Integrating LODs from different sources
A practical view on the CityGML LOD concept

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About virtualcitySYSTEMS

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- For over 10 years, virtualcitySYSTEMS has provided GIS services for customers in the private and public sector. GIS consulting, software development, project implementation and systems integration are our core competencies. The company has further distinguished itself by becoming one of the leading experts in 3D spatial data infrastructures based on the OGC standard CityGML, with customers and business partners all over the world.

- **Our mission:** To consistently deliver high quality, end-to-end 2D and 3D GIS solutions by leveraging our experience, technology, Best Practices and strategic partnerships to extend our global reach to offer products and services for the lifecycle management of digital cities.

The CityGML LOD concept

- Excerpt from a tender document for a 3D GIS system (East Asia, 2013)

> 6.9 **Data Modeling Requirements**
>
> 6.9.1 General Requirements
>
> (a) The Supplier shall adopt the OpenGIS CityGML Level of Detail (LOD) specifications for the 3D digital models. See details at http://www.citygml.org/
>
> (b) The Supplier shall adopt at least LOD3 (City/Site models with architectural details) for High quality 3D digital models.
>
> (c) The Supplier shall adopt at least LOD2 (City/Site models with textured, differentiated roof structures) for Low quality 3D digital models.

- **CityGML** itself **is not requested** as data format
  - Autodesk 3ds and FBX, ESRI SHP and GDB, KML/COLLADA

Benefits of the CityGML LOD concept

- **Common understanding** of the distinct levels of detail
  - City models are categorized into LODs
  - Used in tender documents to specify the requirements for data acquisition and modelling
  - Software tools (and vendors) are associated with LODs
  - Applications of city models are associated with LODs
  - → **Strong (market) acceptance**
- Affects both **geometry and semantics**
- **Manageable complexity**
- One of the **most successful** concepts of CityGML





Shortcomings of the CityGML LOD concept

- **No clear separation** between the LODs
  - *Geometry:* **Only recommendations** regarding accuracy and extent
  - *Semantics:* Strict conformance requirements but **no conclusions about semantic richness** can be drawn from a given LOD
- Often **project-specific definitions and extensions**
  - E.g., “LOD 2.5”, “LOD 2 of the city XYZ”
  - Although “LOD x” is requested by clients it is often unclear what has to be delivered
  - As a result, requirements are often over-specified and cannot be met
- Relevance of **LOD4**
  - Inconsistently used in different CityGML modules
  - No (applications for) high-precision LOD4 **city** models in practice so far

Integrating LODs from different data sources

- City models often exist in **multiple LODs** (LOD1 – 3)
  - Different data acquisition methods and processes
  - Different data providers and software tools
- LOD representations are **kept and managed independently**
  - Mostly separate XML files, no central database
  - No linkage between city objects and their LOD representations
- **Integration of the different LOD representations**
  - **Goal:** Analysis, distribution, visualization of the same city object with regard to different degrees of resolution
  - Requested by the owners of the city models

Integrating LODs from different data sources

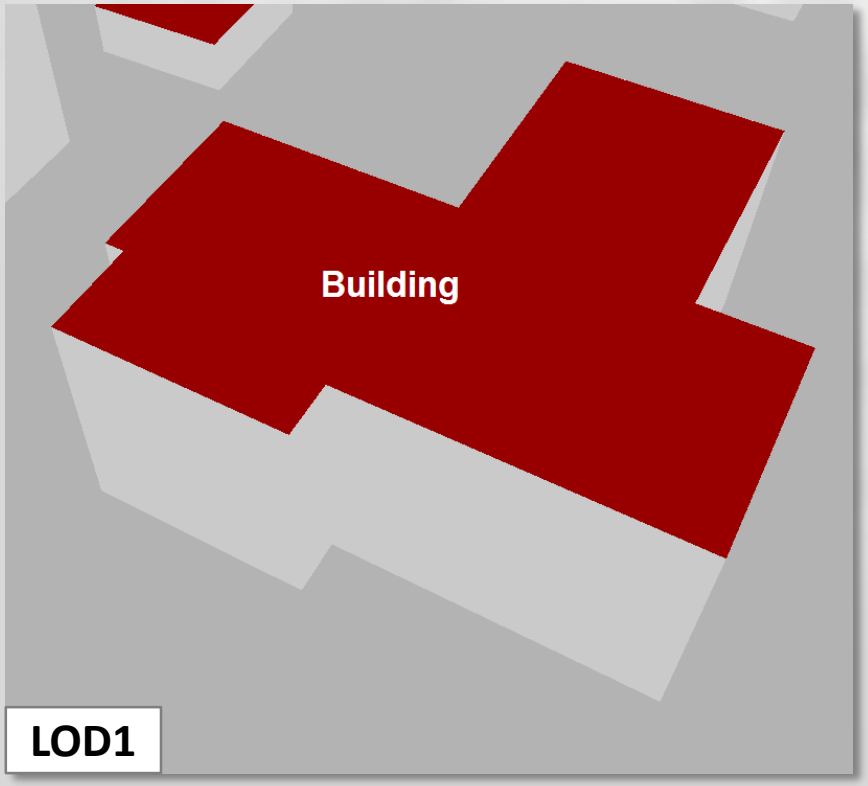
- **CityGML statements** on the integration of different LODs

