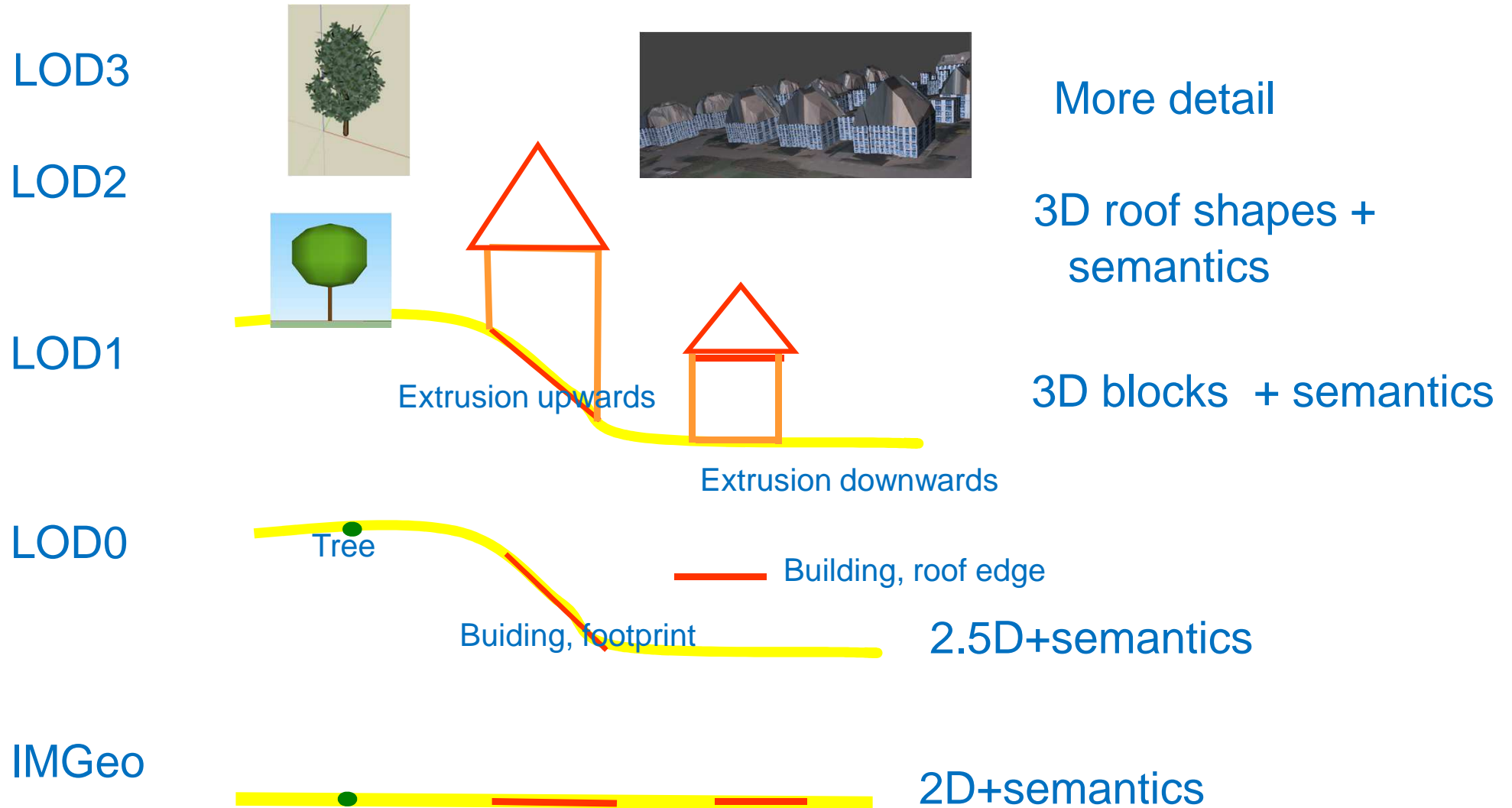




Discussed within SIG3D and submitted as OGC best practice paper

*Linda van den Brink, Jantien Stoter, Sisi Zlatanova, 2012, Modeling an application domain extension of CityGML in UML*

# Levels of detail in IMGeo

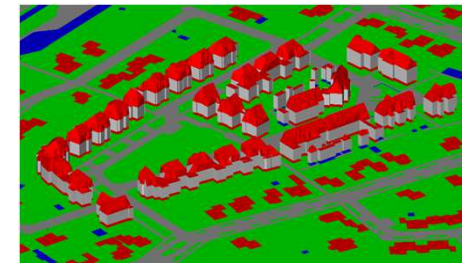
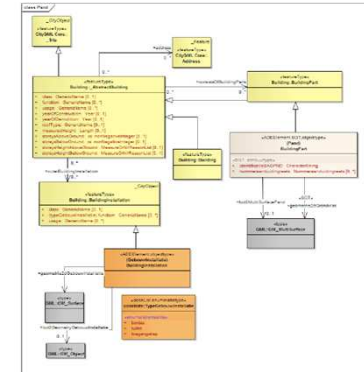


