GUIDELINES for OptEEmAL CityGML Input Files

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1 Introduction

CityGML is a common semantic information model for the representation of 3D urban objects that can be shared over different applications. The latter capability is especially important with respect to the cost-effective sustain-able maintenance of 3D city models, allowing the possibility of selling the same data to customers from different application fields. The targeted application areas explicitly include city planning, architectural design, tourist and leisure activities, environmental simulation, mobile telecommunication, disaster management, homeland security, real estate management, vehicle and pedestrian navigation, and training simulators.

CityGML is designed as an open data model and XML-based format for the storage and exchange of virtual 3D city models. It is implemented as an application schema of the Geography Markup Language 3 (GML3), the extendible international standard for spatial data exchange and encoding issued by the Open Geospatial Consortium (OGC) and the ISO TC211. CityGML is based on a number of standards from the ISO 191xx family, the Open Geospatial Consortium, the W3C Consortium, the Web 3D Consortium, and OASIS.

CityGML defines the classes and relations for the most relevant topographic objects in cities and regional models with respect to their geometrical, topological, semantical, and appearance properties. "City" is broadly defined to comprise not just built structures, but also elevation, vegetation, water bodies, "city furniture", and more. Included are generalization hierarchies between thematic classes, aggregations, relations between objects, and spatial properties. CityGML is applicable for large areas and small regions and can represent the terrain and 3D objects in different levels of detail simultaneously. Since either simple, single scale models without topology and few semantics or very complex multi-scale models with full topology and fine-grained semantical differentiations can be represented, CityGML enables lossless information exchange between different GIS systems and users (Gröger *et al.* 2012).

Initiatives such as CityGML Quality Interoperability Experiment (Wagner and Ledoux 2016) aim to define data quality requirements for a general CityGML data specification. They have created recommended implementation guidance for CityGML encoded 3D data, and provided a suite of tools to carry out quality assurance on CityGML data.

Within OptEEmAL project, a CityGML model is needed for each project. One of the needs of the CityGML is when matching IFC buildings and buildings in CityGML. In addition, the geometry and semantic information contained in the CityGML model is also used in the simulation. In order to have correct and valid CityGML files, a set of guidelines have been defined in order to use in OptEEmAL project.

This document describes the set of rules that all CityGML files used as input to the OptEEmAL platform should comply to. These rules should be followed by the designer of the CityGML files

2 Software tools for CityGML
2.1 Modelling tools

Currently there are several tools available that can be used in order to create CityGML models. Some of the tools are freely available and others are commercial. Besides, most common GIS-based tools and CAD-based applications support CityGML export. However, none of the tools provides a full support to the standard and a result empty of errors is not guaranteed by any of the tool.

The list of tools that can be used for modelling is quite large, but the most used are the following ones:

TOOL NAME	DESCRIPTION
FME Desktop	FME Desktop is a flexible and powerful spatial ETL toolset used to quickly translate, transform and integrate data. https://www.safe.com/fme/fme-desktop/
CityEditor	SketchUp extension CityEditor by 3DIS GmbH allows import, editing and export of CityGML models using SketchUp
3dfier	Open Source software that takes 2D GIS datasets and "3dfies" them by lifting each polygon to its height (obtained with LiDAR). Outputs CityGML
Building Reconstruction	VirtualCitySystem. BuildingReconstruction requires digital surface and terrain models as well as 2D building floors plans and reconstructs valid 3D models. http://www.virtualcitysystems.de/en/products/buildingreconstruction
novaFACTORY 3D Pro	Is designed for automated broad scale generation of 3D building with roof structures from building footprints and LiDAR points clouds. https://www.moss.de/wp-content/uploads/2016/04/novaFACTORY_3DPRO.pdf

2.2 CityGML Viewers

The following tools can be used in order to visualize CityGML models.

TOOL NAME	DESCRIPTION
FZKViewer	FZKViewer visualises the sematic data models IFC, CityGML und gbXML. Supported Versions: IFC 2x, IFC 2x2, IFC 2x3 and corresponding ifcXML; CityGML 0.4.0, CityGML 1.0.0, CityGML 2.0.0, ADE Noise, ADE Subsurface Structure, ADE Bridge. Open Source. Windows-based https://www.iai.kit.edu/1302.php
FME Inspector	The FME Data Inspector is a utility that allows viewing and saving -supported format. It is used primarily to preview data before translation and to verify it after the translation. https://www.safe.com/transformers/inspector/

3 Requirements

3.1 REQ_01: File is compliant with the CityGML Standard

REQUIREMENT	VALIDATION TEST	ERROR MESSAGE	MANDATORY / OPTIONAL
The CityGML file must be XML valid	4.1	XML NOT valid + ERROR MESSAGE	Mandatory
The CityGML file must be validated against the XSD schema	4.2	Not XSD compliant + ERROR MESSAGE	Mandatory
The CityGML file must not contain empty lines	NOT IMPLEMENTED		Mandatory

3.1.1 The CityGML file must be XML valid.

Most of text editors and 3D city modeling tools do validate the XML files.