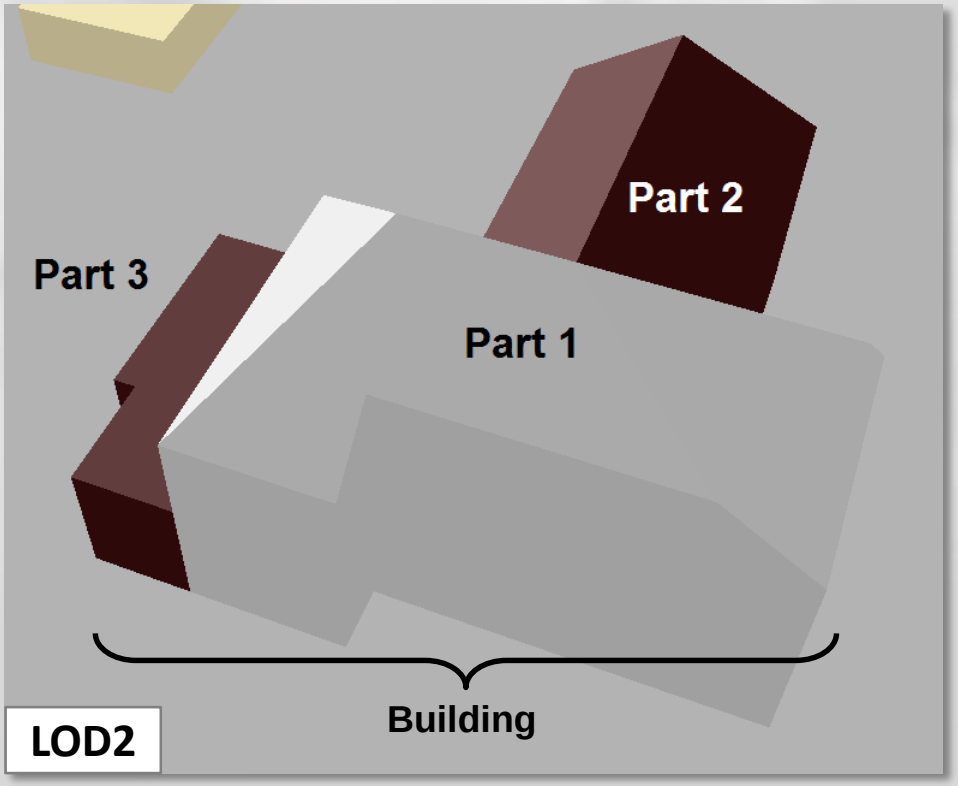
> - "In a CityGML dataset, the **same object** may be represented in **different LODs simultaneously** […]."
> - "Furthermore, **two CityGML data sets** containing the same object in different LODs may **be combined and integrated**."
> - "However, it will be within the responsibility of the user or application to make sure objects in **different LODs refer to the same real-world object**."
>
> *CityGML 2.0, chapter 6.2*

- **Practical issue:** How to identify the same real world object in two or more different data sources?

