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Annex D
(informative)
CityGML and its role in INSPIRE Buildings data specification

D.1 Introduction

D.1.1 Objectives and principles

CityGML is a common model for the representation and the exchange of 3D city models.

There are three main design goals of CityGML:

- **The representation of semantics and relations between objects.** In contrast to 3D city models provided in graphical or geometrical formats such as 3D Studio MAX/3ds Max, KML, X3D or OpenStreetMap-3D, the focus of CityGML is on the semantics of objects and its structures (aggregations, relations). Features like buildings and its components on different levels (building parts, rooms, wall or roof surfaces, doors, windows, balconies, dormers) are classified semantically and further described by attributes (function, year of construction, ...). Furthermore, the relations between those features are explicitly represented, e.g. a relation of a door to the wall surface it contains. The representation of semantics is inevitable for many relevant applications of 3D city models like non-photorealistic rendering according to attribute values (e.g., to building function), spatial analyses like computing the visibility of a location from windows, balconies of flat roofs, or computing the flood level when a door or a window is affected by water. Other applications that require semantics are disaster management, homeland security, real estate management, vehicle and pedestrian navigation and training simulators.
- **Interoperability.** The lossless and smooth exchange of 3D city models between different systems, formats and organizations is facilitated by defining a common semantical model and common levels of detail, as well as by the use of standards like GML, which are based on ISO standard like ISO 19107 (Herring, 2001) and ISO 19109 (International Organization for Standardization, ISO TC 211, 2005).
- **Base model.** CityGML defines the semantical objects, attributes and relations which are required by most applications. It is a base model in the tradition of European topographic or cadastral models, which can be used by multi-functionally by many applications. It is not designed as a model for specific applications. For such specific applications like indoor navigation, energy assessment or noise simulation and mapping, CityGML can be extended by adding feature types or by adding properties to existing feature types. For such extensions, CityGML provides an uniform mechanism called *ADE* (*Application Domain Extension*).

Fig. 1 and Fig. 2 depict two examples for 3D city models in different levels of detail that are represented in CityGML.

Fig. 1: Very detailed 3D city model (Level-of-Detail 3) in CityGML (image: www.de.maila-push.com)

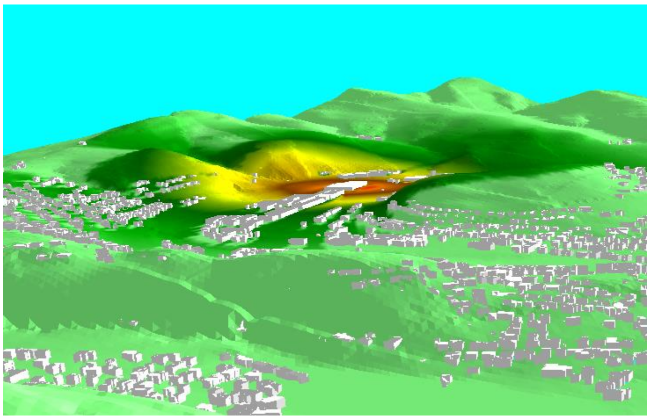


Fig. 2: Low detailed CityGML 3D city model (Level-of-Detail 1) applied for noise emission simulation (Czerwinski et al., 2007)

CityGML defines the geometry, semantics and appearance of topographic objects in urban or rural regions. These objects are divided into thematic modules: the building module, the vegetation module, the transportation module, the water body module, the city furniture module and the digital terrain model module. Fig. 3 gives an overview of the thematic modules of CityGML. However, the focus of that chapter is on the building model, which is most relevant for the scope of TWG BU.

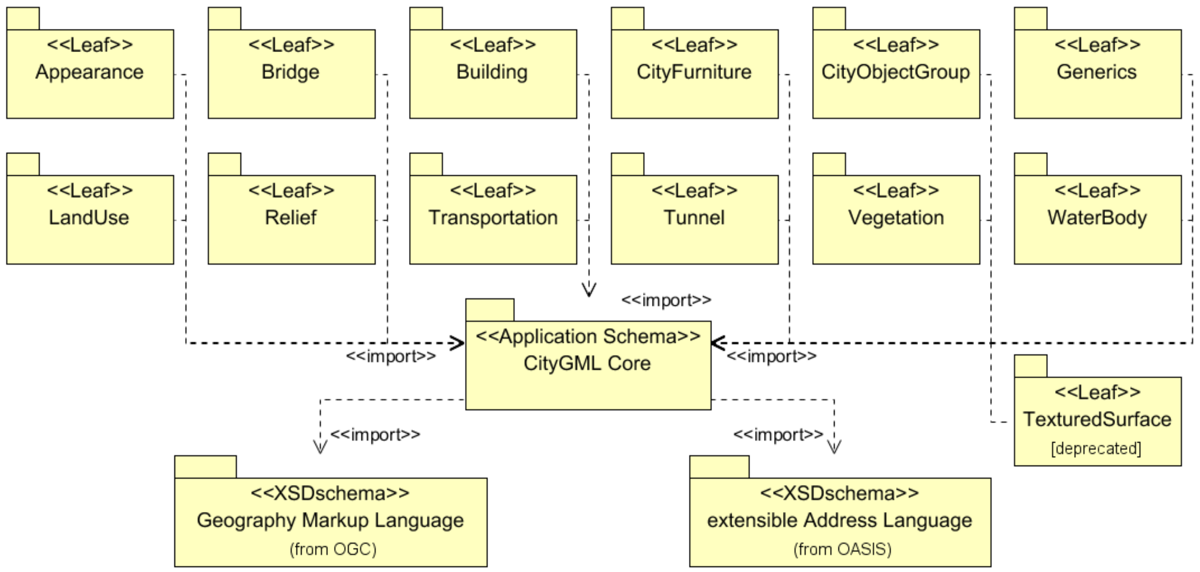


Fig. 3: UML package diagram illustrating the separate modules of CityGML and their schema dependencies (Gröger et al. 2012).

D.1.2 Context

Development of City GML

City GML is an international standard of the Open Geospatial Consortium (OGC, see www.opengeospatial.org) since 2008, based on the Geographic Markup Language GML 3.1.1. (Cox et al., 2003). Version 2.0 of CityGML has been published in 2012.

CityGML has been developed since 2003 (and is developed further) by the *Special Interest Group 3D (SIG 3D)* of the initiative *Spatial Data Infrastructure Germany (GDI-DE),* see www.sig3d.org. Until 2010, the SID 3D was affiliated to the more local GDI.NRW of North Rhine Westphalia.The development of CityGML was motivated by the observations that most existing 3D city models were represented purely geometrically or graphically, and that no standard for semantical 3D city models was available. Since 2008, CityGML is an OGC standard.

Evolutions of CityGML

Currently, version 1.0 of CityGML is widely in use (see Gröger et al, 2008). Version 2.0 (see Gröger et al, 2012) was adopted as OGC standard in March 2012. In this version, semantical models for bridges and tunnels have been added and the building model has been enriched, e.g. by adding a 2.5D representation.

Use of City GML

Many commercial tools support CityGML by providing export or import of CityGML data sets: Oracle Spatial 11g (3D data types and CityGML loader), Safe Software FME, Autodesk Land Explorer, Snowflake Go Publisher WFS, interactive instruments: XtraServer/WFS, Bitmanagement BS Contact Geo, GTA tridicon City Discoverer, Google Sketch up (GEORES), Bentley Map and MetGeoInfo CityGRID.

CityGML has been disseminated worldwide. Examples are the Bati3D project in France, 3D city models of Zürich, Geneva, Monaco and 13 cities in Denmark, 3D city models of Leeuwarden in The Netherlands, projects in Kuala Lumpur, Malaysia, in Istanbul, Turkey, in Wuhan, China and in Korea.

For more details on CityGML see Gröger et al. (2012), Gröger & Plümer (2012) or Kolbe et al. (2008). The next two sections focus on the two aspects which are most relevant for the TWG BU model: the building and the appearance model of CityGML.

D.2 Building Model

The building model is the most important component of CityGML. It enables the representation of buildings and its parts (buildings parts, walls, roofs, windows, doors, rooms, balconies, ...) with regard to geometry as well as to semantics (feature types and properties). In this chapter, the Building model of City GML version 2.0 is introduced.

The geometry model that is employed to represent buildings (as well as to represent other features in CityGML) is based on the well-known *Boundary Representation* (*BRep*) (Mäntylä, 1988), which represents volume objects like buildings by three-dimensional *solids*. The extent of a solid is defined by its bounding surfaces, which delimit the solids without overlaps and without gaps (water tightness). In CityGML, all solids are bounded by planar polygons. Solids representing the geometries of a simple building with a gabled roof and a garage are depicted in Fig. 4. In CityGML, the geometry model (as well as the optional topology model) of GML 3.1, which is based on the standard ISO 19107 'Spatial Schema' (Herring, 2001), is used.

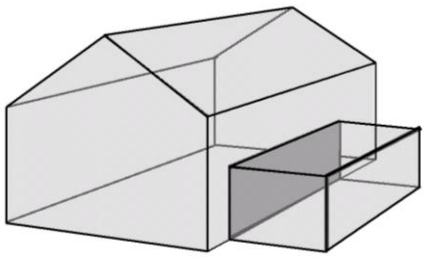


Fig. 4: Example of a Boundary Representation model consisting of two solids. The left solid is bounded by seven rectangles and the right one by six.

The restriction to planar surfaces is due to the restrictions of many tools or spatial data bases which can not deal with non-linear surfaces such as cylinder or spheric surfaces. In Fig. 5, a roof with a chimney and a dormer is depicted which is represented by a composite surface consisting of planar surfaces (total of 16 surfaces, 5 for the dormer and 5 for the chimney). In general, all shapes (including spherical or cylindes shapes) can be approximated by planar surfaces with an arbitrary small error. The smaller the error is, the smaller the surfaces are. Often triangulations are used for this purpose.

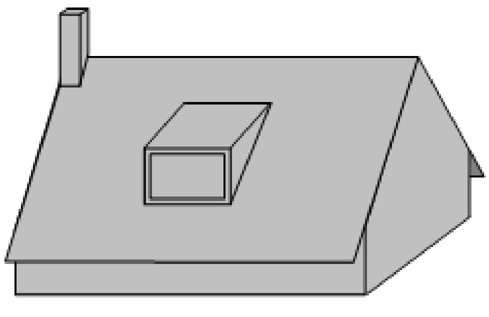


Fig. 5: Representation of a roof and its structures by planar surfaces.