*Courtesy of Sisi Zlatanova*



# But we are not there yet

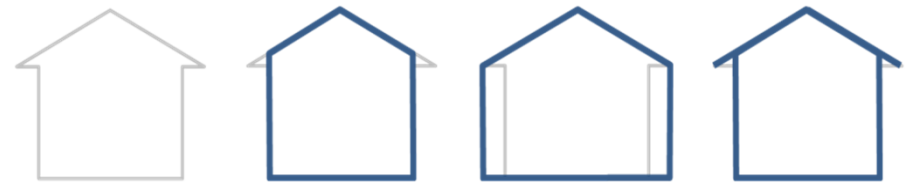
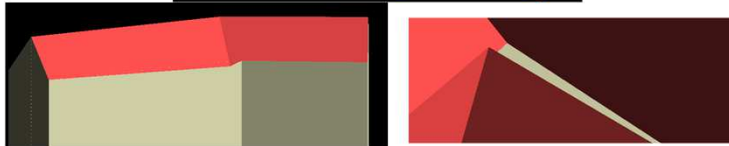
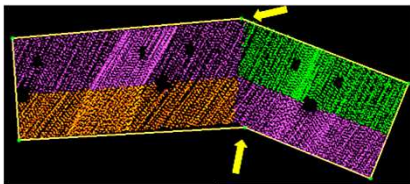
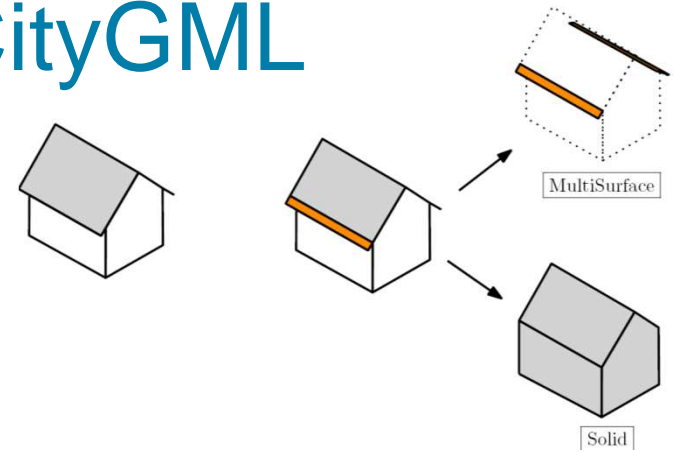
- We have a national 3D standard
- But not a country wide implementation
- 2nd phase of 3D Pilot developed implementation tools for IMGeo-CityGML (Sept 2011- Dec 2012)





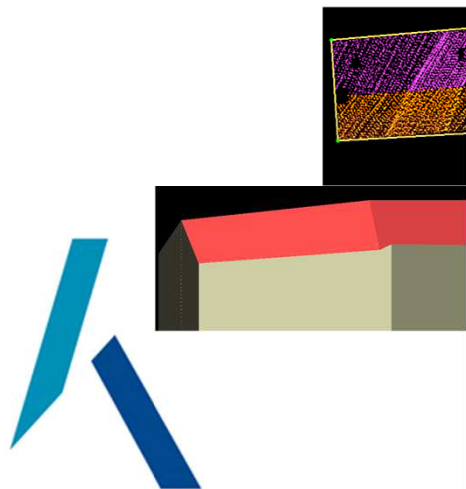
# 1. Specifications on 3D IMGeo-CityGML implementation

- To be used in tendering documents
  - “I want LOD2” is not enough
- Assures that CityGML specs are applied in same way, in situations where specs allow freedom
- Not only buildings
- Contains ~ 40 requirements
- Can also be used as explanation for newcomers



# 1. Specifica implementa

- To be us
- “I w
- Assures
- way, in s
- Not only
- Contains
- Can also



## Technical specifications for the reconstruction of 3D IMGeo CityGML data

### Authors:

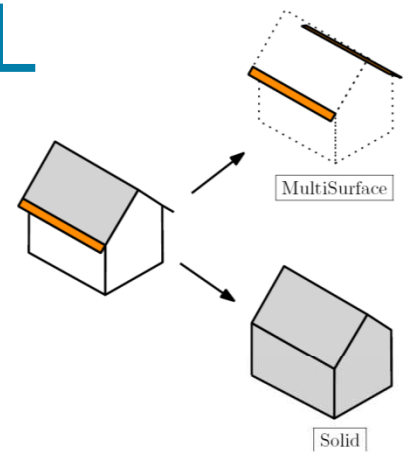
Jan Blaauboer, Bentley  
Joris Goos, Rotterdam Council  
Hugo Ledoux, TU Delft  
Friso Penninga, Den Haag Council  
Marcel Reuvers, Geonovum  
Jantien Stoter, Kadaster, Geonovum & TU Delft  
George Vosselman, NCG & ITC, U Twente

Date:  
8 January 2013

Version:  
1.01

Translated into English

Has led to submitted change requests



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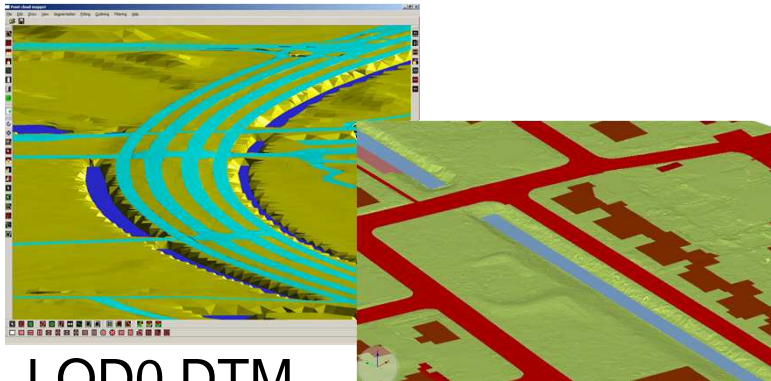
## 2. Example 3D IMGeo data

- Objectives:
  - Provides insight into standard & implementation specifications
  - Test data for software developers