Integrating LODs from different data sources

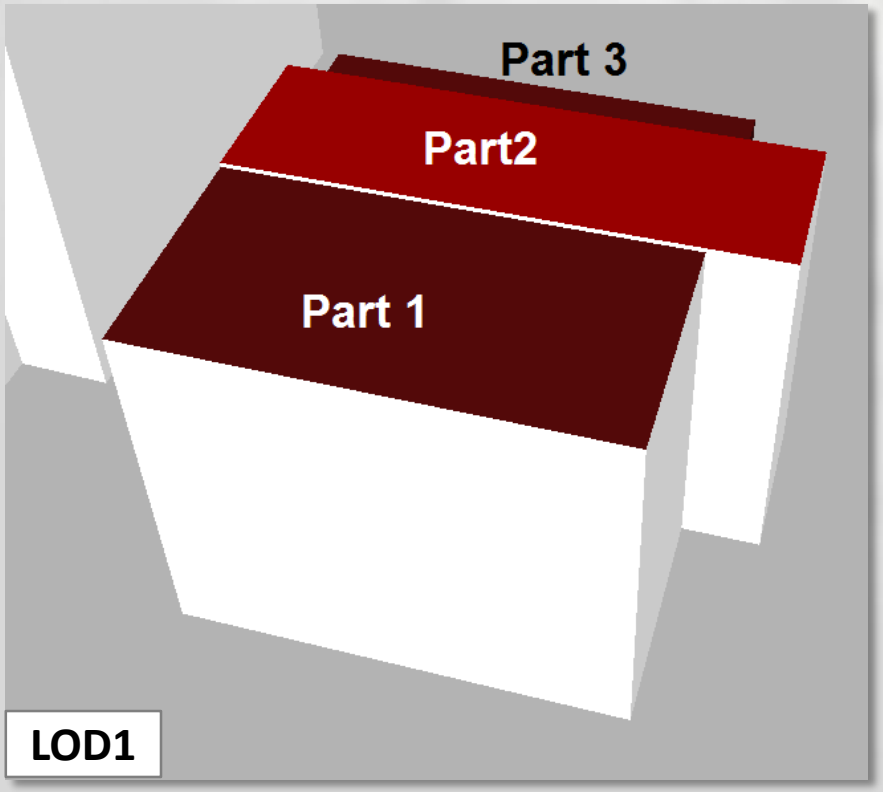
- gml:ids of <Building>s are different
- Integration possible based on spatial checks
- **But:** Inconsistent building decomposition