Each feature that is defined in CityGML (buildings, building parts, rooms, wall surfaces, roof surfaces, doors, windows, etc.) has common attributes. These attributes are a creation and a destruction date as well as an *external reference* pointing to the identifier of the object in another information system, typically in the system the object initially was obtained from (e.g., in the German cadastre system ALKIS, in the German topographic information system ATKIS, or in the OS MasterMap®). This reference facilitates updates of CityGML features and supports the retrieval of additional information, e.g. of the owner of a building from a cadastral system. Furthermore, all *CityObjects* inherit a name, a description and metadata according to ISO 19115 (International Organization for Standardization, ISO

TC 211, 2003) (lineage, accuracy, topological consistency, …) from corresponding GML classes. Fig. 5 shows the UML diagram of the core module which defines the class *_CityObject*.

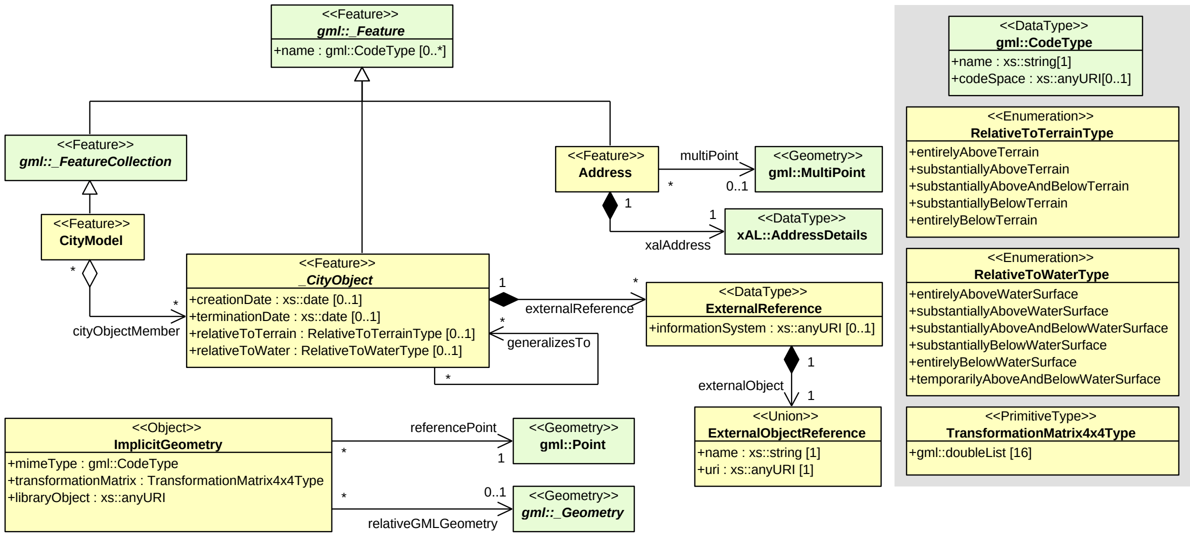
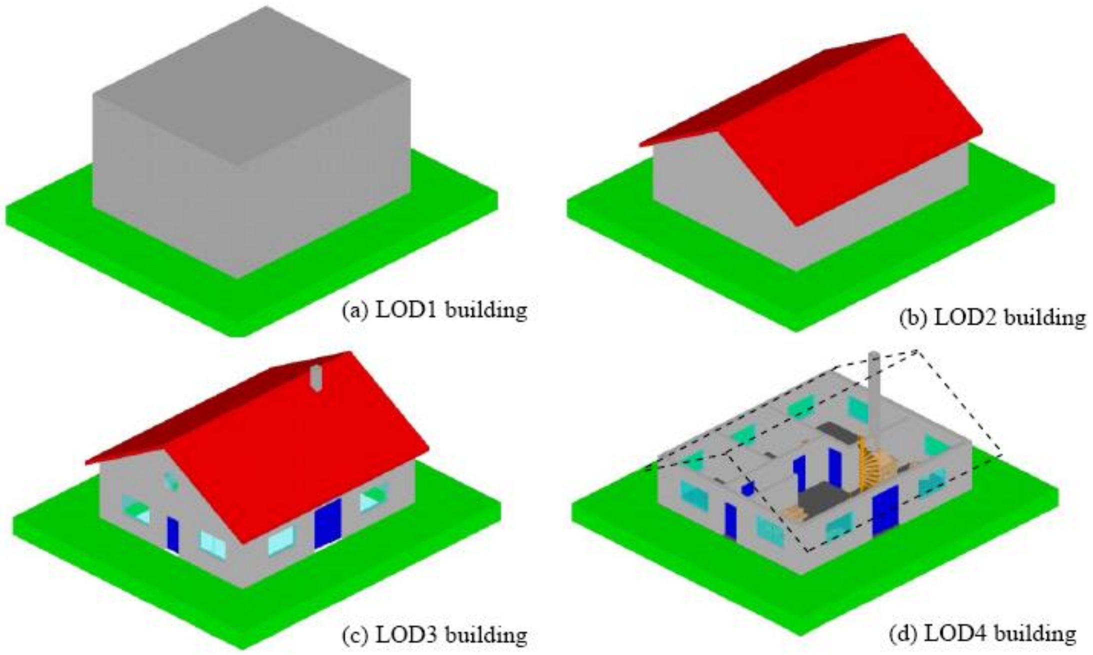


Fig. 6: Properties of the base class *_CityObject* which are inherited by all features in CityGML (Gröger et al. 2012)

Buildings as well as all features in CityGML are represented in different levels of detail. Five consecutive Levels of Detail (LoD) are defined, where features become more detailed with increasing LoD regarding both their geometry and semantic differentiation. CityGML features as well as data sets can - but do not have to - contain multiple representations (and geometries) for each object in different LoD simultaneously. This enables the analysis and visualisation of the same object with regard to different degrees of resolution. LoDs are required to reflect independent data collection processes with differing application requirements. Furthermore, the classification into LoDs facilitates interoperability, since preferably features with the same LoD can be integrated. In the following, the LoDs of CityGML – LoD0 to LoD4 – are introduced. Fig. 6 provides examples for those LoDs.

In all LoDs, buildings are represented by the class *Building*, the attributes of which are inherited from the base class *_AbstractBuilding*. The attributes are a classification of the building (attribute *class*: public building, ...), the *function* (dwelling, office building, ...) and the *usage* in the case the actual usage differs from the intended function. The other attributes represent the year of construction/demolition, the roof type (given as an enumeration of the main types flat, monopitch, gabled, ...), the actual measured height of the building and the numbers and actual heights of the stories above and below ground. The address of the building is given by the reference to an address object (using the OASIS standard for addresses).

A building can consist of building parts, The distinction into *BuildingParts* accommodates the fact that components of a building differ with regard to geometry (different heights, for example) or attributes (*YearOfConstruction, RoofType*, …). *Buildings* and *BuildingParts* potentially have the same spatial and non spatial properties, since both are sub classes of *_AbstractBuilding*. Both must be consistent: If parts are present, the building geometry is represented for the parts only. The attribute values of a part apply only to that part, whereas attribute values of a building refer to all parts. Fig. 7 shows an example for a building consisting of two parts.



Building model in LoD1 to LoD4. In LoD0 (not shown on the figure), only the topmost (or bottommost) rectangle of the LoD1 box is represented (image: KIT Karlsruhe)

Examples of a building that consists of two parts (left) and of a building that consists of one part (right)

D.2.1 Level of Detail 0 (LoD0)

In LOD0, a building is represended by horizontal 3D surfaces (2.5D). These surfaces are either at foot print level (relation *lod0FootPrint*) or at eaves height level (lod0RoofEgde). The UML diagram for LoD0 is given in Fig. 9.

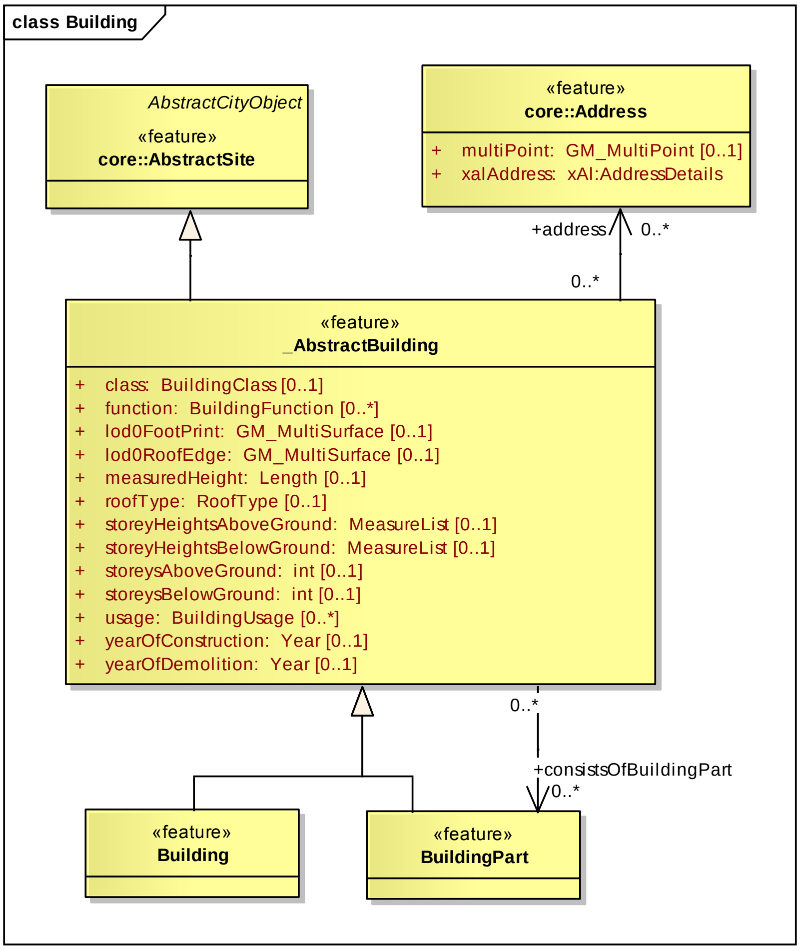


Fig. 7: UML diagram of CityGML's building model: LoD0[1]

D.2.2 Level of Detail 1 (LoD1)

The coarsest volumetric Level of Detail 1 represents buildings as blocks model, i.e. prismatic buildings with flat roofs (c.f. Fig. 6a). The UML diagram for this LoD is given in Fig. 10.

The geometry of LoD1 is represented by a solid (association *lod1Solid*), which is specified by the language GML as Boundary Representation (c.f. Fig. 4). The solid geometry covers the case where the geometry is completely bounded by surfaces. Alternatively, a *MultiSurface* geometry (association *lod1MultiSurface*) allows for building geometries that are not 'water tight', e.g. a geometry without ground surface. Such models occur frequently in practice and should not be excluded. The terrain intersection curve, which is available in each LoD, explicitly represents the line where the building touches the surface of the terrain. That concept facilitates the smooth integration of the building into the terrain.