3.1.2 The CityGML file must be validated against the XSD schema.

The CityGML file must be validated against the XSD schema: http://schemas.opengis.net/citygml/

As an example the CityGML file of the following figure is not compliant with XSD schema, because the yearOfConstruction parameter is not in the correct place within the XML:

```
 4  <core:cityObjectMember>
 5  <grp:CityObjectGroup gml:id='_Prueba58_BD.R1MmiKAkPrPDMisLYpG4'>
 6   <gml:name>4 DE MARZO</gml:name>
 7  <grp:groupMember>
 8  <bldg:Building gml:id='_Prueba58_BD.R1MmiKAkPrPDMisLYpG4_BP.5cFavKhrUdduOFEmuens'>
 9   <gml:description>Subtype 1: Linear block with North-South orientation</gml:description>
10   <gml:name>Building_3-5Turina St.</gml:name>
11   <gen:stringAttribute name='@cityeditor:layer'><gen:value>3D_Building</gen:value></gen:stringAt
12   <bldg:yearOfConstruction>1960</bldg:yearOfConstruction>
13   <bldg:function>1000</bldg:function>
14   <bldg:usage>1000</bldg:usage>
15   <bldg:roofType>1030</bldg:roofType>
16   <bldg:measuredHeight uom='m'>17.3</bldg:measuredHeight>
17   <bldg:storeysAboveGround>5</bldg:storeysAboveGround>
18   <bldg:storeysBelowGround>0</bldg:storeysBelowGround>
19   <bldg:storeyHeightsAboveGround uom='m'>3</bldg:storeyHeightsAboveGround>
20   </bldg:Building>
21  </grp:groupMember>
22  </grp:CityObjectGroup>
```

In the XSD schema the order that each tag must follow is indicated:

```
      The name will be represented by gml:name (inherited from _GML) . list order for storeyHeightsAboveground: f
      order for storeyHeightsBelowground: first floor below ground, second floor below ground,... The lodXMultiSu
      of a building is just a collection of surfaces bounding a solid, but not a topologically clean solid bounda
      boundaries.
  </xs:documentation>
</xs:annotation>
<xs:element name="class" type="gml:CodeType" minOccurs="0"/>
<xs:element name="function" type="gml:CodeType" minOccurs="0" maxOccurs="unbounded"/>
<xs:element name="usage" type="gml:CodeType" minOccurs="0" maxOccurs="unbounded"/>
<xs:element name="yearOfConstruction" type="xs:gYear" minOccurs="0"/>
<xs:element name="yearOfDemolition" type="xs:gYear" minOccurs="0"/>
<xs:element name="roofType" type="gml:CodeType" minOccurs="0"/>
<xs:element name="measuredHeight" type="gml:LengthType" minOccurs="0"/>
<xs:element name="storeysAboveGround" type="xs:nonNegativeInteger" minOccurs="0"/>
<xs:element name="storeysBelowGround" type="xs:nonNegativeInteger" minOccurs="0"/>
<xs:element name="storeyHeightsAboveGround" type="gml:MeasureOrNullListType" minOccurs="0"/>
<xs:element name="storeyHeightsBelowGround" type="gml:MeasureOrNullListType" minOccurs="0"/>
<xs:element name="lod0FootPrint" type="gml:MultiSurfacePropertyType" minOccurs="0"/>
<xs:element name="lod0RoofEdge" type="gml:MultiSurfacePropertyType" minOccurs="0"/>
<xs:element name="lod1Solid" type="gml:SolidPropertyType" minOccurs="0"/>
<xs:element name="lod1MultiSurface" type="gml:MultiSurfacePropertyType" minOccurs="0"/>
<xs:element name="lod1TerrainIntersection" type="gml:MultiCurvePropertyType" minOccurs="0"/>
```

