## Section IV

# CityGML in Detail – Part 2

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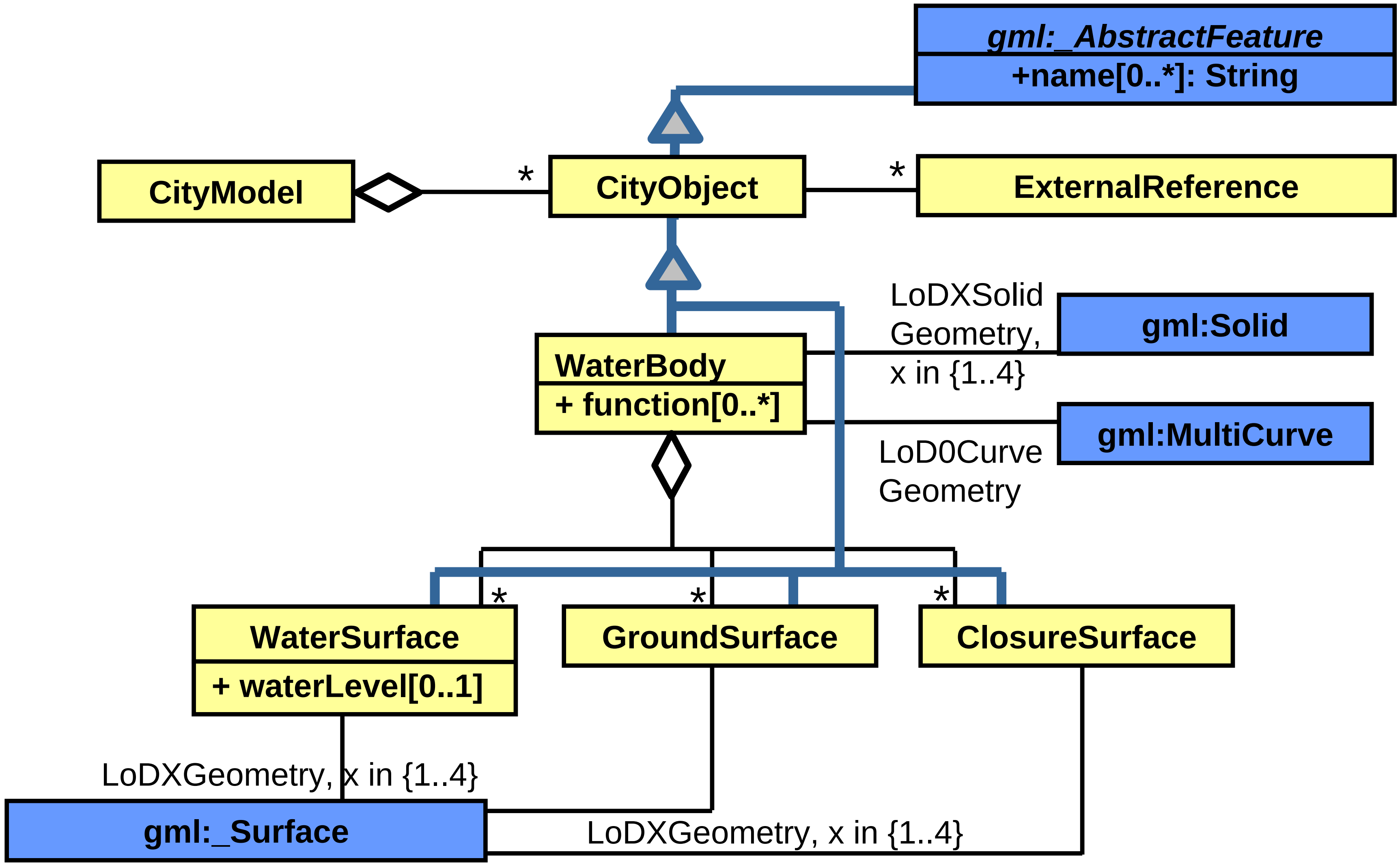
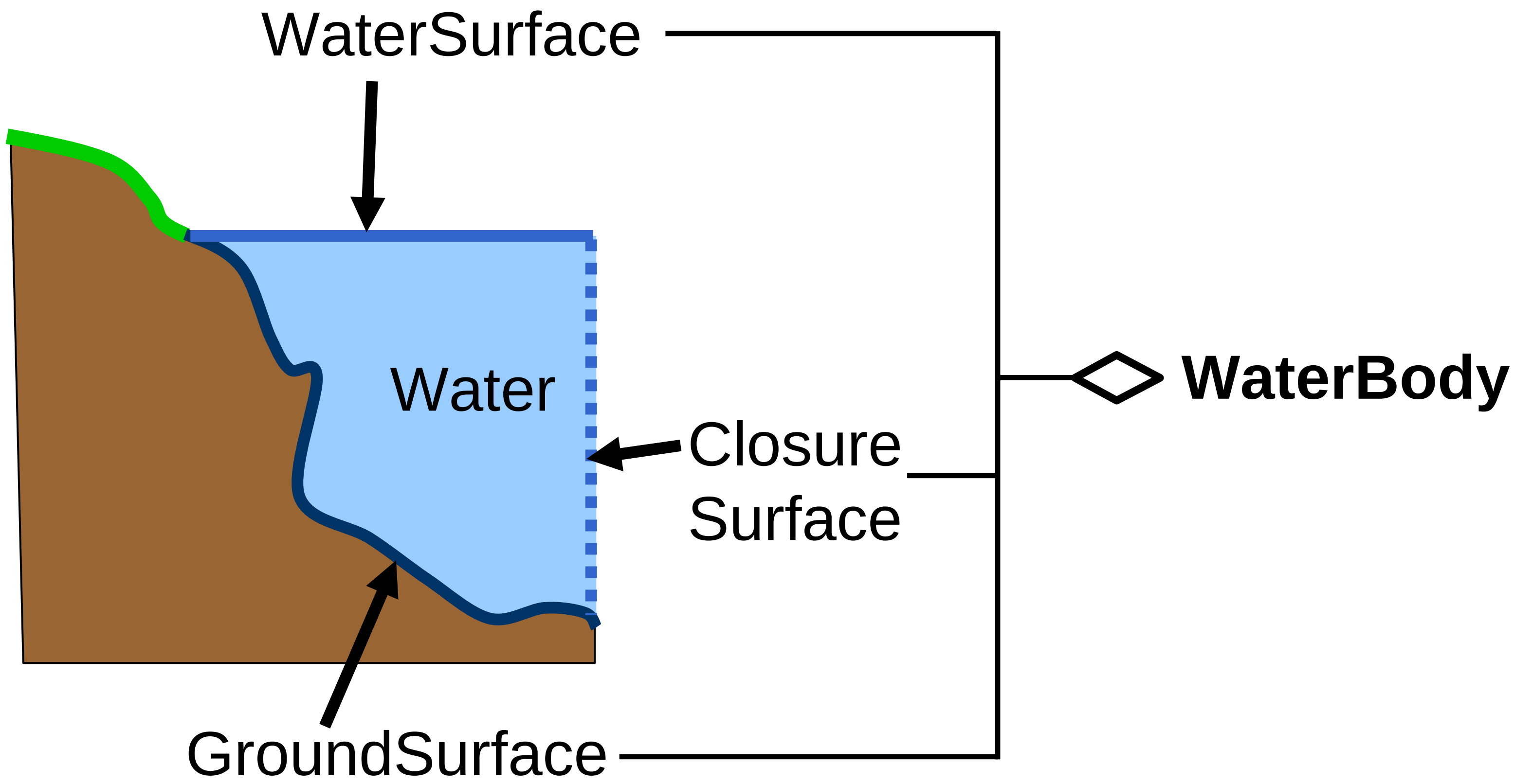
CityGML