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[1] Note that for clarity reasons, the geometry in the UML diagrams for LoD0 – LoD4 is represented by attributes. In the specification document, UML classes and relations are used instead. Both representations are equivalent in these cases.

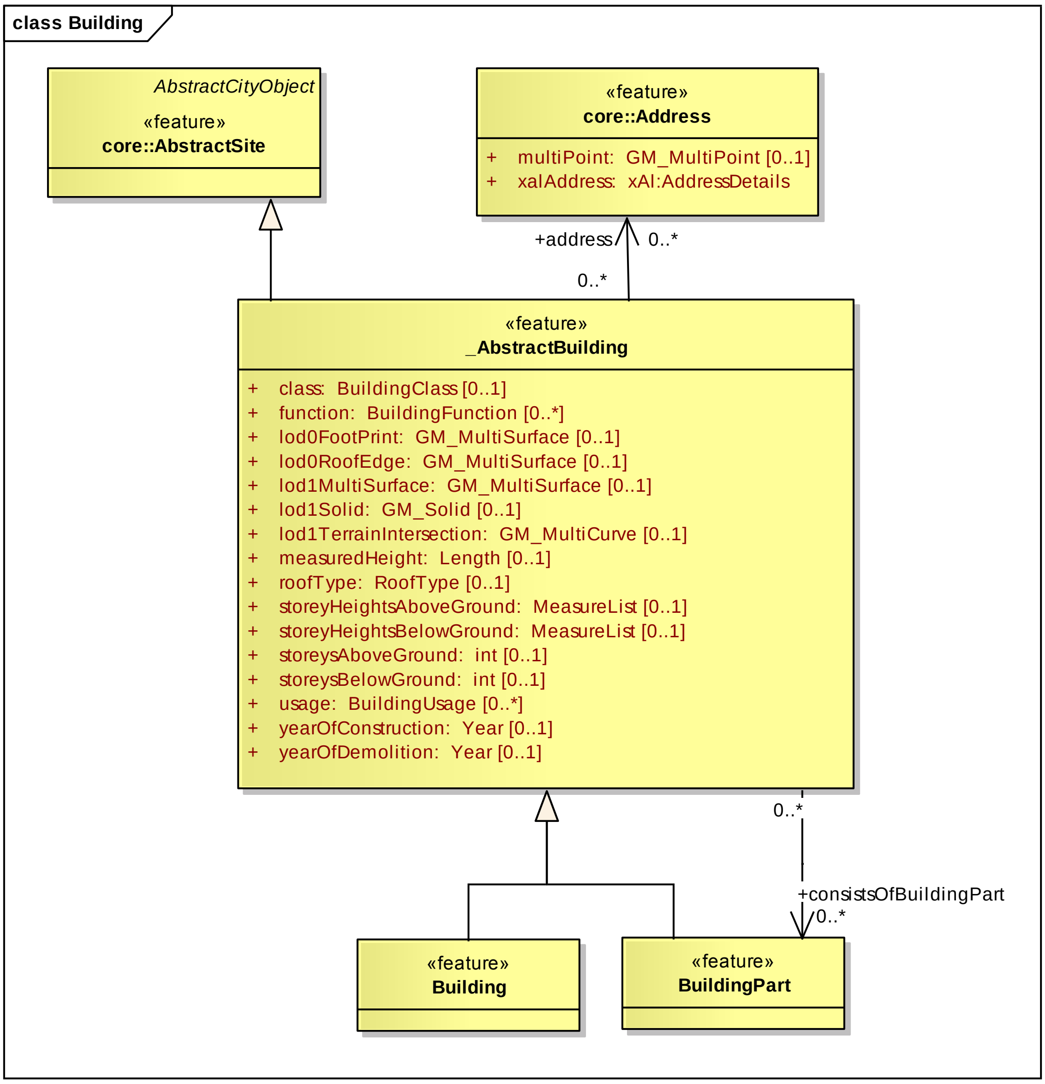

Fig. 8: UML diagram of CityGML's building model: LoD1

D.2.3 Level of Detail 2 (LoD2)

Geometrically, a building in LoD2 provides the prototypic, i.e. generalized, roof shape, optionally including roof overhangs. The walls are represented geometrically by vertical surfaces, as in Lod1. Semantically, a LoD2 building has thematically differentiated surfaces particularly for the roof and the walls. The UML diagram for this LoD is depicted in Fig. 11. The semantic aspects of the classes *Building*, *BuildingPart* and *_AbstractBuilding* are identical to LoD1. The geometry is represented again either as a *Solid* or as a *MultiSurface*, which both are more detailed. The Lod2 geometry is distinguished from the LoD1 geometry by using different association names (*lod2Solid*, *lod2MultiSurface*, *lod2TerrainIntersection*). Note that LoD1 and LoD2 (as well as LoD3 and 4) are not used in a mutually exclusive way: a single building can simultaneously be represented in more than one LoD. Such a multiple representation is enabled by providing distinct names for geometry associations for each LoD.

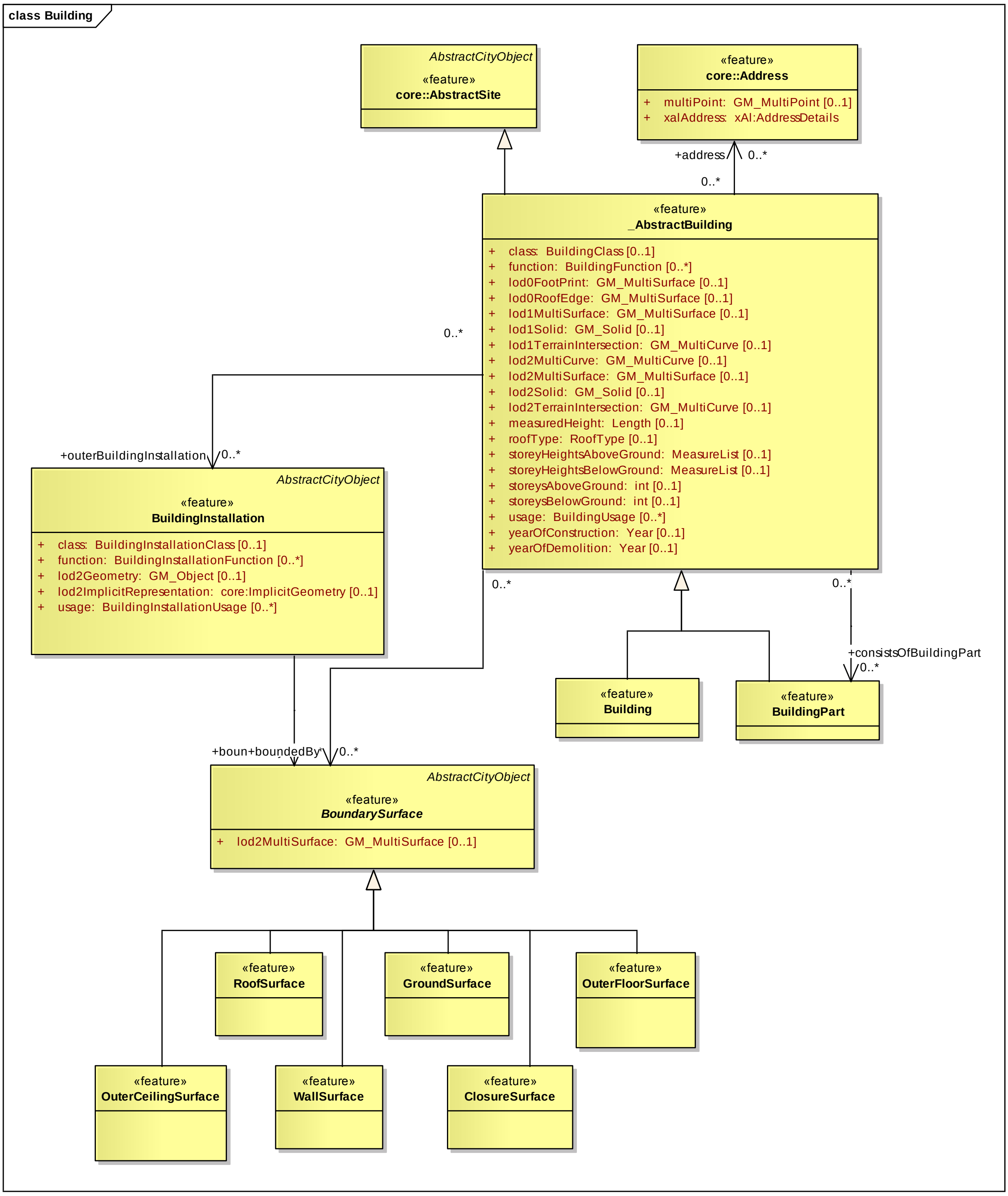

Fig. 9: UML diagram of CityGML's building model: LoD2

In LoD2 boundary surfaces can be represented not only on a geometrical level (as part of a solid geometry), but on a semantical level as *_BoundarySurface* features. Such a feature can be a *RoofSurface, a WallSurface, a GroundSurface, a ClosureSurface, an OuterCeilingSurface* and an*OuterFloorSurface*[2]. In order to avoid duplicated, redundant geometries, the geometry of a thematic Boundary Surface must be shared with the corresponding solid geometry of the building. Fig. 12 illustrates this concept.

In LoD2 *BuildingInstallations* are added in addition, which represent small extensions like balconies, chimneys or outer stairs semantically.

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[2] In LoD4, *FloorSurface, InteriorWallSurface,* and *CeilingSurface* are provided in addition.