In the following figure a CityGML file that is XSD schema valid is presented:

```
 4  <core:cityObjectMember>
 5  <grp:CityObjectGroup gml:id='_Prueba58_BD.R1MmiKAkPrPDMisLYpG4'>
 6   <gml:name>4 DE MARZO</gml:name>
 7  <grp:groupMember>
 8  <bldg:Building gml:id='_Prueba58_BD.R1MmiKAkPrPDMisLYpG4_BP.5cFavKhrUdduOFEmuens'>
 9   <gml:description>Subtype 1: Linear block with North-South orientation</gml:description>
10   <gml:name>Building_3-5Turina St.</gml:name>
11   <gen:stringAttribute name='@cityeditor:layer'><gen:value>3D_Building</gen:value></gen:stringAtt
12   <bldg:function>1000</bldg:function>
13   <bldg:usage>1000</bldg:usage>
14   <bldg:yearOfConstruction>1960</bldg:yearOfConstruction>
15   <bldg:roofType>1030</bldg:roofType>
16   <bldg:measuredHeight uom='m'>17.3</bldg:measuredHeight>
17   <bldg:storeysAboveGround>5</bldg:storeysAboveGround>
18   <bldg:storeysBelowGround>0</bldg:storeysBelowGround>
19   <bldg:storeyHeightsAboveGround uom='m'>3</bldg:storeyHeightsAboveGround>
20  </bldg:Building>
21  </grp:groupMember>
22  </grp:CityObjectGroup>
23  </core:cityObjectMember>
```

3.1.3   The CityGML file must not contain empty lines.

The CityGML file must not contain empty lines

In the previous version of the CityGML file of 4 de Marzo, the model contains empty lines in the file.

```
 1   <?xml version="1.0" encoding="utf-8"?>
 2   <!-- Exported with 3DIS GmbH (http://www.3dis.de) CityEditor 2.6.1.720 -->
 3   <!-- Date: 2016-12-29 16:12:09 +0100 ModelName: unnamed ModelPath: d:\Documents\02_OptEEmAL\4 M
 4
 5
 6
 7   <core:CityModel xmlns:core="http://www.opengis.net/citygml/2.0" xmlns:xAL="urn:oasis:names:tc:c
 8    <gml:name>VALLADOLID (SPAIN) LOD2</gml:name>
 9
10   <core:cityObjectMember>
11
12   <grp:CityObjectGroup gml:id="_Prueba58_BD.RlMmiKAkPrPDMisLYpG4">
13
14
15    <gml:name>4 DE MARZO</gml:name>
16   <app:appearance>
17   <app:Appearance>
18   <app:surfaceDataMember>
19   <app:X3DMaterial>
20    <app:ambientIntensity>0.2</app:ambientIntensity>
21    <app:diffuseColor>0.8392156862745098 0.8392156862745098 0.8392156862745098</app:diffuseColor>
22    <app:emissiveColor>0.0 0.0 0.0</app:emissiveColor>
23    <app:specularColor>1.0 1.0 1.0</app:specularColor>
24    <app:shininess>0.2</app:shininess>
25    <app:transparency>0.0</app:transparency>
26    <app:isSmooth>false</app:isSmooth>
```

Tools such as Notepad++ have functionalities that allow removing the empty lines. Edit → Line operations → Remove empty lines

3.2   REQ_02: CityGML version 2.0

REQUIREMENT	VALIDATION TEST	ERROR MESSAGE	MANDATORY / OPTIONAL
The CityGML file must be version 2.0	NOT IMPLEMENTED		Mandatory