# Details

# Water Bodies

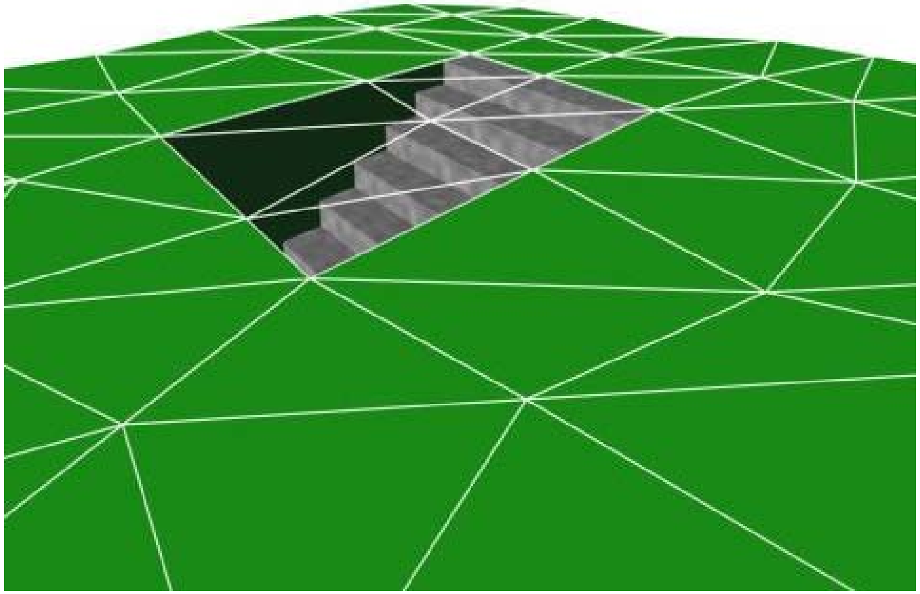


# Illustration of a Water Body



„Seal open 3D objects“

- in order to be able to compute their volumes

Feature type **CityObjectGroup**

- has **arbitrary CityObjects** as members

CityObjectGroup is a CityObject

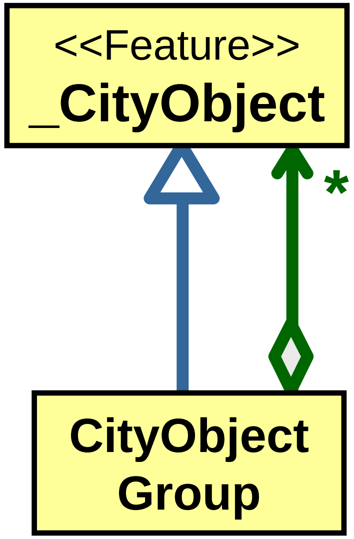
- can become again member of another group
- every member can denote its role in a group

usable for **user-defined aggregations**

- e.g. results of classifications or selection

usable also to **group** CityObjects **wrt.** some **function or area**, e.g.

- city districts, building storeys, or evacuation areas



## Implicit geometries (Prototypic shapes)

- Shape of a 3D object in local coordinates
- Instancing at anchor points (+ further transformations)

## Surface Materials

- Colors, Textures (adopted from X3D & COLLADA)
- Appearance information can be assigned to any surface

Both are concepts used in scene graphs

- directly transformable to VRML, X3D, U3D etc.
- however **only simple & limited extensions**
- tailored to the demand of 3D city models
- easy to support by exporting / importing applications

3D city models often contain large numbers of geoobjects of identical shape but at different locations

- Examples: trees, traffic lights, street lamps, benches, etc.