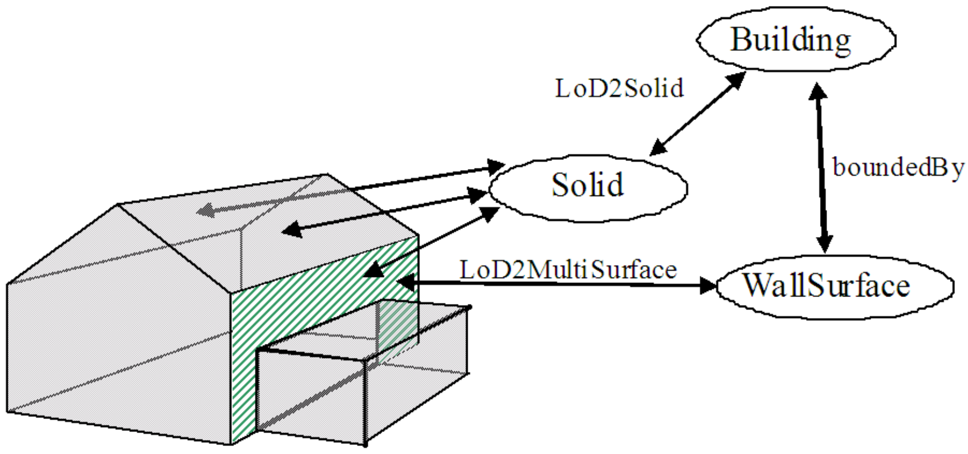

Fig. 10: Sharing of geometries: The right surface of the building (depicted hatched) is part of a solid geometry as well as part of the *WallSurface* geometry

D.2.4 Level of Detail 3 (LoD3)

LoD3 is the most detailed level for the outermost shape of objects (see Fig. 1). This level denotes architectural models with detailed facade and roof structures such as balconies, bays, projections, dormers and chimneys. These objects are represented gemetrically as well as semantically. High-resolution textures can be mapped onto these structures. An example for a LoD3 building is given in Fig. 6c and the corresponding UML diagram in Fig. 13.

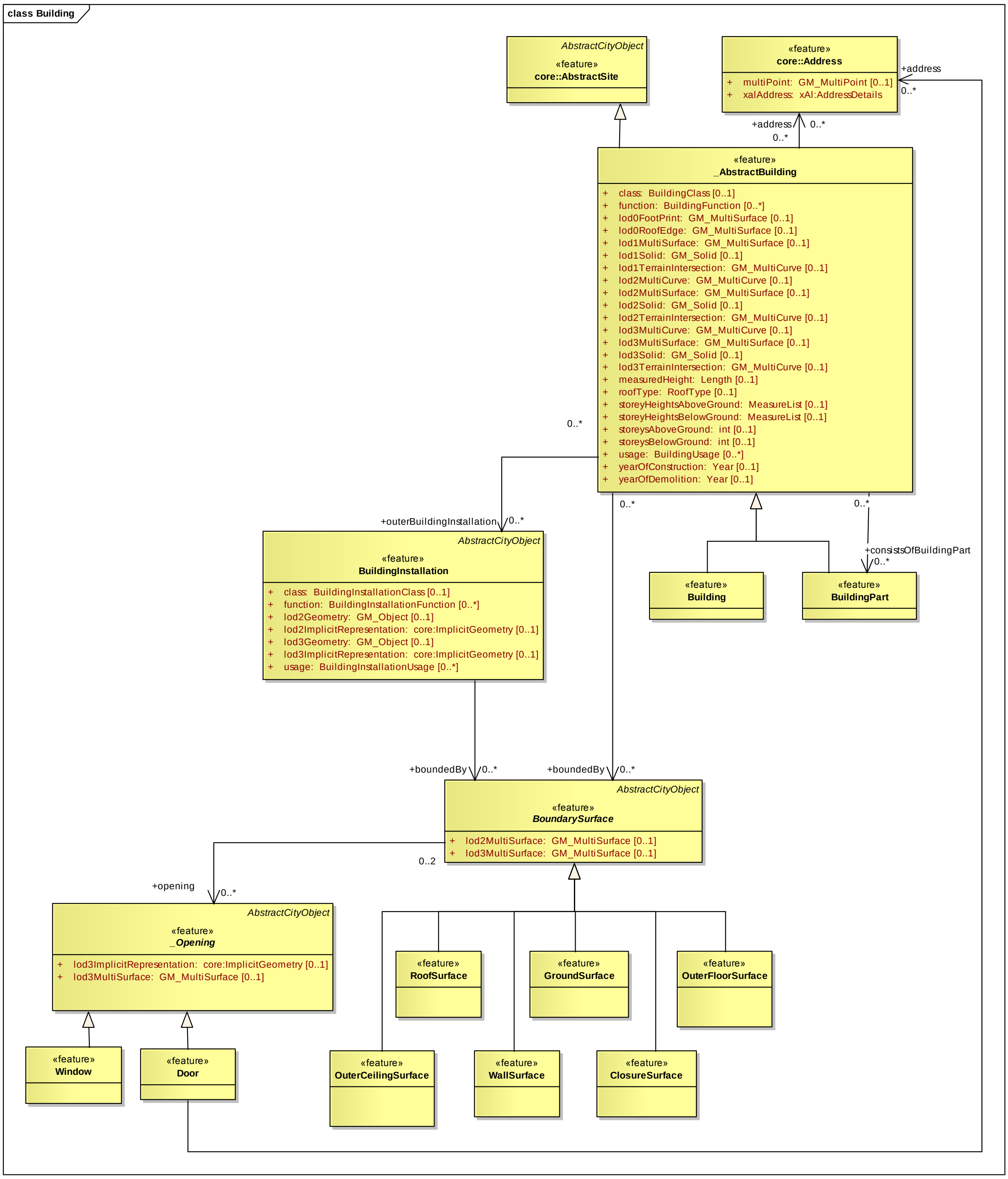

Fig. 11: UML diagram of CityGML's building model: LoD3

The semantics and the structure of *Buildings*, *BuildingParts*, *_AbstractBuildings*, *_BoundarySurfaces* and *BuildingInstallations* are identical to the LoD2 case. The more detailed geometry of those features is again represented by a different association names. There is only one semantical concept added in LoD3: *_BoundarySurface* objects may have *_Openings* (doors and windows) which can be represented as thematic objects with a surface geometry. *BuildingInstallations* in LoD3 represent dormers, balconies, chimneys or similar objects.

D.2.5 Level of Detail 4 (LoD4)

LoD4 adds detailed interior structures such as rooms, (immovable) interior installations and (movable) building furniture to LoD3 (see Fig. 6d). With respect to the outermost shape of a building, LoD3 and LoD4 are identical. Fig. 14 depicts the UML diagram for LoD4.

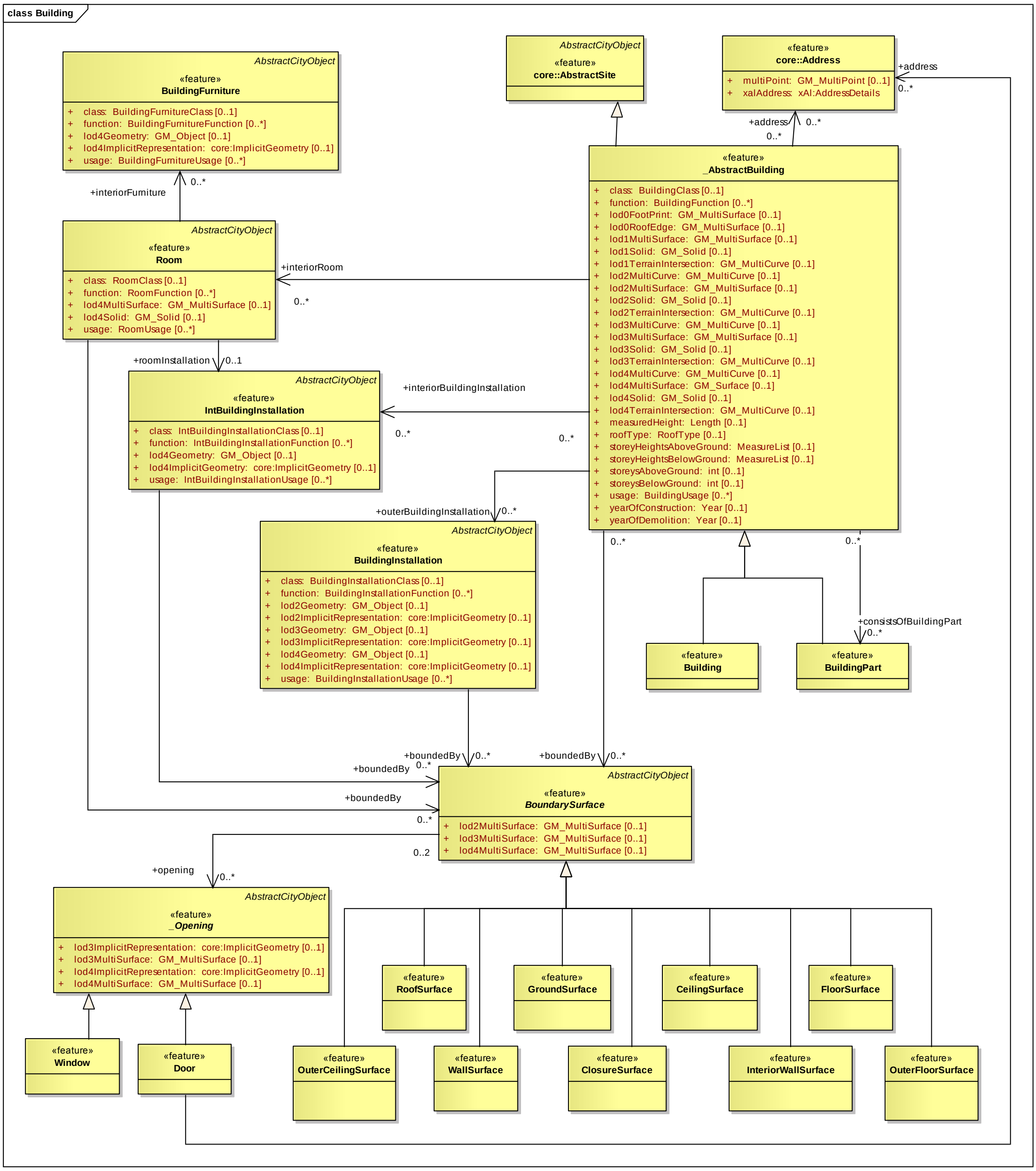

Fig. 12: UML diagram of CityGML's building model: LoD4

D.3 Appearance Model

In addition to spatial and semantical properties, CityGML features have *appearances* – observable properties of the feature's surface. Appearances are not limited to visual data (textures showing the visual nature of a facade) but represent arbitrary categories called *themes* such as infrared radiation, noise pollution, or earthquake-induced structural stress. The UML diagram of CityGML's appearance model is depicted in Fig. 12.

It is assumed that the image or the observation that is used to represent the material has been mapped properly to the (wall, roof or terrain) surface by using texture mapping methods from computer graphics or photogrammetry.