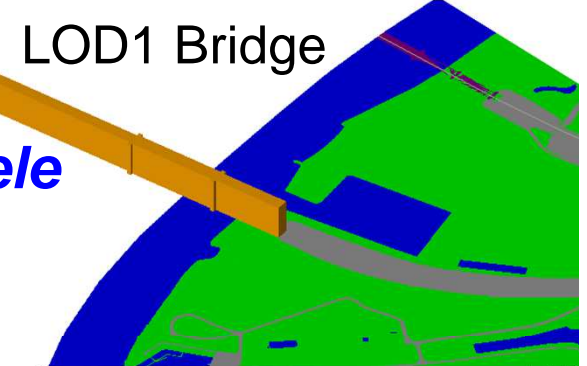
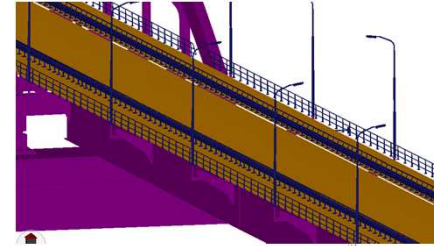
# Example data

*Structured in CityGML by Dr Karl Heinz Heafele*

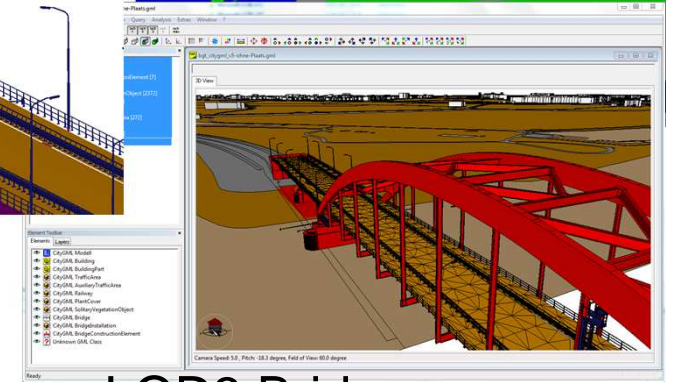


LOD0 DTM

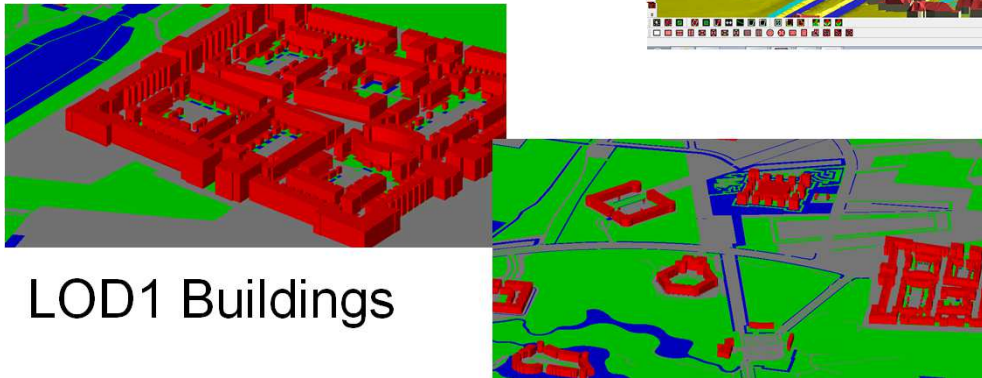
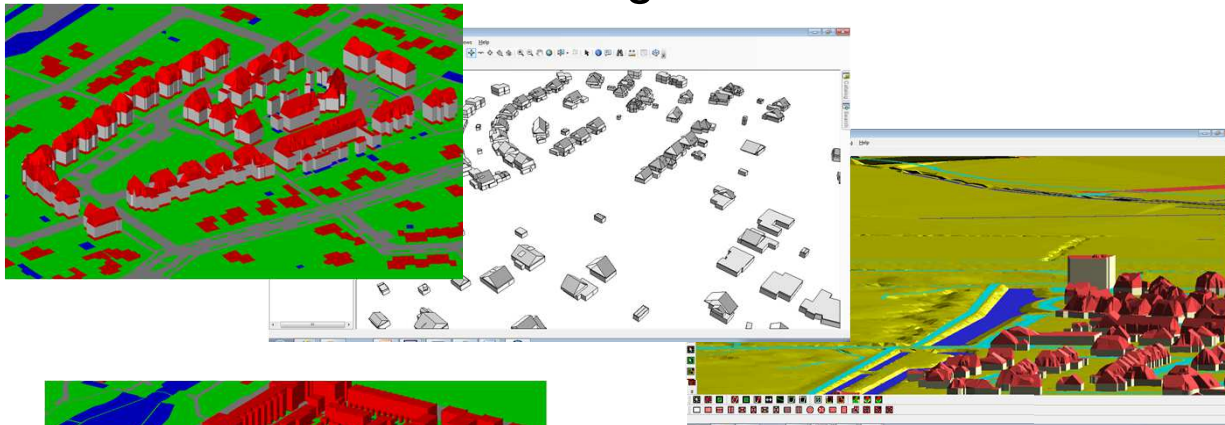
LOD2 Bridge