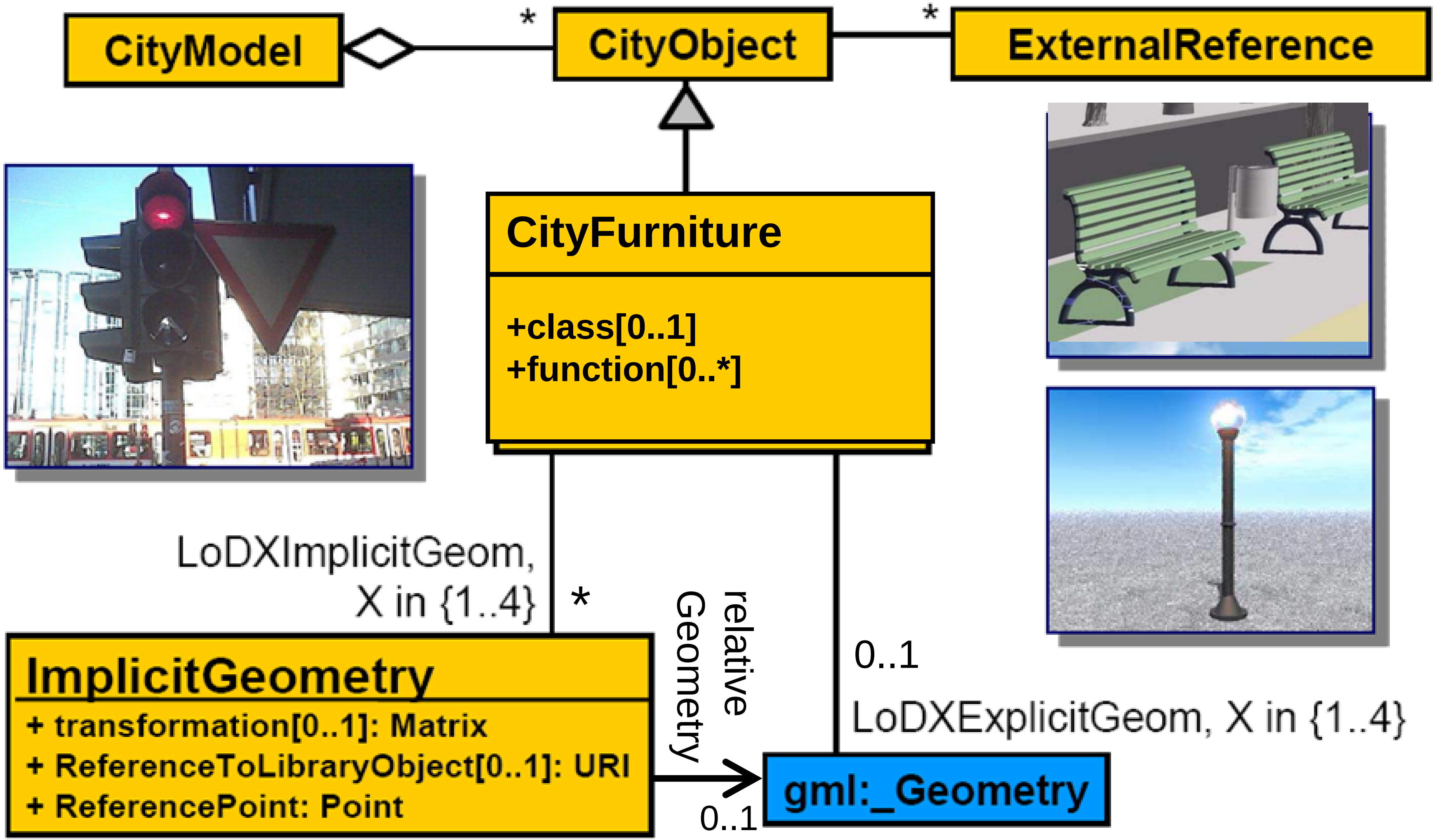
in GML3, all geometries have absolute coordinates