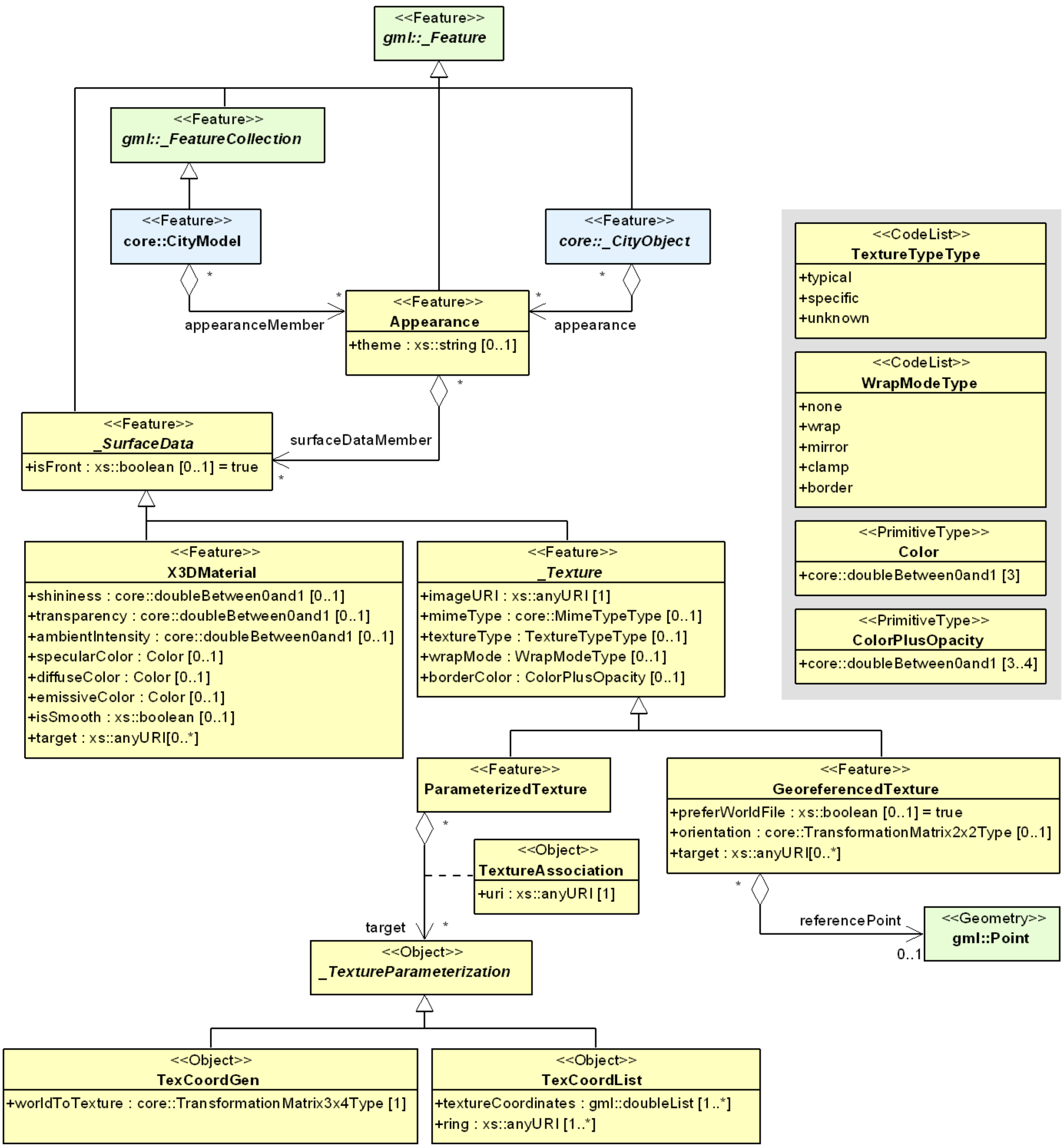

Fig. 13: UML diagram of CityGML's appearance model.

An *Appearance* object collects surface data either for individual features or the whole city model in any LoD. Surface data is represented by objects of class *_SurfaceData*. The relation between surface data and surface geometry (e.g., the geometry of a wall of a building) is expressed by an URI (Uniform Resource Identifier) link from a *_SurfaceData* object to an object of type *gml:AbstractSurfaceType* or type *gml:MultiSurface*. A surface property being constant over the whore surface is modeled as material (class *X3DMaterial* in the UML diagram). A surface property, which depends on the location within the surface, is modeled as texture. A texture can either be a *GeoreferencedTexture* or a *ParametrizedTexture*. The class *GeoreferencedTexture* describes a texture that uses a planimetric projection. Alternatively, a concept similar to a reference by a world file (e.g. an ESRI world file) can be

used. For Parametrized Textures, the mapping from 2D image space to 3D space is achieved either by providing texture coordinates or by applying a 3x4 transformation matrix specified by class *TexCoordGen*. This matrix defines a linear transformation from a spatial location in homogeneous coordinates to texture space.

Texture coordinates for a surface geometry object are specified using class *TexCoordList* as a texture parameterization object in the texture's *target* property. Each exterior and interior *Ring* composing the boundary of the target surface geometry object requires its own set of texture coordinates. Fig. 16 illustrates this concept. A *TexCoordList* contains as many *textureCoordinate* elements as the target surface geometry object contains *gml:LinearRing*s. The content of a texture coordinate list is an ordered list of double values where each two values defines a $(s,t)^T$ texture coordinate pair with *s* denoting the horizontal and *t* the vertical texture axis. The list contains one pair per ring point with the pairs' order corresponding to the ring points' order.

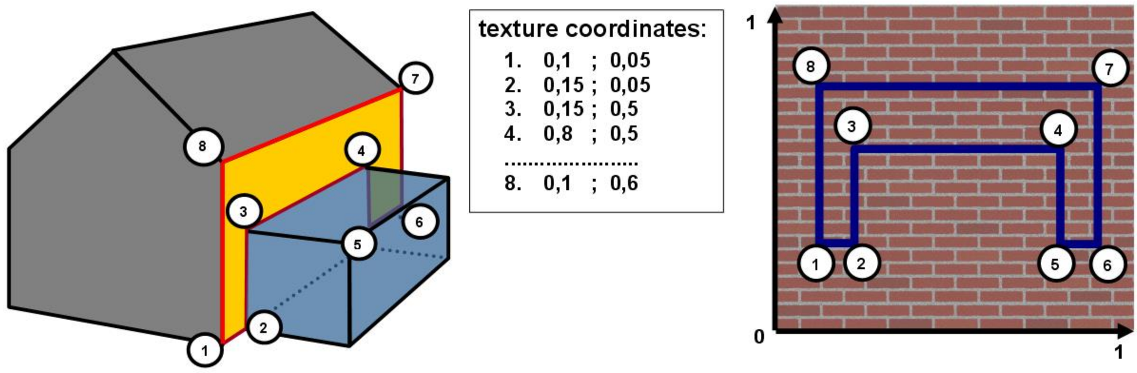

Fig. 14: Positioning of textures using texture coordinates: Example

D.4 Integration of CityGML into the INSPIRE BU model

D.4.1 Commonalities between INSPIRE BU model and City GML

CityGML has strongly influenced the development of the INSPIRE BU model, both for 2D and for 3D profiles.

- The philosophy of base model defining semantical objects, attributes and relations which are required by most applications has been adopted by INSPIRE BU (as core profiles)
- The concept of External Reference to enable link to more domain-specific information systems or to ensure consistency between 2D and 3D representations of buildings has also been reused by TWG BU.
- The design pattern of *Building – BuildingPart* aggregation is also included in all the INSPIRE applications schemas
- Many attributes (e.g. *RoofType*, *YearOfConstruction*) have been included in INSPIRE BU profiles

Moreover, many use cases that were considered by the INSPIRE BU require a three-dimensional representation of buildings. Examples are noise emission simulation and mapping, solar radiation computation or the design of an infrastructure project. To allow for that, the building representation in LoD1 - LoD4 of CityGML has been added to the INSPIRE BU model as *core 3D* profile, whereas the whole content of LoD1 - LoD4 (including the features attached to buildings, such as boundaries, openings, rooms, …) are the base of the *extended3D* profile.

INSPIRE BU model is based on City GML v2.0.

D.4.2 Differences between INSPIRE BU model and City GML

TWG BU has introduced the following changes to City GML:

- City GML has been adapted for INSPIRE:

    - Example 1: the attributes regarding the classification of buildings that are loosely harmonised in City GML (declared as string or code list from German Cadastre given as examples) have been modified/restructured to fit better with the user requirements collected by INSPIRE TWG BU.
    - Example 2: to ensure cross-theme consistency, the attributes that are common to all INSPIRE themes (identifier, temporal attributes in data set) have received the name and definition supplied by the INSPIRE Generic Conceptual Model rather than the ones supplied by CityGML
- CityGML has been simplified for INSPIRE
    - Example 1: in CityGML, the aggregation between Building and BuildingPart is recursive (a part can have parts), whereas in INSPIRE, a part can not have parts (in the CityGML UML diagram, the aggregation starts at AbstractBuilding and is inherited by both Buildings and parts, whereas in INSPIRE, the aggregation starts at Buildings).
    - Example 2: the model for appearance has been greatly simplified; only the modelling of Parameterized Texture has been kept (because being the only one relevant to model the natural appearance of a building whereas CityGML enables to model also the effect of physical phenomena, such as infrared radiation or noise pollution)
- INSPIRE TWG BU has enriched the content of CityGML
    - Example 1: some feature types *(BuildingUnit)* and many attributes *(e. g. numberOfDwellings, ConditionOfConstruction)* have been added to INSPIRE BU model to fulfil the user requirements related to environmental policies, that is the scope of INSPIRE. Typicaly, City GML is about topographic data wheras INSPIRE BU model also includes some official data.
    - Example 2: in INSPIRE BU model, the geometry is defined as a data type including the geometry itself and some metadata to document it (accuracy, geometry reference) whereas in City GML, the geometry is just provided by geometic primitives, such as GM_Object or GM_MultiSurface
    - Example 3: in the extended2D/extended3D profiles, the scope of the CityGML model has been extended to include constructions that are not considered as buildings like monuments or antennas.

D.4.3 Mapping between CityGML and INSPIRE BU model

The following table shows the possible mapping from CityGML data to INSPIRE model for feature type Building.

The mapping would be quite similar for feature type BuildingPart.