LOD3 Bridge

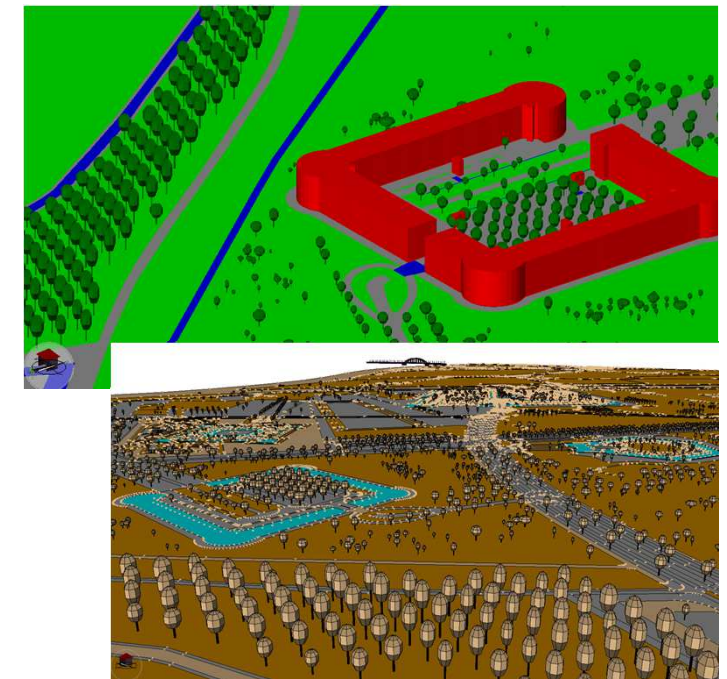


LOD2 Buildings



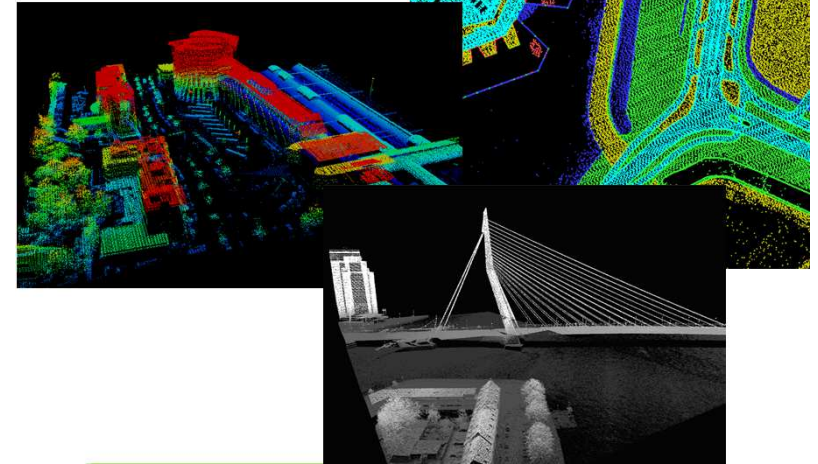
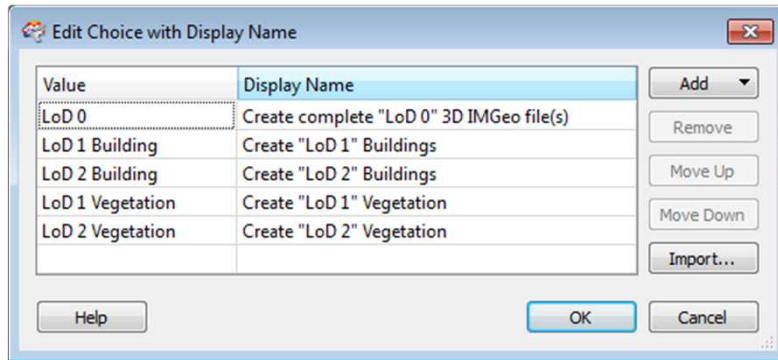
LOD1 Buildings

LOD2 Trees





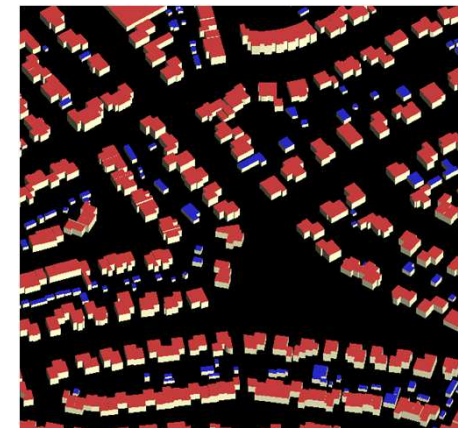
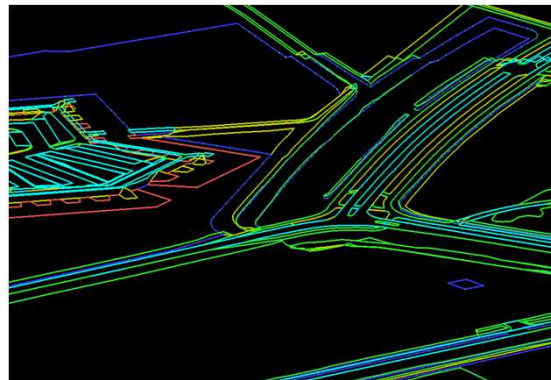
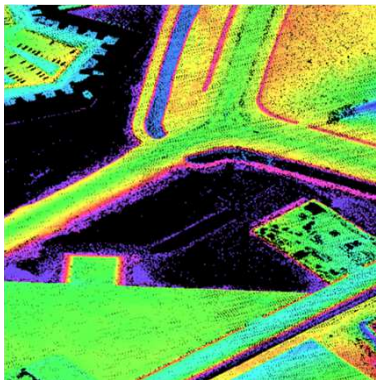
# FME Workbench, developed by Christian Dahmen, Con terra



Read, validate and  
combine IMGeo +  
Lidar data  
Process Control

3D IMGeo  
reconstruction tools  
U Twente/Open  
Source

Adding coloring,  
semantics  
CityGML output





# FME

- Workbench and functionality to generate LOD0/LOD1/LOD2 from 2D + Lidar might be included in FME software
- Discussed during FME days, Berlin, earlier this week