- every copy / instance would have to be explicitly represented

CityGML: **Implicit Geometries**

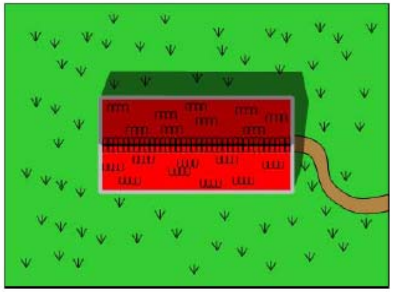
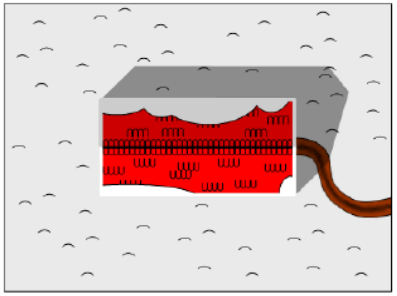
- Separation of shape definition and georeferencing (anchor point + transform.)
- Comparable to scene graph concepts

# City Furniture

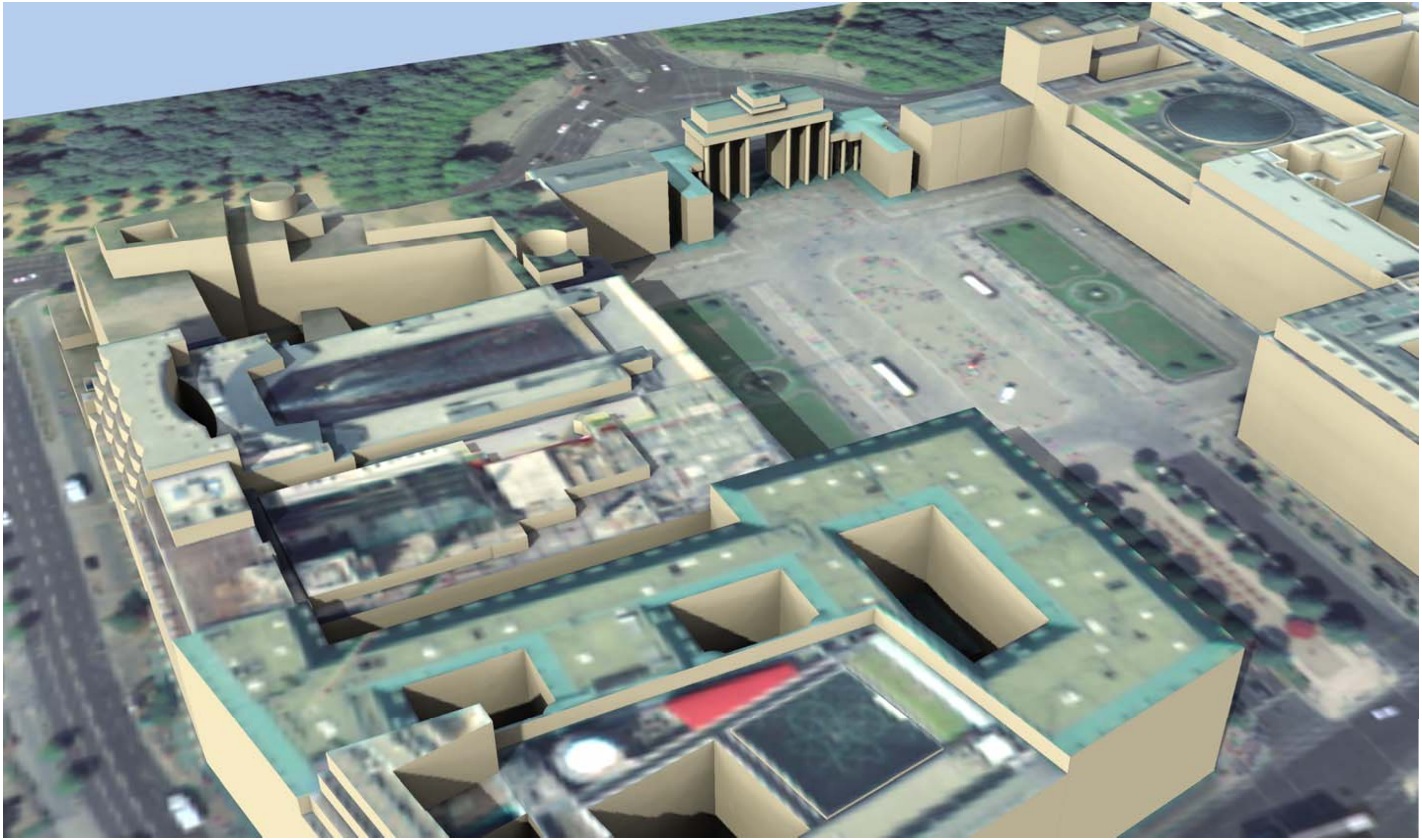


- explicit texture coodinates
- georeferenced textures
- parameterized textures
- material


- multiple appearances per object (~ themes)

# Georeferenced Textures



# Parameterized Textures

Georeferenced Photography:

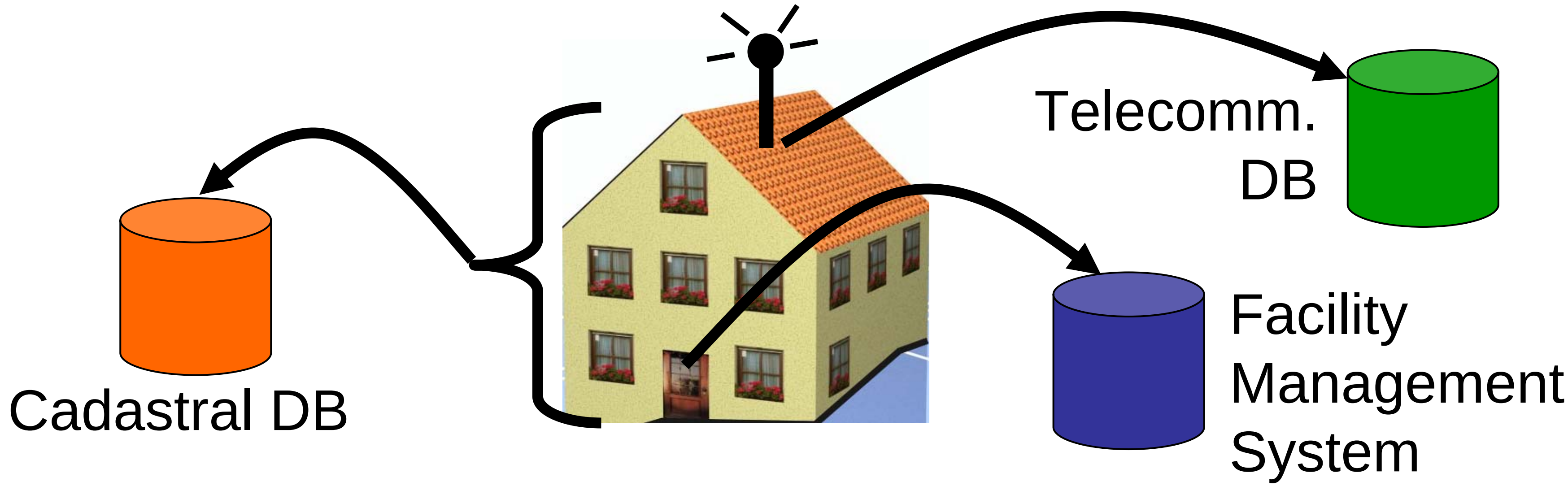
Projected onto 3D surfaces:

using *worldToTexture* parameterization

# Further CityGML Concepts

- Support for **generalization of 3D data**
  - Generalized objects are linked to the original objects on the larger scale
- Object **history**
  - Objects may have a lifespan (creation & termination date)
- Explicit **linking**
  - Every CityGML object can have an arbitrary number of links to external resources (files, objects, database entries)
- Support for spatial homogenization / integration
  - e.g. **Terrain Intersection Curves** (for integration of 3D objects with the terrain)
- Representation of **topology**

# External References




Every object (part) may have **references** to **corresponding objects** from **external resources**