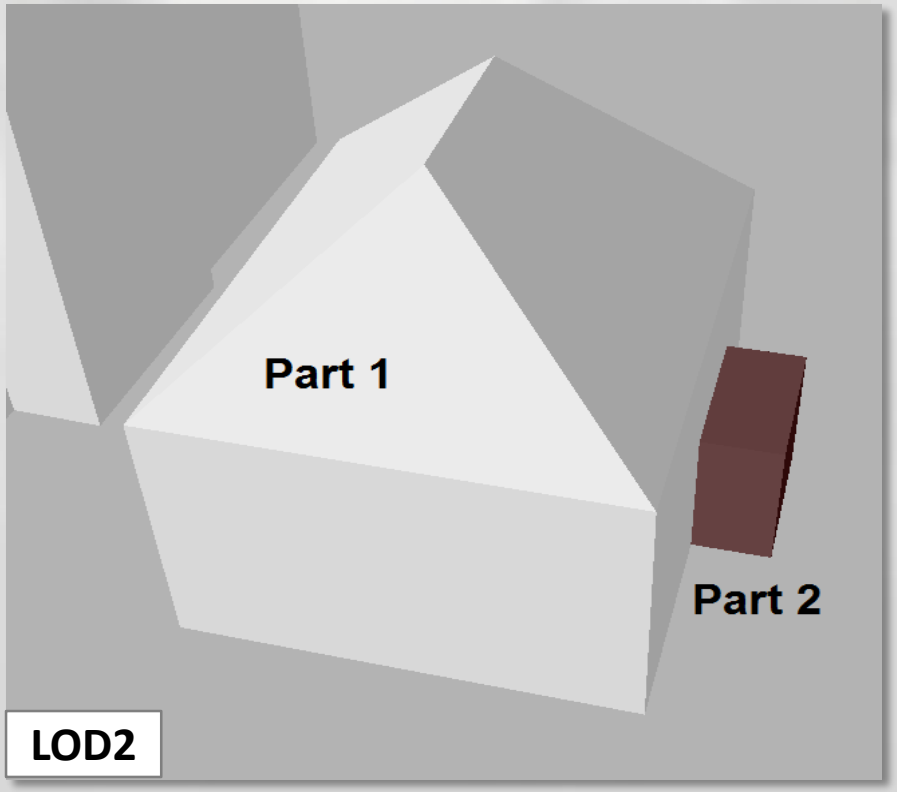




Integrating LODs from different data sources

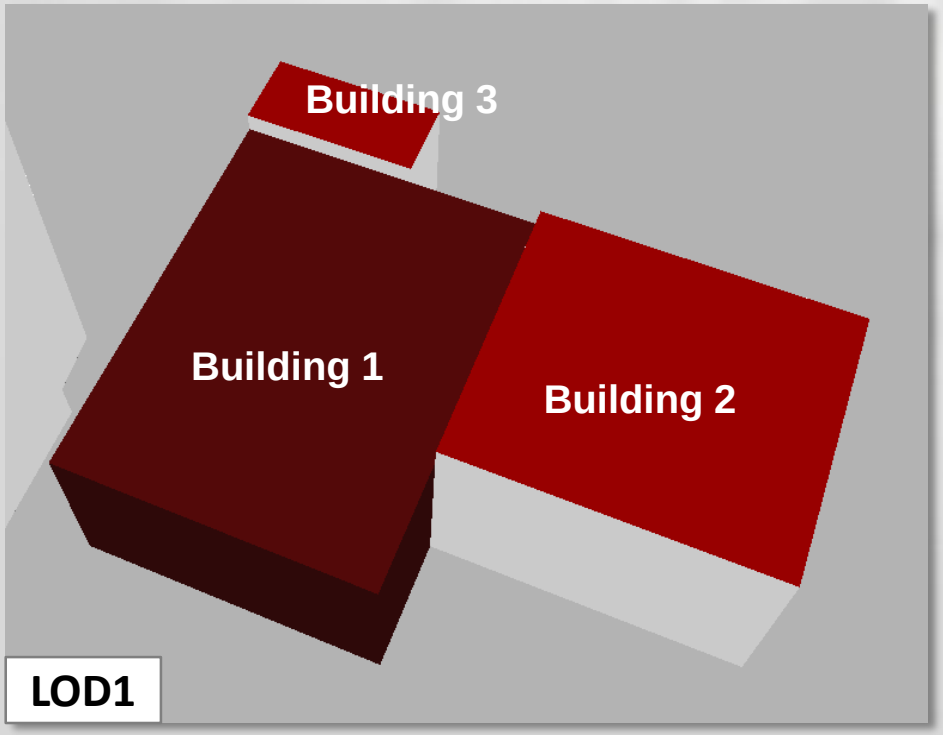
- gml:ids of <Building>s and <BuildingPart>s are different
- Different building decompositions hinder spatial checks
- What is the expected result? Five building parts?

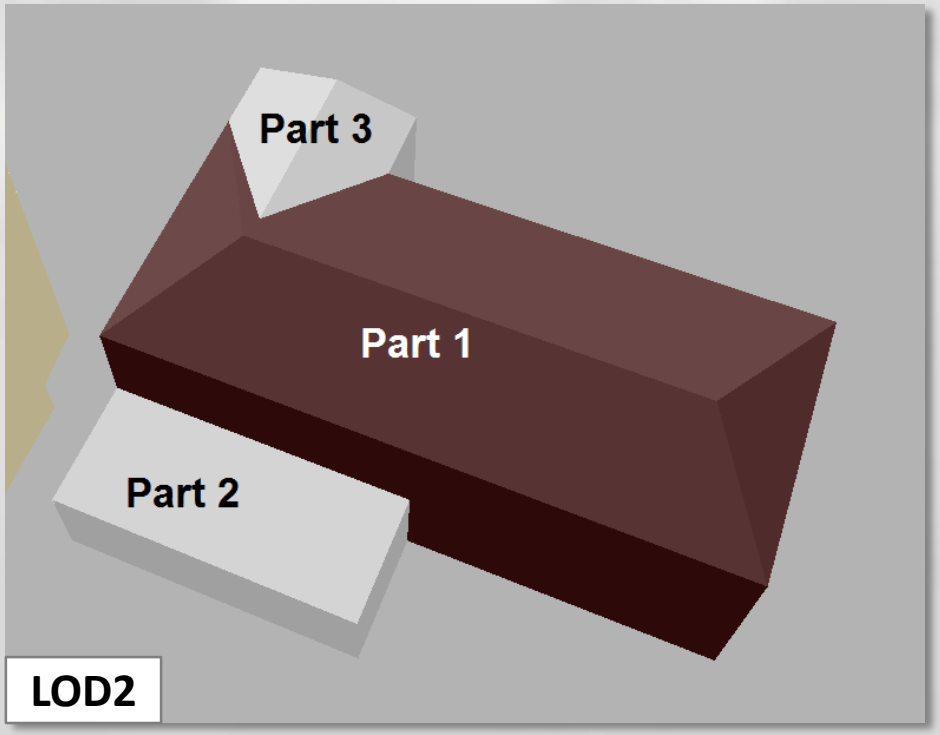




Integrating LODs from different data sources

- The semantic and spatial representations are different…
- … but describe the **same real world object**
- Integration requires changing the semantics