# 3. 3D Validator; validates according to ISO19107 and GML (by Hugo Ledoux & Junqiao (John) Zhao TU Delft)



Error report in GML

**Error messages:**

**Points:**

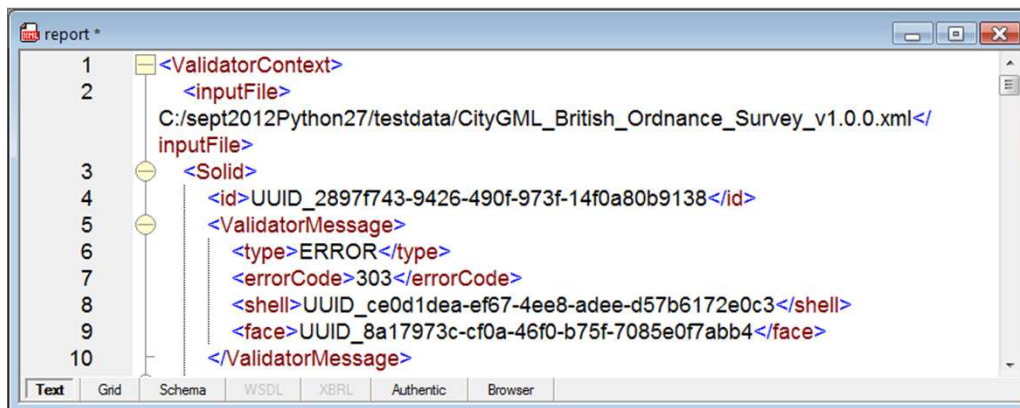
**Lines:**

**Faces:**

**Shells:**

100: 'DUPLICATE\_POINTS',  
110: 'RING\_NOT\_CLOSED',  
200: 'INNER\_RING\_WRONG\_ORIENTATION',  
210: 'NON\_PLANAR\_SURFACE',  
220: 'SURFACE\_PROJECTION\_INVALID',  
221: 'INNER\_RING\_INTERSECTS\_OUTER',  
222: 'INNER\_RING\_OUTSIDE\_OUTER',  
223: 'INNER\_OUTER\_RINGS\_INTERSECT',  
224: 'INTERIOR\_OF\_RING\_NOT\_CONNECTED',  
300: 'NOT\_VALID\_2\_MANIFOLD',  
301: 'SURFACE\_NOT\_CLOSED',  
302: 'DANGLING\_FACES',  
303: 'FACE\_ORIENTATION\_INCORRECT\_EDGE\_USAGE',  
304: 'FREE\_FACES',  
305: 'SURFACE\_SELF\_INTERSECTS',  
306: 'VERTICES\_NOT\_USED',  
310: 'SURFACE\_NORMALS\_BAD\_ORIENTATION',  
400: 'SHELLS\_FACE\_ADJACENT',  
410: 'SHELL\_INTERIOR\_INTERSECT',  
420: 'INNER\_SHELL\_OUTSIDE\_OUTER',  
430: 'INTERIOR\_OF\_SHELL\_NOT\_CONNECTED',

Error report in XML

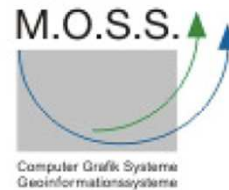


# 3D Validator (Open Source)

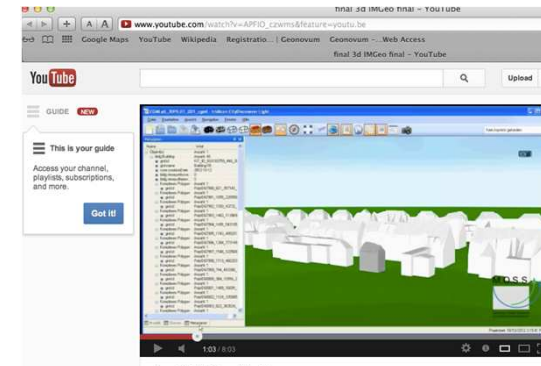
- Matured during our many experiences
- Request to start interoperability experiment (within 3DIM ?), preferably with other available 3D validator (Prof Volker Coors, Stuttgart)
- Also automatically repair (developed by John Junqiao (John) Zhao TU Delft)



## 4. Update and maintenance of 3D IMGeo



- 3D IMGeo CityGML contest: to show support of private industry for CityGML AND our ADE
- Results available at:  
<http://www.youtube.com/watch?v=U0UBNrAr-j0&feature=youtu.be>



Toolkit voor 3D IMGeo | Geonovum

www.geonovum.nl/3D/toolkit

Google Maps YouTube Wikipedia Toolkit voo... Geonovum Mijn gegeve... Geonovum bitly | your bitmarks 3D SIG NL, 3.

Toolkit voor 3D IMGeo | Geonovum

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TOOLKIT VOOR 3D IMGEO

View Bewerken

De implementatie tools voor 3D IMGeo

Hier vindt u de tools, documenten en technieken van 3D Pilot fase II om 2D BGT op te werken naar verschillende 3D detailniveaus. Wij nodigen u van harte uit met dit materiaal aan de slag te gaan. Bij vragen kunt u contact opnemen met [Jantien Stoter](#).

**1a. Handreiking met keuzes voor de aanbesteding van opbouw van 3D IMGeo data**

- > [Rapport "Technische specificaties voor de opbouw van 3D IMGeo-CityGML"](#)
- > [Technical specifications for the reconstruction of 3D IMGeo CityGML data \(English\)](#)

**1b. FME Work Bench for automatically reconstructing 3D IMGeo-CityGML data based on 2D IMGeo and AHN2**

Voor meer uitleg, zie ook de [presentaties rond de oplevering van de FME Workbench](#) tijdens de kick off van de 3D SIG NL op 9 april 2013

**Important: First read the guidelines (Handleiding)!**

- > [Handleiding \(Guidelines\)](#) (in English)
- > [FME Workbench and 3D IMGeo tools](#)

If you are going to experiment with the FME Workbench, please join the 3D IMGeo workflow working group. Subscription via [Jantien Stoter](#).