City GML (Building)		**TWG BU model (Building)**
Core attributes (inherited)		*From BuildingBase::AbstractConstruction*
name		inspireId
creationDate		name
terminationDate		beginLifespanVersion
ExternalReference		endLifespanVersion
Association to Address		externalReference
Building attributes		dateOfConstruction
geometry		dateOfDemolition
class		dateOfRenovation
function		heightAboveGround
usage		elevation
yearOfConstruction		conditionOfConstruction
yearOfDemolition		*From BuildingBase::AbstractBuilding*
storeysAboveGround		buildingNature
storeyHeightsAboveGround[3]		currentUse
storeysBelowGround		numberOfDwellings
storeyHeightsBelowGround[4]		numberOfBuildingUnits
aggregation into Parts		numberOfFloorsAboveGround
		aggregation into Parts
		From buildings2D::AbstractBuilding
		geometry2D
		From extended2D::AbstractBuilding
		association to Address
		association to Cadastral Parcel
		address
		document
		numberOfFloorsBelowground
		heightBelowGround
		materialOfRoof
		materialOfStructure
		materialOfFacade
		officialArea
		officialValue
		roofType
		energyPerformance
		heatingSystem
		heatingSource
		floorDescription
		floorDistribution
		connectionToWater
		connectionToSewage
		connectionToGas
		connectionToElectricity
		connectionToWater

NOTE: attributes coloured in green are those coming from Core profiles

References

[3] In CityGML, the heights of each storey above ground are represented separately as elements of an array storeyHeightsAboveGround. In INSPIRE, the total height above ground is represented.
[4] In CityGML, the heights of each storey below ground are represented separately as elements of an array storeyHeightsBelowGround. In INSPIRE, the total height below ground is represented.

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Presentation: *http://inspire.jrc.ec.europa.eu/events/conferences/inspire_2013/pdfs/26-06-2013_ROOM-3_09.00%20-%2010.30_92-Tatjana%20Kutzner_Tatjana-Kutzner.pdf*

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Annex E
(informative)
Template for additional information

Chosen profile

Explain shortly which profile the data set has implemented among the ones proposed by INSPIRE

- core 2D profile
- extended 2D profile (whole profile or part of it)
- core 3D profile
- extended 3D profile (whole profile or part of it)

Population of spatial objects, attributes and associations

In the column "Populated", tick (X) the populated elements. The feature type or property should be ticked if it is populated, at least for some objects.

Feature types and attributes related to core profiles are shown in grey in the following table.

INSPIRE element	Populated	INSPIRE element	Populated
Building		**BuildingPart**	
geometry2D		geometry2D	
geometry3DLoD1		geometry3DLoD1	
geometry3DLoD2		geometry3DLoD2	
geometry3DLoD3		geometry3DLoD3	
geometry3DLoD4		geometry3DLoD4	
inspireId		inspireId	
elevation		elevation	
conditionOfConstruction		conditionOfConstruction	
dateOfConstruction		dateOfConstruction	
dateOfRenovation		dateOfRenovation	
dateOfDemolition		dateOfDemolition	
externalReference		externalReference	
heightAboveGround		heightAboveGround	
name		name	
beginLifespanVersion		beginLifespanVersion	
endLifespanVersion		endLifespanVersion	
currentUse		currentUse	
numberOfBuildingUnits		numberOfBuildingUnits	
numberOfFloorsAboveGround		numberOfFloorsAboveGround	
BuildingNature		BuildingNature	
numberOfDwellings		numberOfDwellings	
Aggregation with BuildingPart		Aggregation with BuildingPart	
officialArea		officialArea	
officialValue		officialValue	
heightBelowGround		heightBelowGround	
numberOfFloorsBelowGround		numberOfFloorsBelowGround	
floorDistribution		floorDistribution	
floorDescription		floorDescription	
materialOfStructure		materialOfStructure	
materialOfRoof		materialOfRoof	
materialOfFacade		materialOfFacade	
roofType		roofType	
energyPerformance		energyPerformance	
heatingSource		heatingSource	

heatingSystem		heatingSystem	
connectionToElectricity		connectionToElectricity	
connectionToGas		connectionToGas	
connectionToSewage		connectionToSewage	
connectionToWater		connectionToWater	
association with installations		association with installations	
association with building units		association with building units	
association with cadastral parcels		association with cadastral parcels	
association with address		association with address	
OtherConstruction		**Installation**	
geometry2D		geometry2D	
geometry3D		geometry3D	
inspireId		inspireId	
elevation		elevation	
conditionOfConstruction		conditionOfConstruction	
dateOfConstruction		dateOfConstruction	
dateOfRenovation		dateOfRenovation	
dateOfDemolition		dateOfDemolition	
heightAboveGround		heightAboveGround	
externalReference		externalReference	
name		name	
beginLifespanVersion		beginLifespanVersion	
endLifespanVersion		endLifespanVersion	
otherConstructionNature		installationNature	
BuildingUnit			
externalReference			
inspireID			
geometry2D			
geometry3D			
beginLifespanVersion			
endLifespanVersion			
currentUse			
officialArea			
officialValue			
energyPerformance			
heatingSource			
heatingSystem			
connectionToElectricity			
connectionToGas			
connectionToSewage			
connectionToWater			
association with cadastral parcels			
association with address			
ClosureSurface		**GroundSurface**	
geometry3D		geometry3D	
inspireId		inspireId	
beginLifespanVersion		beginLifespanVersion	
endLifespanVersion		endLifespanVersion	
OuterFloorSurface		**OuterCeilingSurface**	
geometry3D		geometry3D	
inspireId		inspireId	
beginLifespanVersion		beginLifespanVersion	
endLifespanVersion		endLifespanVersion	
RoofSurface		**WallSurface**	
geometry3D		geometry3D	
inspireId		inspireId	
beginLifespanVersion		beginLifespanVersion	
endLifespanVersion		endLifespanVersion	

materialOfRoof		materialOfWall	
Door		**Window**	
geometry3D		geometry3D	
inspireId		inspireId	
beginLifespanVersion		beginLifespanVersion	
endLifespanVersion		endLifespanVersion	
Room		**InteriorInstallation**	
geometry3D		geometry3D	
inspireId		inspireId	
beginLifespanVersion		beginLifespanVersion	
endLifespanVersion		endLifespanVersion	
roomNature		internalInstallationNature	
ParameterizedTexture			
imageURI			
mimeType			
textureType			

Selection criteria:

Building (and BuildingPart, if any)

Explain which buildings are captured for INSPIRE and which are not.

For instance, is there a minimum size for data capture? Are there some categories of buildings that are not captured?

If the definition is significantly different from the one used by INSPIRE, provide it.

OtherConstruction (if any)

Explain which OtherConstructions are captured and which are not.

BuildingUnit (if any)

Explain what is considered as a BuildinUnit

Installation (if any)

Explain which Installations are captured and which are not.

Data capture process – data capture rules

For 2D profiles, explain if data is captured as 2D or as 2,5D data.

For 3D data, explain briefly which levels of details are used; if textures are provided, give explanations about them (for which buildings, which kind of textures, …).

Provide the main rules to capture buildings and constructions, with focus on the aspects that are not already included in UML model

Examples:

- What is considered as a building? What is considered as part of building (if any)?
- in case of a generalised capture of building, which are the main generalisation rules?
- how are specific buildings (without roof) captured?
- are buildings cut by cadastral boundaries?
- may two buildings overlap? In which cases?

Temporal aspects

Old data

Explain if the building data set published for INSPIRE contains only current version or also depreciated features. If it is the case, explain which (e.g. from when?)

If necessary, give more detailed explanations about temporal attributes (e.g. how demolished buildings are considered)

Life-cycle rules:

Give the life-cycle rules of buildings and constructions (i.e. in which cases an object will get a new inspire identifier and in which case an object will just be considered as a new version of same object)

Mapping with INSPIRE values

Attribute currentUse

The classification of buildings in source data is likely different from the one proposed by INSPIRE. Explain the mappings that are not obvious, that are only approximations (e.g. what occurs in case of mix use?)

Other attributes

Any mapping that is not obvious correspondence should be documented.

Generic mechanisms

ExternalReference

Explain which information systems may be connected to buildings (and building units) and what kind of information may be found.

For instance:

- cadastral register: information about owner(s), evaluation of building
- dwelling register: information about type of dwelling (number of rooms) and comfort elements (toilets, type of heating …)
- database of buildings receiving public : type of building, capacity, …

Document

Explain which kinds of document are generally available.

For instance:

- sketch of each floor for all buildings
- construction permits for buildings after 1980
- photos of façade for noticeable buildings

Extendable code lists

Some code lists in theme BU are extendable. In case a producer adds some possible values to one or several of these code lists, these values must be documented (by definition and possibly description)

Any other useful information

Add in this paragraph any other information you consider helpful for users (and not already included in the INSPIRE specification or in previous paragraphs of this template or in other metadata elements).

Annex F
(informative)
Extension of INSPIRE Buildings model

F.1 Introduction - Context

As a general rule, the INSPIRE application schemas may be extended by data providers, under conditions given in the Generic Conceptual Model, i.e. only if the extension does not break any of the INSPIRE requirements.

This data specification offers two extended profiles, one for 2D (or 2,5D) data and one for 3D data. These extended profiles may and even should be used by data providers, willing to provide more information than the information included in the normative core profiles. For instance, a data provider who wants to replace its current products by INSPIRE themes will have to supply all its data through an INSPIRE conformant model.

The INSPIRE extended profiles may be applied as a whole but also aim to be a “reservoir” of proposals for extensions of core INSPIRE profile, i.e. only a selection of proposed feature types and attributes may be added. The two methods are described in next chapter.

Extended 2D profile includes many concepts coming mainly from cadastral/official information systems. Typically, it is expected that most cadastral/official organisation will adopt (at least partly) the feature types and attributes proposed in the extended profile, taking into account the possible restrictions/adaptations due to national regulations (e.g. privacy issues). It concerns for instance building units, official area, official value, address, connections to networks.

For extended profiles both 2D and 3D include also some detailed topographic data (e.g. height and number of floors for the underground part of building, roof type, materials, installations) and even walls, roof, openings, rooms, textures in case of 3D profile; the main purpose is to encourage data producers to capture this information in future. Of course, it is also expected that the possibilities of extension will be used soon, but likely by very few data providers (as few data is available until now).

INSPIRE data specifications will evolve in future; of course, the concepts that are now in the extended profile might be candidates for inclusion in the normative profile, during the future updates of INSPIRE specifications.

The other extension mechanism relates to the code lists; some INSPIRE code lists are extendable, either “narrower” or “any”. Examples of such extensions are provided in last chapter of this annex.

F.2 Extension of INSPIRE UML application schema

F.2.1 Using whole schema

Data providers may use the extended application schemas provided in this document, either extended 2D or extended 3D profiles.
These INSPIRE application schemas are formal extensions of the core profiles, i.e. they inherit from the application schemas of core profile. The inheritance mechanism ensures that all requirements from core profile have been imported into the extended profile, and so, that the extension has been done respecting the rules given in the Generic Conceptual Model.
Consequently, a data provider supplying its data according to an INSPIRE *Buildings* extended profile will be automatically conformant to the Implementing Rule related to theme *Buildings*.