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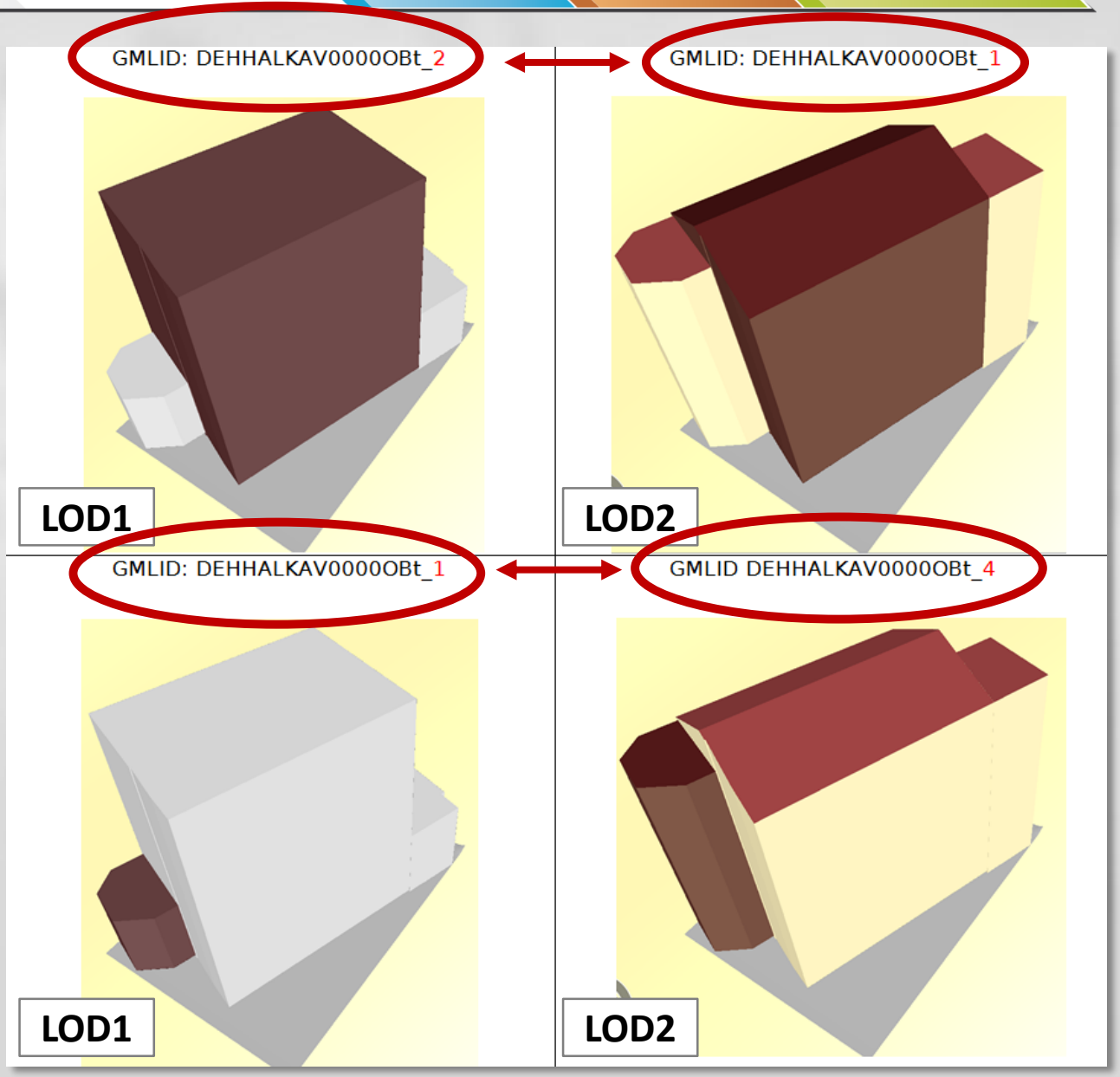
- Identical gml:ids are not necessarily helpful…