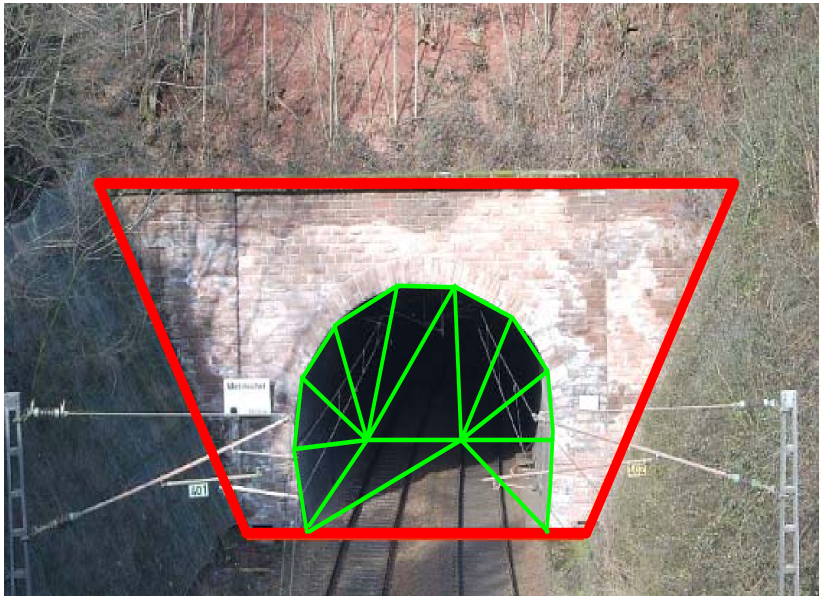
Connection with external information, e.g.:

- building: link to cadastre, owner's contact information
- door, antenna: link to facility management systems

# Terrain Intersection Curve (TIC)

„Interface between 3D objects and the terrain“

- ensure matching of object textures with the DTM
- DTM may be locally warped to fit the TIC