- > Picture of [FME Workbench I](#): 3D data reconstruction with AHN2 and 2D BGT
- > Picture of [FME Workbench II](#): Producing 3D IMGeo-CityGML output
- > Testdata for FME workflow:
  - [2D IMGeo 2.1 Den Bosch data set](#)
  - [AHN2 test data Den Bosch](#) (for login details, contact [Jantien Stoter](#))

**2. Voorbeeld data 3D IMGeo**

Op dit moment wordt nog gewerkt aan zowel een FME workbench als een open source workflow om op basis van BGT/BAG en AHN2 automatisch een 3D IMGeo data set te reconstrueren. Deze software zal voorjaar 2013 beschikbaar komen.

[2D IMGeo](#)  
[LOD0 DTM](#) (terrein-representaties voor alle IMGeo-vlak objecten)  
[LOD1 gebouwen](#)  
[LOD1 brug](#)  
[LOD2 gebouwen](#)  
[LOD2 bomen](#)  
[LOD3 brug](#)

[Rapport van de voorbeelddata](#)

**3. 3D Validator**

[3D Validatorsoftware](#)  
[Rapport](#)

**4. Uitleg over het beheer van 3D IMGeo data**

[Rapport](#)  
[Films relay](#)

**5. 3D Toepassingen ter inspiratie**

[Website](#)  
[Rapport](#)

**6. Gebruik van informatie uit de design- en constructiefase (BIM) bij 3D Geo Informatie**

De [sneekursus IFC voor beginners](#), gehouden op 15 januari 2012.



# Our experiences with CityGML for hamonisation with 2D

- Linking to 2D makes 3D feasible
- A national 3D standard provides solid base for developments
- Our ADE is supported by software
- Not easy to structure data according to CityGML
- Problems are met by users who only want to use 2D:
  - Multiplicity of attributes are inherited from CityML classes (function/usage)
  - Geometry not as attribute



# Ongoing activities: National 3D SIG

- 3D Pilot -> 3D SIG: to address open 3D issues with the stakeholders:
  - Further implementation of 3D IMGeo
  - Active link to OGC SWG CityGML/ SIG3D
  - Integration with other domains (BIM, underground)
  - Extension 3D in other domains (spatial planning)



# Ongoing initiatives on international level: 3D SIG EuroSDR



- EuroSDR/OGC workshop: CityGML for national mapping, January 2013, IGN, France
  - <http://www.geonovum.nl/content/programme-workshop-national-mapping>
- EuroSDR will employ structural/long term approach to study 3D issues
- Start a 3D interest group:
  - define (and execute) common research topics
  - design implementation profiles for CityGML
- Active NMAs: Swisstopo, Ordnance Survey, Kadaster

## Change requests from Dutch experiences

- **To be voted on for v3.x**
  - 11-101\_Clearer\_guidelines\_for\_extending\_CityGML, presented by Linda
  - **11-102\_LOD0\_footprints\_for\_all\_CityGML\_classes**
  - 11-104\_Additional\_class\_for\_constructions\_other\_than\_buildings, presented by Linda and Marie-Lise
- **Pending**
  - **13-025 Allow LOD0 footprints that will be determined by the connection of the terrain and the building**
  - **13-028 Enforce LOD1 and LOD2 buildings to be Solid**
- **Accepted for 2.0**
  - 11-103 Add land cover information

## Change requests

- **11-102: LOD0 footprints for all CityGML classes**
- 13-025 Allow non-horizontal LOD0 footprints
- 13-028 Enforce LOD1 and LOD2 buildings to be Solid.



## CR 11-02: LOD0 footprints for all CityGML classes

- Examples:
  - Transportation objects
  - SolitaryVegetationObject and PlantCover
  - CityFurniture
- to integrate full range of possible geometries of semantic objects in one model, i.e. 2D, 2.5D and volumetric geometries.
- Required for harmonisation with 2D models
- Extends topological rule currently defined for Land Use:
  - *LandUse* objects can be employed to establish a coherent geometric/semantical tessellation of the earth's surface.

Class LandUse should be limited to those objects which do not represent the other classes, such as water, road, railway, vegetation

### C.5 LandUse module

#### Code list of the *LandUse* attribute class

[http://www.sig3d.org/codelists/standard/landuse/2.0/LandUse\\_class.xml](http://www.sig3d.org/codelists/standard/landuse/2.0/LandUse_class.xml)

1000	Settlement Area	3000	Vegetation
1100	Undeveloped Area	4000	Water
2000	Traffic		

#### Code list of the *LandUse* attributes *function* and *usage*

[http://www.sig3d.org/codelists/standard/landuse/2.0/LandUse\\_function.xml](http://www.sig3d.org/codelists/standard/landuse/2.0/LandUse_function.xml)

[http://www.sig3d.org/codelists/standard/landuse/2.0/LandUse\\_usage.xml](http://www.sig3d.org/codelists/standard/landuse/2.0/LandUse_usage.xml)

1010	Residential	2050	Track
1020	Industry and Business	2060	Square
1030	Mixed use	3010	Grassland
1040	Special Function Area	3020	Agriculture
1050	Monument	3030	Forest
1060	Dump	3040	Grove
1070	Mining	3050	Heath
1110	Park	3060	Moor
1120	Cemetery	3070	Marsh
1130	Sports, leisure and recreation	3080	Untilled land
1140	Open pit, quarry	4010	River
2010	Road	4020	Standing Waterbody
2020	Railway	4030	Harbour