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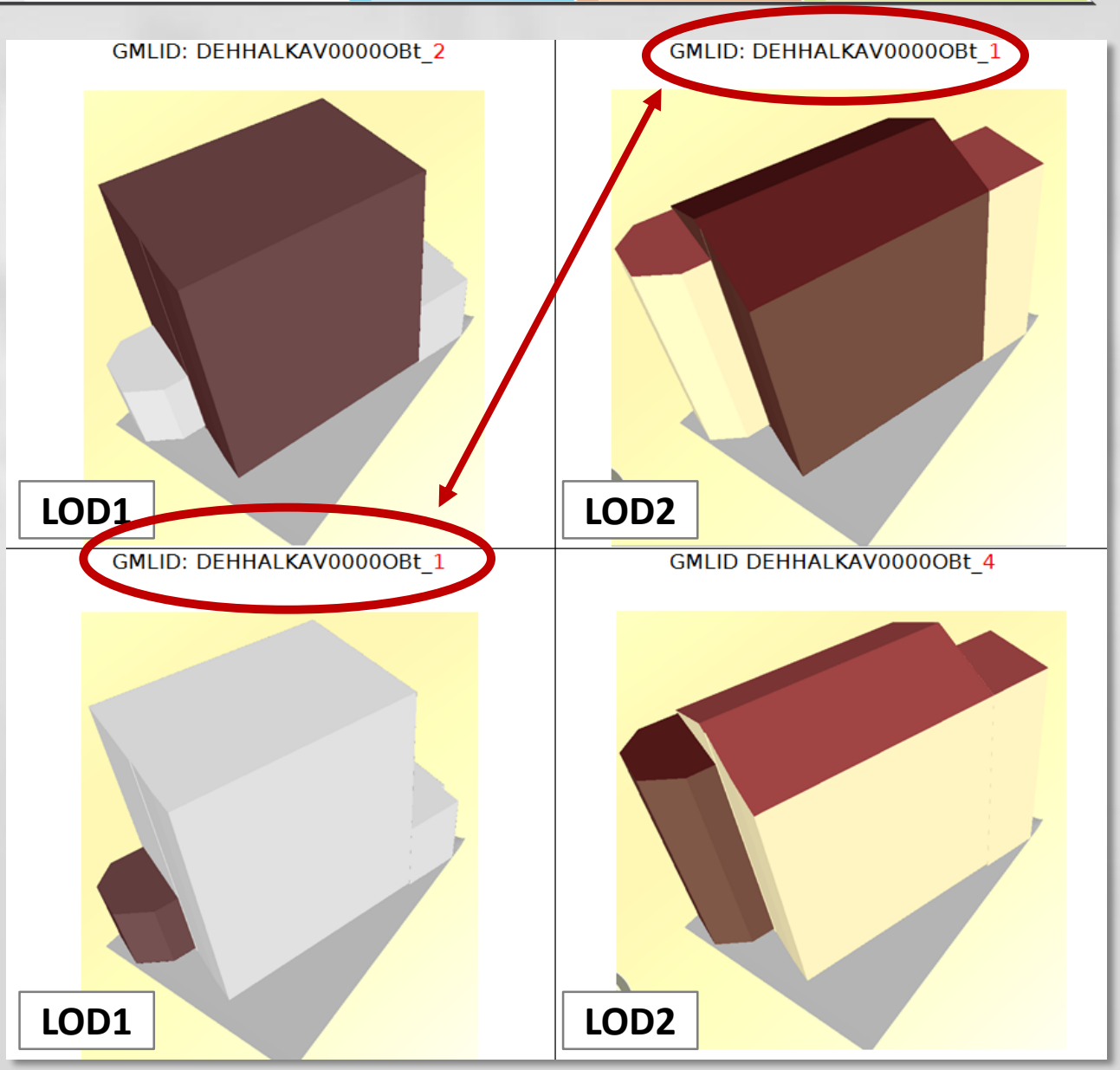
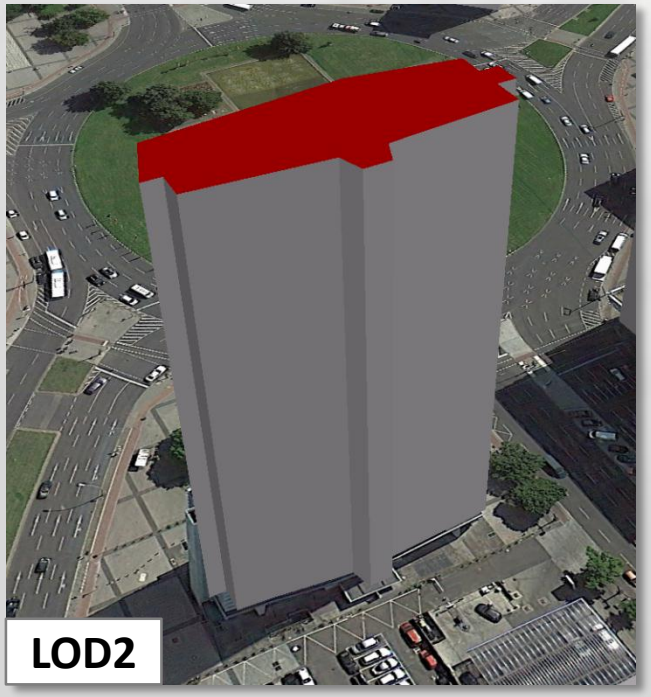
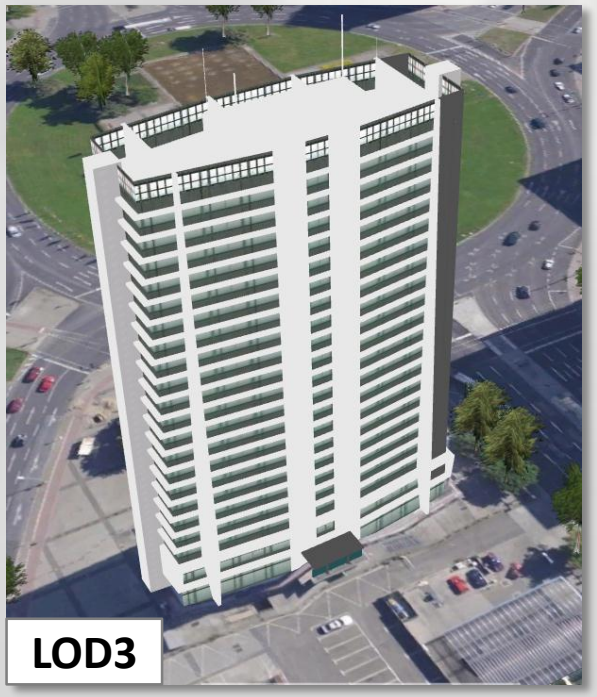