3.2.1   The CityGML file must be version 2.0.

Not valid file:

```
 1   <?xml version="1.0" encoding="UTF-8" ?>
 2   <core:CityModel xmlns="http://www.opengis.net/citygml/profiles/base/1.0" xmlns:core="http://www.opengis.net/citygml/1.0" xmlns:bldg="
     http://www.opengis.net/citygml/building/1.0" xmlns:grp="http://www.opengis.net/citygml/cityobjectgroup/1.0"
 3   xmlns:app="http://www.opengis.net/citygml/appearance/1.0" xmlns:gml="http://www.opengis.net/gml" xmlns:xAL=
     "urn:oasis:names:tc:ciq:xsdschema:xAL:2.0" xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:xsi="
     http://www.w3.org/2001/XMLSchema-instance" xmlns:frn="http://www.opengis.net/citygml/cityfurniture/1.0"
 4   xmlns:wtr="http://www.opengis.net/citygml/waterbody/1.0"
 5   xmlns:dem="http://www.opengis.net/citygml/relief/1.0" xmlns:luse="http://www.opengis.net/citygml/landuse/1.0"
 6   xmlns:veg="http://www.opengis.net/citygml/vegetation/1.0"
 7   xmlns:tran="http://www.opengis.net/citygml/transportation/1.0"  xmlns:gen="http://www.opengis.net/citygml/generics/1.0"
 8   xsi:schemaLocation="http://www.opengis.net/citygml/1.0 http://schemas.opengis.net/citygml/1.0/cityGMLBase.xsd
     http://www.opengis.net/citygml/appearance/1.0 http://schemas.opengis.net/citygml/appearance/1.0/appearance.xsd
     http://www.opengis.net/citygml/building/1.0 http://schemas.opengis.net/citygml/building/1.0/building.xsd
 9   http://www.opengis.net/citygml/cityfurniture/1.0 http://schemas.opengis.net/citygml/cityfurniture/1.0/cityFurniture.xsd
     http://www.opengis.net/citygml/vegetation/1.0 http://schemas.opengis.net/citygml/vegetation/1.0/vegetation.xsd
     http://www.opengis.net/citygml/generics/1.0 http://schemas.opengis.net/citygml/generics/1.0/generics.xsd
10   http://www.opengis.net/citygml/transportation/1.0 http://schemas.opengis.net/citygml/transportation/1.0/transportation.xsd
     http://www.opengis.net/citygml/waterbody/1.0 http://schemas.opengis.net/citygml/waterbody/1.0/waterBody.xsd
     http://www.opengis.net/citygml/landuse/1.0 http://schemas.opengis.net/citygml/landuse/1.0/landUse.xsd
     http://www.opengis.net/citygml/relief/1.0 http://schemas.opengis.net/citygml/relief/1.0/relief.xsd">
11   <gml:boundedBy>
```

Valid file:

```
1    <?xml version="1.0" encoding="utf-8"?>
2  ⊟<core:CityModel xmlns:core="http://www.opengis.net/citygml/2.0" xmlns:xAL="urn:oasis:names:tc:ciq:xsdschema:xAL:2.0" xmlns:app=
     "http://www.opengis.net/citygml/appearance/2.0" xmlns:brid="http://www.opengis.net/citygml/bridge/2.0" xmlns:bldg=
     "http://www.opengis.net/citygml/building/2.0" xmlns:frn="http://www.opengis.net/citygml/cityfurniture/2.0" xmlns:grp=
     "http://www.opengis.net/citygml/cityobjectgroup/2.0" xmlns:gen="http://www.opengis.net/citygml/generics/2.0" xmlns:luse=
     "http://www.opengis.net/citygml/landuse/2.0" xmlns:dem="http://www.opengis.net/citygml/relief/2.0" xmlns:tran=
     "http://www.opengis.net/citygml/transportation/2.0" xmlns:tun="http://www.opengis.net/citygml/tunnel/2.0" xmlns:veg=
     "http://www.opengis.net/citygml/vegetation/2.0" xmlns:wtr="http://www.opengis.net/citygml/waterbody/2.0" xmlns:tex=
     "http://www.opengis.net/citygml/texturedsurface/2.0" xmlns:gml="http://www.opengis.net/gml" xmlns:xal=
     "urn:oasis:names:tc:ciq:xsdschema:xAL:2.0" xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language" xmlns:smil20=
     "http://www.w3.org/2001/SMIL20/" xmlns:wfs="http://www.opengis.net/wfs" xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:xsi=
     "http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.opengis.net/citygml/2.0
     http://schemas.opengis.net/citygml/2.0/cityGMLBase.xsd http://www.opengis.net/citygml/appearance/2.0
     http://schemas.opengis.net/citygml/appearance/2.0/appearance.xsd http://www.opengis.net/citygml/bridge/2.0
     http://schemas.opengis.net/citygml/bridge/2.0/bridge.xsd http://www.opengis.net/citygml/building/2.0
     http://schemas.opengis.net/citygml/building/2.0/building.xsd http://www.opengis.net/citygml/cityfurniture/2.0
     http://schemas.opengis.net/citygml/cityfurniture/2.0/cityFurniture.xsd http://www.opengis.net/citygml/cityobjectgroup/2.0
     http://schemas.opengis.net/citygml/cityobjectgroup/2.0/cityObjectGroup.xsd http://www.opengis.net/citygml/generics/2.0
     http://schemas.opengis.net/citygml/generics/2.0/generics.xsd http://www.opengis.net/citygml/landuse/2.0
     http://schemas.opengis.net/citygml/landuse/2.0/landUse.xsd http://www.opengis.net/citygml/relief/2.0
     http://schemas.opengis.net/citygml/relief/2.0/relief.xsd http://www.opengis.net/citygml/transportation/2.0
     http://schemas.opengis.net/citygml/transportation/2.0/transportation.xsd http://www.opengis.net/citygml/tunnel/2.0
     http://schemas.opengis.net/citygml/tunnel/2.0/tunnel.xsd http://www.opengis.net/citygml/vegetation/2.0
     http://schemas.opengis.net/citygml/vegetation/2.0/vegetation.xsd http://www.opengis.net/citygml/waterbody/2.0
     http://schemas.opengis.net/citygml/waterbody/2.0/waterBody.xsd http://www.opengis.net/citygml/texturedsurface/2.0
     http://schemas.opengis.net/citygml/texturedsurface/2.0/texturedSurface.xsd">
```