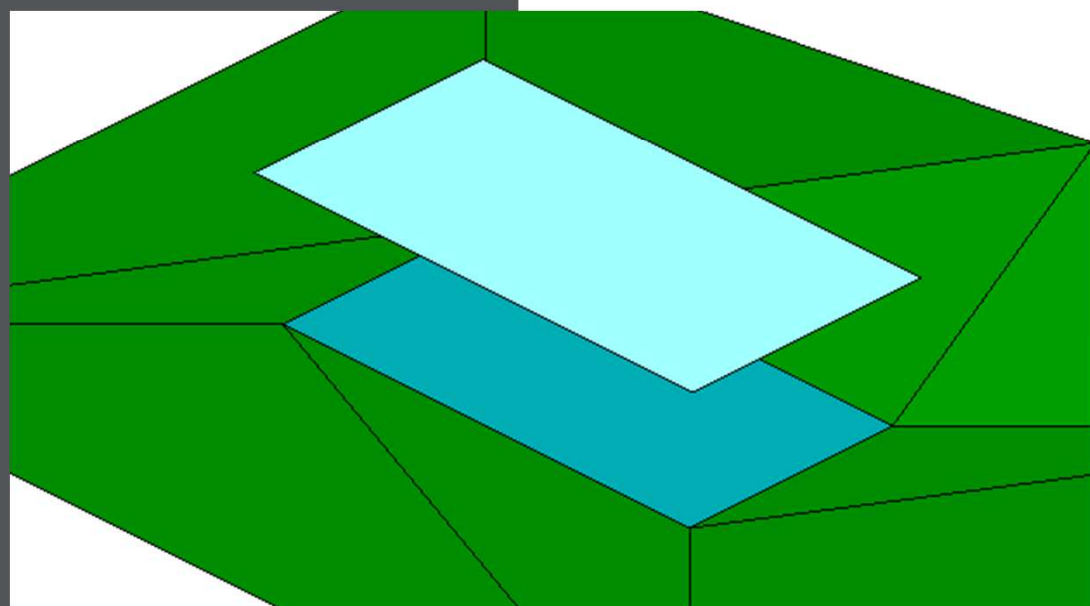
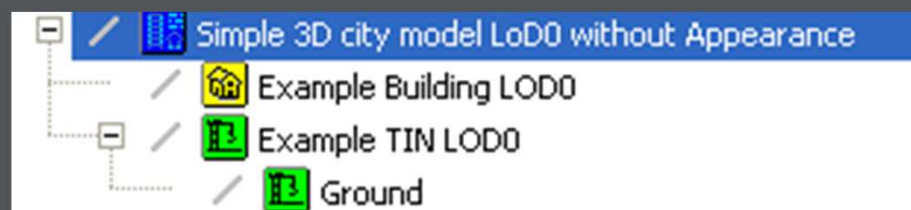
- 11-102: LOD0 footprints for all CityGML classes
- **13-025 Allow non-horizontal LOD0 footprints**
- 13-028 Enforce LOD1 and LOD2 buildings to be Solid, because a solid is the only way a building can be represented as a volume.

## 13-025 Allow non-horizontal LOD0 footprints

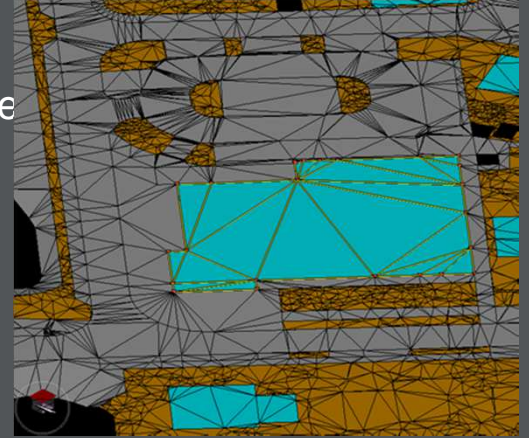
- determined by the connection of the terrain and the building

Currently:"

- height values of all vertices belonging to the same footprint are identical.
- typically located at the lowest elevation of the ground surface of the building
- polygon defining the ground plate (*GroundSurface, LOD2*) is congruent with the building's footprint."