Integrating LODs from different data sources

- LOD integration also affects other CityGML feature types
- **LOD2:** 4 <WallSurface>s with 1 polygon each
- **LOD3:** 1 <WallSurface> with hundreds of polygons
- Now add different decompositions into parts…





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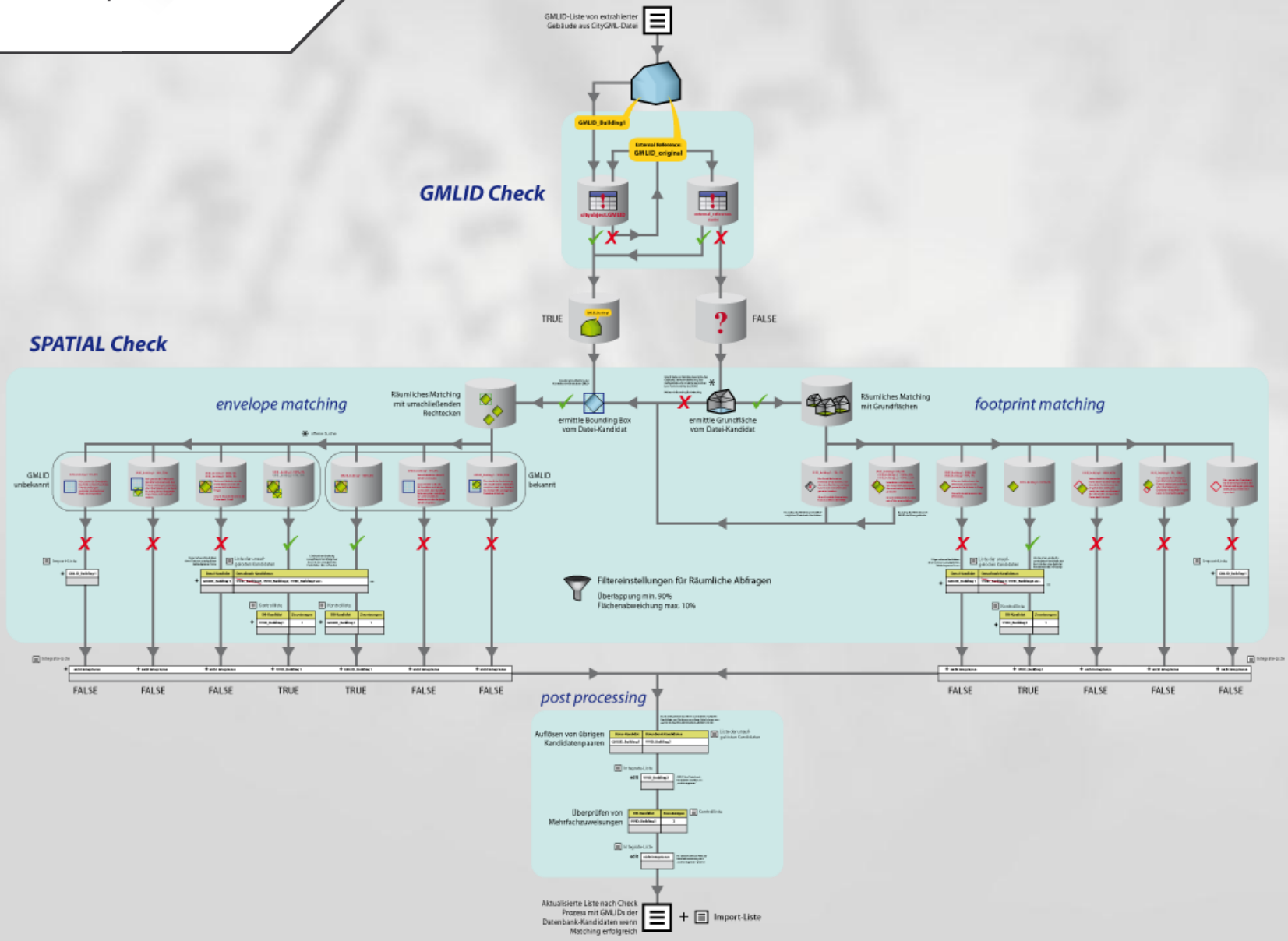