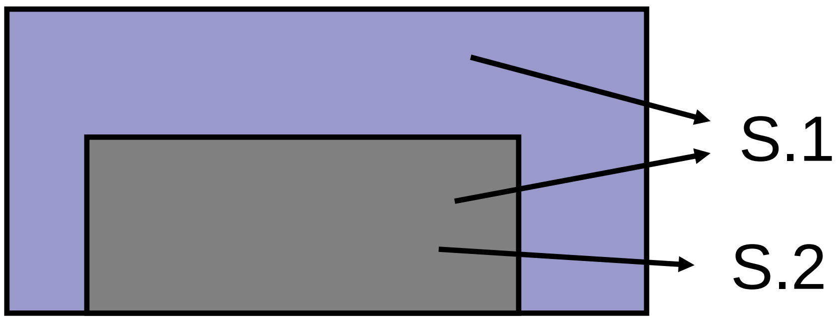


# Geometric-topological Composition

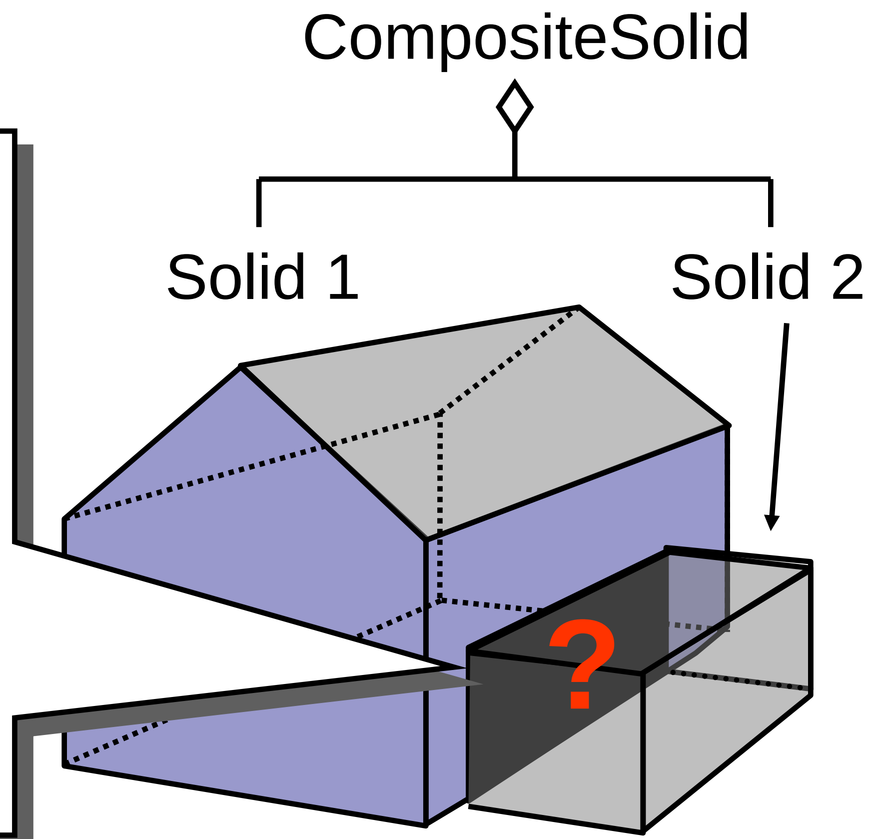
recursive aggregation

➔ arbitrary depth

- Wall face should be partitioned into 2 faces




➔ explicit topol. connection
- but: goes beyond B-Rep



# “Backdoor Topology“

How to allow for **flexible usage of topology?**

- until now, most 3D city models do not consider topology
- need to represent city models with geometry only

Topology model of GML3 sophisticated, but complex

- would make it necessary to implement 2 options for the representation of spatial properties

**Approach in CityGML:**

- **topological connections** are represented by **Xlinks**
- GML3 geometries are objects; composites/aggregates can include subgeometries by value or by reference;
- references express topological relations

**Multiple referencing** of geometry (components) by distinct geospatial features (from different feature classes)

- realizes topological, but also semantic relations
- redundancy free description of space and surfaces possible, thus no overlaps occur

# (Some)
# CityGML Implementation Issues

# CityGML Implementation Issues (I)

- **(City)GML files** become **very large** (several GB for bigger cities)
  - file sizes can be effectively reduced by gzip compression (≈10%)
  - but: XML validation and processing can be problematic (classical DOM parsing not feasible due to main memory limitations)
  - WFS access might have to be realized in an asynchronous way in order to avoid timeouts
- **Complex data model**
  - extensive use of OO modeling -> puts **considerable demands on the modelling power** of processing and storage components
  - Aggregation hierarchies: nested objects
  - Specialization hierarchies: inheritance of object properties

# CityGML Implementation Issues (II)

## XLinks

- Complex objects can be represented inline, in a self-contained way
- But: **sub-objects may be also distributed** over different files (even Web Services) and only referenced by their parent objects
- GML object referencing employs the XLink standard of the W3C

## Topology

- topological relations are realized by reusing (partial) geometries;
- reusage: referencing the same geometry from different objects
- referencing uses XLinks, referenced geometries need to have IDs

## Geometry Model

- See next slide

# Geometry Model of ISO 19107 / GML3

- **3D GML geometries** are represented as **B-Rep** with absolute (world) coordinates (but always **with CRS**!)
  - no scene graph concepts like transformation nodes
  - the CRS is (one) key to the integration of different spatial datasets
- **No generative modeling** principles like CSG, Sweep Repr.
  - Very few implicit (parametric) shape definitions (e.g. Box, TIN)
- Reusability of geometry within a dataset is limited
  - However useful to express topological connectivity of different features or semantic relations between them
- **Advantages** of the GML3 geometry model
  - easy to spatially index and manage within spatial databases and GIS; native support by Oracle, PostGIS, MySQL etc.
  - visualization (transformation to X3D) is immediate