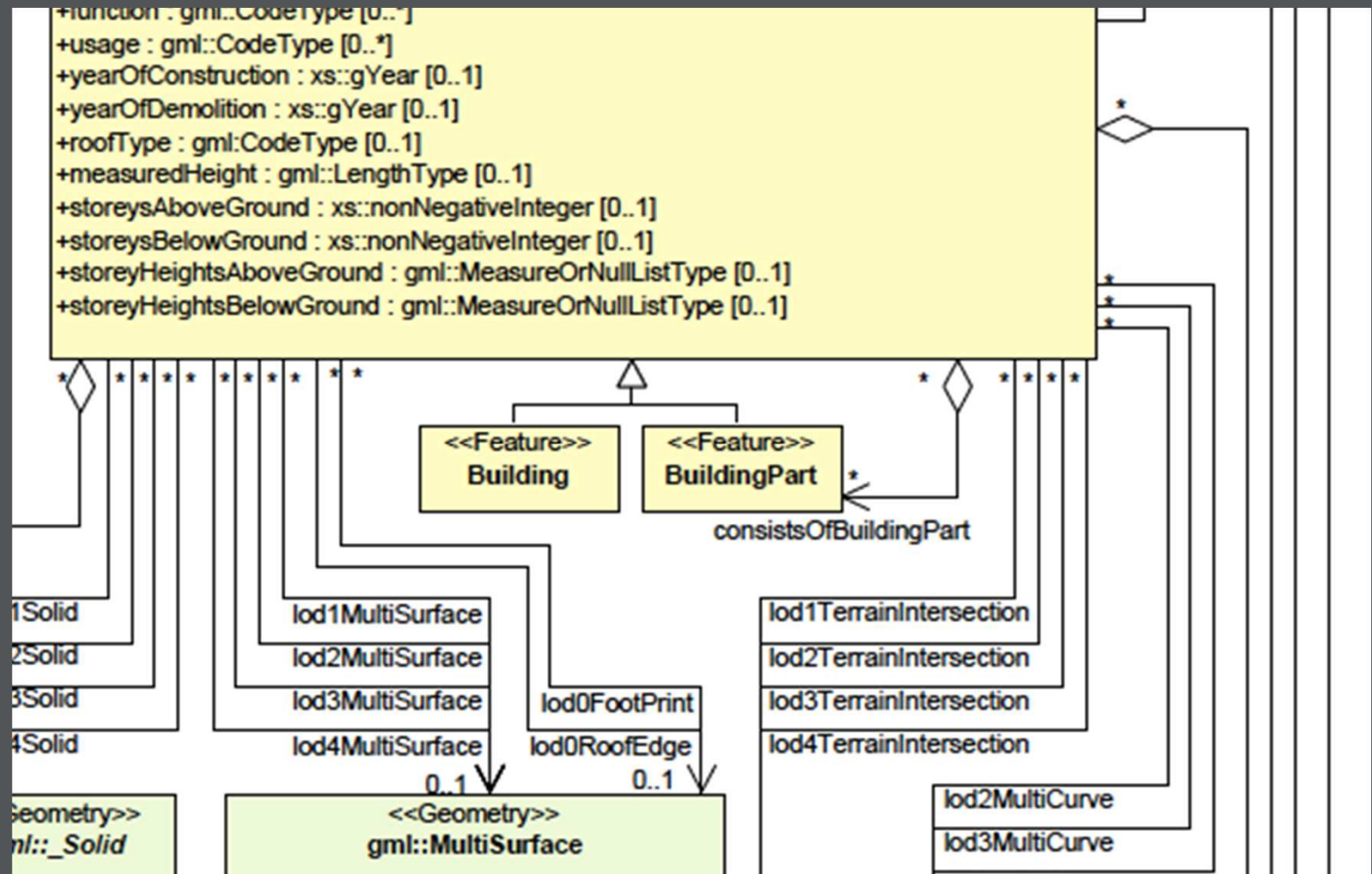




## Our issues

- LOD0 is collection of (surface) objects represented by triangulatedSurface.
- Footprints are represented in this terrain
- If not: houses on dikes/hills, need (almost) vertical surfaces to connect the horizontal surface to the surrounding terrain
- Lot of software cannot work with them
- If two of such houses meet at a vertex, the shared vertex should ideally not have two different heights; not possible if horizontal is required
- Roofedge similar issues are expected

## Or allow LOD0 representation for Buildings



- 11-102: LOD0 footprints for all CityGML classes
- 13-025 Allow non-horizontal LOD0 footprint
- **13-028 Enforce LOD1 and LOD2 buildings to be Solid**

## **13-028: All surfaces of LOD1/LOD2 building should form closed volume(s), represented by the GML type Solid**

- CityGML permits buildings to be modelled with the Multisurface type, problems:
  - no topological connection, solid is not explicit
- We propose: If surfaces of a multisurface geometry form a closed entity/whole, a solid (a composite surface) should be formed to enforce a building to be represented as a volume
- For LOD2 a building can be represented by a mixture of a solid and other geometry types for e.g. roof overhang and antennas

# Summarising our wish list:

- Interoperability experiment on 3D validation and automated reparation
- Collaboration with SIG3D/3D SIG NL/ EuroSDR
- Considerations to better harmonise with 2D:
  - 11-102: LOD0 footprints for all CityGML classes
  - 13-025: Allow non-horizontal LOD0 footprint
  - 13-028: Enforce LOD1 and LOD2 buildings as solid
  - Modelling method ADE in standard
  - Add class Other construction
  - Address issues if one only wants to work with the ADE



# More information

- STOTER J., VOSSELMAN, G., GOOS, J., ZLATANOVA, S., VERBREE, E., KLOOSTER, R. REUVERS, M., 2011: Towards a National 3D Spatial Data Infrastructure: Case of The Netherlands. PFG Photogrammetrie, Fernerkundung, Geoinformation, 2011(6): 405-420.
- Jantien Stoter, Linda van den brink, Jakob Beetz, Hugo Ledoux, Marcel Reuvers, Rick Klooster, Paul Janssen, Friso Penninga, George Vosselman, Establishing and implementing a national 3D standard, Journal for Photogrammetry and Geoinformation (PFG), In press
- Van den Brink, L., Jantien Stoter, Sisi Zlatanova, 2013, UML-Based Approach to Developing a CityGML Application Domain Extension, Transactions in GIS, Article first published online: 22 May 2013 DOI: 10.1111/tgis.12026
- VAN DEN BRINK L., J.E. STOTER, S. ZLATANOVA, 2012: Establishing a national standard for 3D topographic data compliant to CityGML, in: International Journal of Geographical Information Science, in press. URL:  
<http://www.tandfonline.com/doi/abs/10.1080/13658816.2012.667105>







Bentley



# Thanks for your attention!

More information:



<http://www.geonovum.nl/3d>



@jantienstoter



Linkedin group **3D SIG NL**