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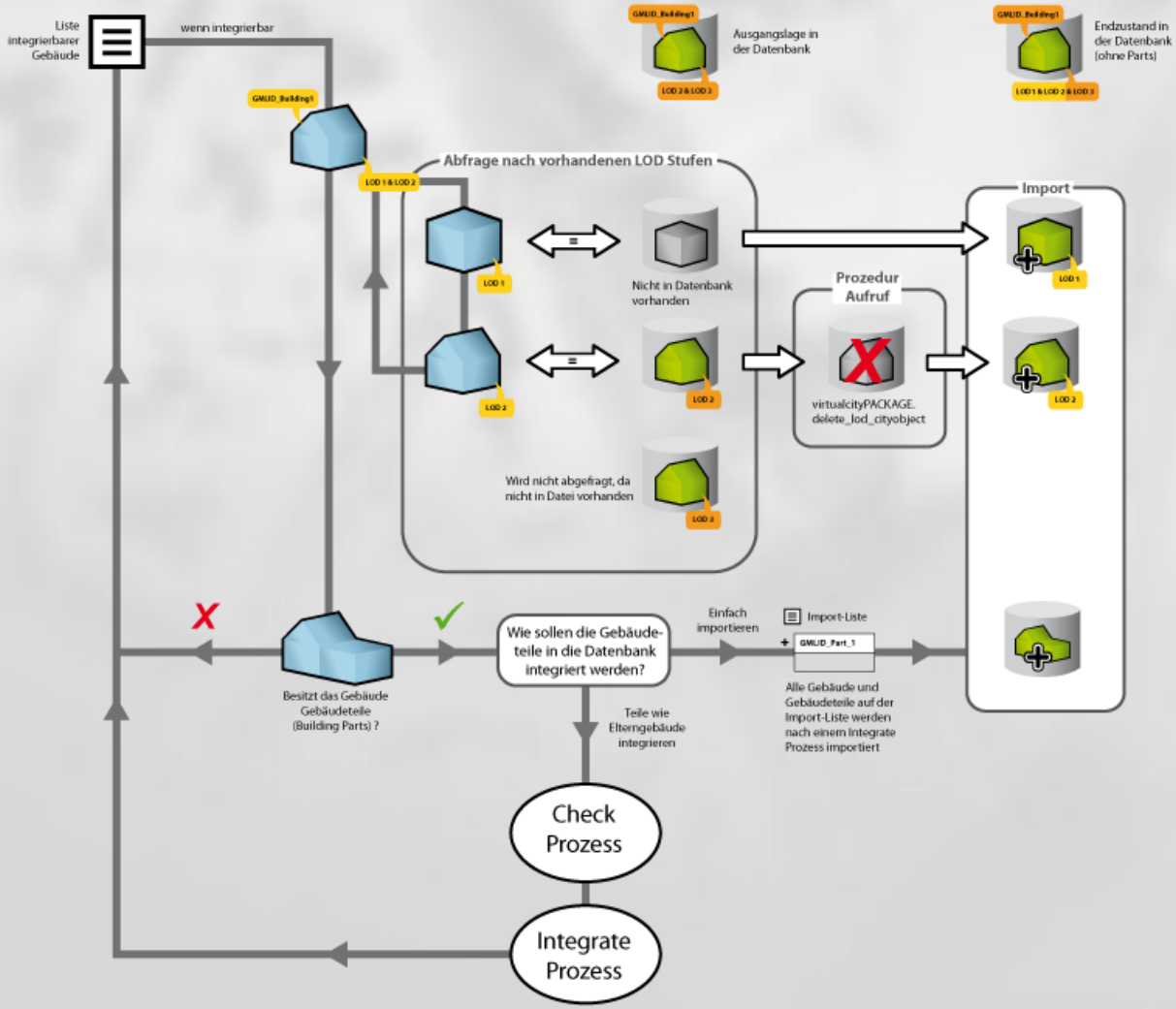

Some thoughts…

- LODs (1 – 3) are **accepted and used** in practice
  - Discussion and evaluation of current LOD concept is necessary
  - But should reflect and be aligned with **market needs**

- **Modelling guidelines** (or **enforcements**) for existing LODs rather than new LODs
  - "However, it will be within the responsibility of the user or application to make sure objects in different LODs refer to the same real-world object."

- **Keep focused** on the essential
  - Improve **interface to 2D** data (LOD0)
  - Improve **interface to BIM**
  - Use CityGML at the urban/regional scale and use BIM at the building scale
    → Redefine LOD4 with this in mind