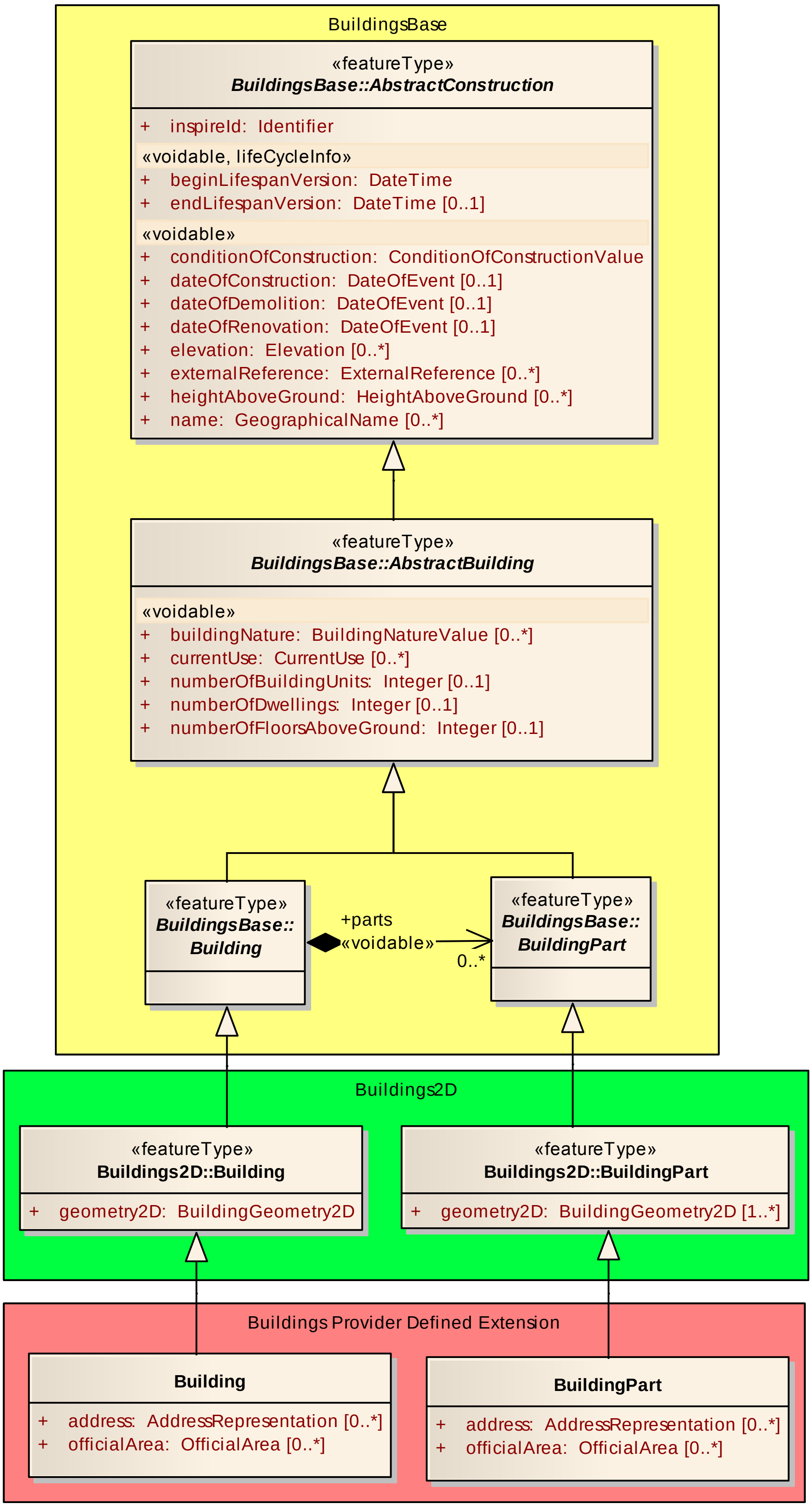
Advantage: the schema is used as it is; so, no modelling effort is required from data provider.
Drawback: data provider and data users have to handle whole extended schema; this may add complexity for data transformation (e.g. dealing with unpopulated features and attributes) and for daily use of data (manipulating a big model).

This option is quite suitable if data provider has a significant ratio of the additional concepts offered by the INSPIRE extended profiles.

F.2.2 Using extract of extended schema

Data providers may define their own extension, by importing (and so inheriting) one of the core profiles and by adding attributes or even features based on the concepts given in the INSPIRE extended profiles, in order to include in this home-made extension only the data they have.

EXAMPLE: A provider of cadastral data wants to supply only additional attributes address and official area as additional elements of core 2D profile. This may be done as shown in figure below.



Data producer extension importing <Buildings 2D> and using INSPIRE <Buildings Extended2D> concepts.

Data provider must do some modelling effort to design its home-made extended application schema.

Drawback: Data provider must do some modelling effort to design its home-made extended application schema. Data users that expect standardised datasets will need to be able to deal with different schemas, depending on the data producer.
Advantage: Data providers and data users will only need to deal with a reasonably compact application schema, as the additional parts only include the populated attributes. This option is suitable if data provider has only few extra-content in addition to the core profiles.

F.3 Extension of INSPIRE code lists

Some of the code lists included in Buildings application schemas are extendable by Member States ; it is for instance, in core profiles, the case of the code lists regarding classification of Building (CurrentUseValue and BuildingNature).

F.3.1 Hierarchical code list (CurrentUseValue)

Code list CurrentUseValue has a hierarchical structure and may be extended only by giving more detailed level; this is expressed in Feature Catalogue by extensibility being “narrower”.

EXAMPLE:
The hierarchic code list related to currentUse might be extended, giving for instance more details under value agriculture.

- residential
  - Individual
  - Collective
    - twoDwellings
    - moreThanTwoDwellings
- agriculture
  - **culture**
  - **breeding**
  - **storage**
- industry
- commercesAndServices
  - office
  - retail
  - publicService
- ancillary

In this case, a mechanism should be set up to ensure that a user requiring buildings whose currentUse is “agriculture” would also receive buildings whose currentUse is “culture”, “breeding” and “storage”.

F.3.2 Other code lists

The other INSPIRE code lists that are not hierarchical and that are extendable may be extended both by giving more details under a current value or by giving other values independent from the ones that are in the INSPIRE code list. In case of giving more details, a mechanism to retrieve child values from parent ones must be implemented.

EXAMPLE: the code list for attribute buildingNature might be extended as follow

- …
- storageTank
- synagogue
- temple
- tower
  - **controlTower**

    - **lookoutTower**
    - **clockTower**
    - **coolingTower**
    - **communicationTower**
- windmill
- windTurbine
- windmill
- **kiosk**
- **phoneBooth**
- **busShelter**
- …

F.3.3 Code lists in extended schemas

Note that code lists in extended schemas have obligation set to “Technical Guidelines”. As the extended application schema itself, the code lists are not normative but only recommendations. Consequently; most of them have also extensibility set to “any”; however, some code lists may have extensibility set to “none” in case extending the code list would break the consistency in the list of possible values. This is typically the case of the code list related to official area and based on the CLGE standard: the code list is not extendable at all but the model offers the possibility to use another code list.

Annex G
(informative)
Acknowledgements

G.1 As-is analysis

Person	Organisation	Product	Country
WG on CadastreINSPIREd	EuroGeographics – Permanent Committee on Cadastre	Cadastre data	Europe
Julius Ernst	Federal office of Surveying and Metrology (BEV).	Digital Cadastral Map (DKM)	Austria
Frederic Mortier	General Administration of Patrimonial Documentation	CadMap - CaBu	Belgium
Frederic Mortier	NGI (Nationaal Geografisch Insituut) IGN (Institut Géographique National)	ITGI VRef	Belgium
Frederic Mortier	NGI (Nationaal Geografisch Insituut) IGN (Institut Géographique National)	ITGI VGen	Belgium
Frederic Mortier	NGI (Nationaal Geografisch Insituut) IGN (Institut Géographique National)	TOP250v-GIS	Belgium
Geoffroy Detry	Comité Technique de Cartographie de la Région wallonne (SPW)	PICC	Belgium
Frederic Mortier	GIS-Flanders (AGIV)	GRB	Belgium
Frederic Mortier	Brussels Region Informatics Center (BRIC)	UrbIS Adm, UrbIS Top and UrbIS Map	Belgium
Karen Skeljo	FOT (municipalities) and KMS	FOT + BDR	Denmark
Hanno Kuus	Estonian Land Board	Estonian National Topographic Database	Estonia
Mare Braun	Ministry of Economic Affairs and Communications	Register of Construction Works	Estonia
Laurent Breton	Institut Géographique National	BD UNI , BD TOPO	France
Grégoire Maillet	Institut Géographique National	Bâti 3D	France
Gerhard Gröger	Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany (AdV) –	AAA project (ALKIS-AFIS-ATKIS), unified model for cadastre (ALKIS) and topography (ATKIS)	Germany

Zsuzsanna Ferencz	Institute of Geodesy, Cartography and Remote Sensing	Land Administration-cadastral map	Hungary
Bronislovas Mikuta	State Enterprise Centre of Registers (SECR)	Real property cadastre DB Real property cadastral map	Lithuania
Frank Kooij	Kadaster (Netherlands' Cadastre, Land Registry, and Mapping Agency)	National Registers of Addresses and Buildings (BAG)	Netherlands
Lars Mardal Morten Borrebaek	Geovekst (Norwegian Mapping Authorithy in cooperation with other public authorithies)	FKB-Bygning (Base Data Building	Norway
Ewa Wysocka	GUGiK (Head Office of Geodesy and Cartography)	EGiB (Land and Building Cadastre) – cadastral data TOPO/TBD (Topographical database) – topographical data	Poland
Adriana Padureanu	Romania-National Agency for Cadastre and Land Registration(NACLR)	E-terra **(**cadastre and land book) INTRAVILAN (census)	Romania
Adriana Padureanu	Minister of Regional Development and Tourism	SISDIEBU **(**estate domain and urban data base)	Romania
Martina Behulakovia	Geodesy, Cartography and Cadastre Authority of the Slovak Republic	CSKN (Centrálny systém katastra nehnuteľností) and ZB GIS (Topographic database GIS)	Slovakia
Tomas Petek	Surveying and Mapping Authority of the Republic of Slovenia	Building cadastre database	Slovenia
Amalia Velasco	Spanish Directorate General for Cadastre, - Ministry of Economy and Finance	Spanish Cadastre	Spain
Eddie Bergström	National Land Survey	Grunddata Byggnad (Base Data Building)	Sweden
Marc Nicodet	Swiss cadastral surveying	Federal Directorate of Cadastral Surveying	Switzerland
Simon Barlow	Ordnance Survey	MasterMap Topography Layer	Great Britain
Simon Barlow	Local Government Information House	National Land and Property Gazetteer	England and Wales

G.2 User requirements

Person	Organisation	Result
	EEA (European Environmental Agency)	Joint meeting with TWG BU
Julián Álvarez Gallego	ADIF (Administrador de Infraestructuras Ferroviarias).	Check-list about railway building management

	Dirección de Patrimonio y Urbanismo.	
Giorgio Arduino	Regione Piemonte, DG ENV	Check-list about air quality monitoring and assessment
Olivier Banaszak	Direction of Urban Studies and Prospective – Le Havre City	Check-list about urban studies –Le Havre
Dolors Barrot	CENG (Specialised Commission for Geographic Standards)	Check-list about Urban Topographic database - Spain
Jose I. Barredo	Floods Action, IES, JRC	Check-list about implementation of Flood Directive in Europe
François Belanger	INVS (Institute of Health Monitoring) - France	Check-list about Health studies - France
Laurent Breton	Vector database Service - Institut Géographique National - France	Check-list about accurate land cover - France
Bert Boterbergh	Agency for Roads and Traffic, Flemish Government - Belgium	Check-list about ADA Road database - Belgium
Eric Cajoly	Marketing Unit - Institut Géographique National - France	Check-list about Territoire 3D - France
Aline Clozel	Community of Agglomeration Avignon - France	Check-list about Habitat – Avignon-France
Marie-Christine Combes	Direction of Urbanism – Paris municipality - France	Check-list about urbanism in Paris - France
Antony Cooper	Commission on Geospatial Data Standards – International Cartographic Association	Contribution to check-list crowd-sourcing for INSPIRE
Jerôme Cortinovis	Air Normand - France	Check-list about air quality – Normandy - France
A. Czerwinski	IGG, University of Bonn, coordinator of Noise emission simulation and mapping implementation in North Rhine Westphalia	Check-list about Implementation of EU Environmental Noise Directive in North Rhine Westphalia
Matthijs Danes	Alterra Wageningen UR	Check-list about effects of city on temperature and air quality
Tom De Groeve	Joint Research Centre of the European Commission	Check-list about risk analysis and loss estimation for wind storms
Laurent Delgado	Consulting Unit - Institut Géographique National - France	Check-lists : - Urban Units (for Statistical Institute) - Efficiency of antenna (for telecommunication company) - Population grid for television coverage (for (National Council of Audiovisual).
Jean-Luc Déniel	SHOM (Hydrographic and Oceanograpic Service of Navy)	Check-list about safety of marine navigation
Alexandra Delgado Jiménez	Observatory on Sustainability in Spain (OSE)/Studies of location of new services	Check-list about architecture and urban planning - Spain
Yannick Depret	Marketing Unit - Institut Géographique National - France	List of possible use cases - France
Ekkehard Petri	Statistical Office of the European Communities - DG Eurostat -Unit D.2 - Geographical Information LUXEMBOURG	Check-list about GISCO data base
M Foote	Willis Research Network	Check list about insurance
Jean-Marie Fournillier	Grand Lyon - France	Check-list about Grand Lyon
Julien Gaffuri	Joint Research Centre (JRC) -	Check-list about research projects

	European Commission Contact point for TWG BU	- urban analysis - simulation of urban development Check-list about Waste Water Treatment Directive
Jean-François Girres	COGIT (Research Laboratory) – Institut Géographique National - France	Check-list about OpenStreetMap
Bruno Gourgand	CERTU (Centre for Studies on Transport, Network, Urbanism and Public Constructions) - France	List of possible use cases + contact points - France
Silvio Granzin	Federal environment agency Austria, department for Contaminated Sites, Vienna	Check-list about Register of potentially contaminated sites, Austria
Cédric Grenet	Community of municipalities Seine Valley – Caux region - France	Check-list about 3D models
G. Gröger	Project leader of project to implement tool for estimation of solar potential of roof surfaces, at IGG, University of Bonn	Check-list about Sun Exposure Calculation for Roof Surfaces
Anders Grönlund	Lantmäteriet - Sweden	Check-list about flood forecasting
Mark Halliwell	UK Hydrographic Office	Check-list about marine charts
Javier Hervás	Land Management and Natural Hazards Unit Institute for Environment and Sustainability Joint Research Centre (JRC) - European Commission	Check-list about landslide risk
Jan Hjelmager	Commission on Geospatial Data Standards – International Cartographic Association	Contribution to check-list crowd-sourcing for INSPIRE
Hanne Moller Jensen	Region Zealand - Denmark	Check list about earth pollution.
Hooft Elise	Flemish Heritage Institute (Vlaams Instituut voor het Onroerend Erfgoed)	Check-list about inventory of architectural Heritage in the Flemish Region
Kenneth Ibsen	Agency for Spatial and Environmental Planning - Denmark	Check-list about modelling and monitoring wastewater discharge - Denmark
INSPIRE TWG Production and Industrial Facilities	INSPIRE TWG Production and Industrial Facilities	Check-list about industrial risk
Yolène Jahard	Consulting Unit – Institut Géographique National - France	Check-list about valorisation of patrimony for railway company.
Frédérique Janvier	SOeS - Ministry of Sustainable Development - France	Check-list about environmental statistics
Laurent Jardinier	CERTU (Centre for Studies on Transport, Network, Urbanism and Public Constructions) - France	Check-list about sustainable transport - France
Steffen Kuntz	geoland2 project	Check-list about Urban Atlas
Gregor Kyi	Eurostat – Census unit	Check-list about census of population and dwellings
Jean-Christopher Lambert	Belgian Institute for Space Aeronomy (IASB-BIRA)	Check-list about atmospheric Research - Belgium
Gerard Leenders	Land Registry and Mapping Agency, Netherlands	Check-list about EULIS

Luc Lefebvre	CNES (French Spatial Agence)	Check-list about stratospheric balloons - France
Marc Léobet	MIG (Mission of Geographic Information) - France	Check-list about Risk management - France
Matthew Longman	Ashfield District Council - UK	Check-list about Local Authority Refuse Collection - UK
Josefa Lopez Barragán	INE (National Statistics Institute)	Check-list about Population and Housing Census - Spain
David Ludlow	Centre for Research in Sustainable Planning and Environments – UK (?)	Check-list about Urban sprawl – EEA initiative
José Ramón Martinez Cordero	Subdirección General de Dominio Público Marítimo-Terrestre. Secretaría General del Mar. Ministerio de Medio Ambiente y Medio Rural y Marino.	Check-list about protection of coastal areas - Spain
Johan Mortier	Elia	High voltage power line management - Belgium
Susana Munoz	Gas Natural Fenosa - Spain	Check-list about database for gas and electricity management - Spain
Anne Nærvig-Petersen	Statistics Denmark	Check-list about Housing inventory- Denmark
Ana-Maria Olteanu	France Telecom	Check-list about implementation of new antennas for mobile phone.
Nicolas Paparoditis	MATIS (Research Laboratory on Images) - Institut Géographique National - France	Check-list about façade thermography
Simon Parkinson	Smart Industry Design Team - Iberdrola-ScottishPower	Check-list about energy retail – supply
Véronique Pereira	Consulting Unit - Institut Géographique National - France	Check-lists : - obstacles for air transport (for SIA -Service of Aeronautical Information) - easements for air transport (for STBA Technical Service of Aerial Bases) - Noise maps (for CSTB Centre Technical Security of Buildings) - Sun exposure (for electricity companies)
Manuela Pfeiffer	State agency for agriculture, environment and rural areas of the state Schleswig-Holstein - Germany	Check-list about implementation of Flood Directive in Germany
Odile Rascol	INSEE (National Statistical Institute) - France	Check-list about buildings for census
Marianne Ronsbro	Region Zealand - Denmark	Check list about earth pollution.
Jean-Pierre Sabatier	CUB Bordeaux (Community of Agglomeration) – France	Check-list about roof thermography - France
François Salgé	Ministry of Sustainable Development - France Facilitator TWG LU	Check-list about GéoPLU (France) and plan4all (Europe)
Marc Salvador Segarra	General Directorate of Department of the Interior, institutional relations and participation, Generalitat de Catalunya - Spain	Check-lists: -security and emergency – Spain - prevention, extinction of fires and bailouts and rescues
David Sánchez Blázquez	Programa de Impulso al Urbanismo en Red - Spain	Check-list about “urbanismo en red”

Per Sandqvist	Lantmäteriet - Sweden	Check-list about blue lights services
Jesus San Miguel	JRC FOREST Action (European Forest Fire Information System – EFFIS) :	Check-list about forest fire risk
Tristan Saramon	IBERDROLA RENOVABLES FRANCE.	Check-list about new wind farms
Claudia Secco	Regione Piemonte Department of Environment	Check-list about noise map calculation
Markus Seifert	Facilitator of INSPIRE TWG PS	Check-list about protection of historic buildings
J. Steinrücken	IGG, Univ. of Bonn, project leader of several bicycle and tourism route planning tools/portals - Germany	Check-list about tourism/leisure - Germany
Yvan Strubbe	Flemish public transport company (VVM De Lijn)	Check-list about scheduling of public transport. (new bus stops) - Belgium
Karl-Erik Svensson	National Board of Housing, Building and Planning	Check-list about Energy Performance of Building Directive (EPDB)
Fabio Taucer	Joint Research Centre, ELSA Unit, IPSC, European Commission	Check-list about Seismic risk analysis and loss estimation.
Guilllaume Touya	COGIT (Research Laboratory) – Institut Géographique National - France	Check-list about OpenStreetMap
Gaspar Valls Solé	Office of Urbanism and economic activities. Diputació de Barcelona (Barcelona Provincial Council)- Spain	Check-lists: - location of economic activities – Spain - SITMUN project: Municipal Territorial Information System Barcelona
Miet Van Den Eeckhaut	Land Management and Natural Hazards Unit- Institute for Environment and Sustainability Joint Research Centre (JRC) - European Commission	Check-list about landslide risk
Frans van der Storm	Program manager X-border-GDI (Netherlands – Germany)	Check-list about X-Border GDI applications (risk atlas, spatial planning)
Ana Velasco	CartoCiudad project- (National Geographic Institute of Spain- National Center of Geographic Information CNIG).	Check-list about CartoCiudad project - Spain
Maarten Vermeyen	Flemish Heritage Institute (Vlaams Instituut voor het Onroerend Erfgoed)	Check-list about inventory of architectural Heritage in the Flemish Region
François Virevialle	Mapping Unit – Institut Géographique National - France	Check-list about historic and archaeological GIS in Bordeaux
Magnus Walestad	Statistics Sweden	Check-list about building permits as indication for economic forecasts
Scott Wilson	EUROCONTROL	Check-list about Air Traffic Management