3.3   REQ_03: Buildings must be represented in LoD2

| REQUIREMENT	VALIDATION TEST	ERROR MESSAGE	MANDATORY / OPTIONAL
Every real building must be represented as a building in the CityGML	User Acceptance Test (UAT)		Mandatory
Buildings must be represented in LoD2	4.5	Building are NOT in LoD2 + ERROR MESSAGE	Mandatory

3.3.1   Every real building must be represented as a building in the CityGML

Each IFC model must have a building in CityGML associated and both buildings need to represent the same.
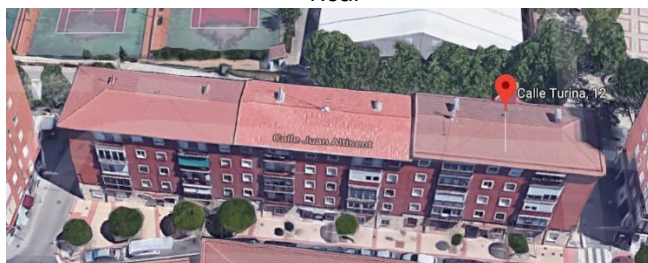
As can be seen in the figures below:

- Antzieta 23. Donostia → 1 portal = 1 building
- Turina 12-16. Valladolid → 3 portals = 1 building

Antzieta 23 - Donostia
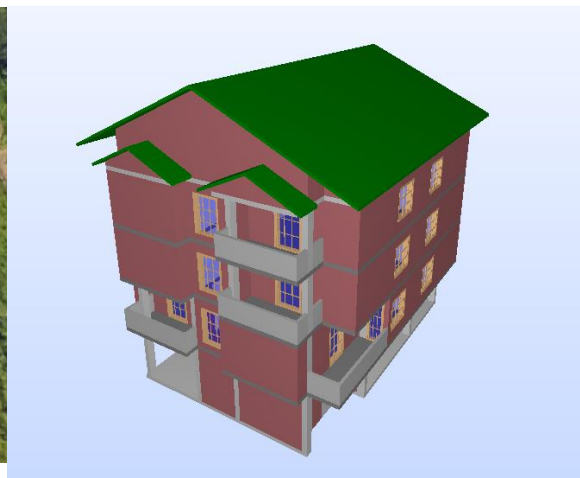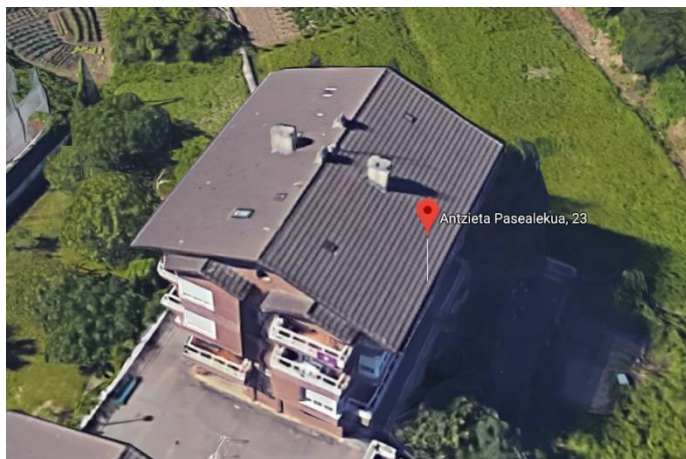
Real   IFC

Turina 12-16. Valladolid
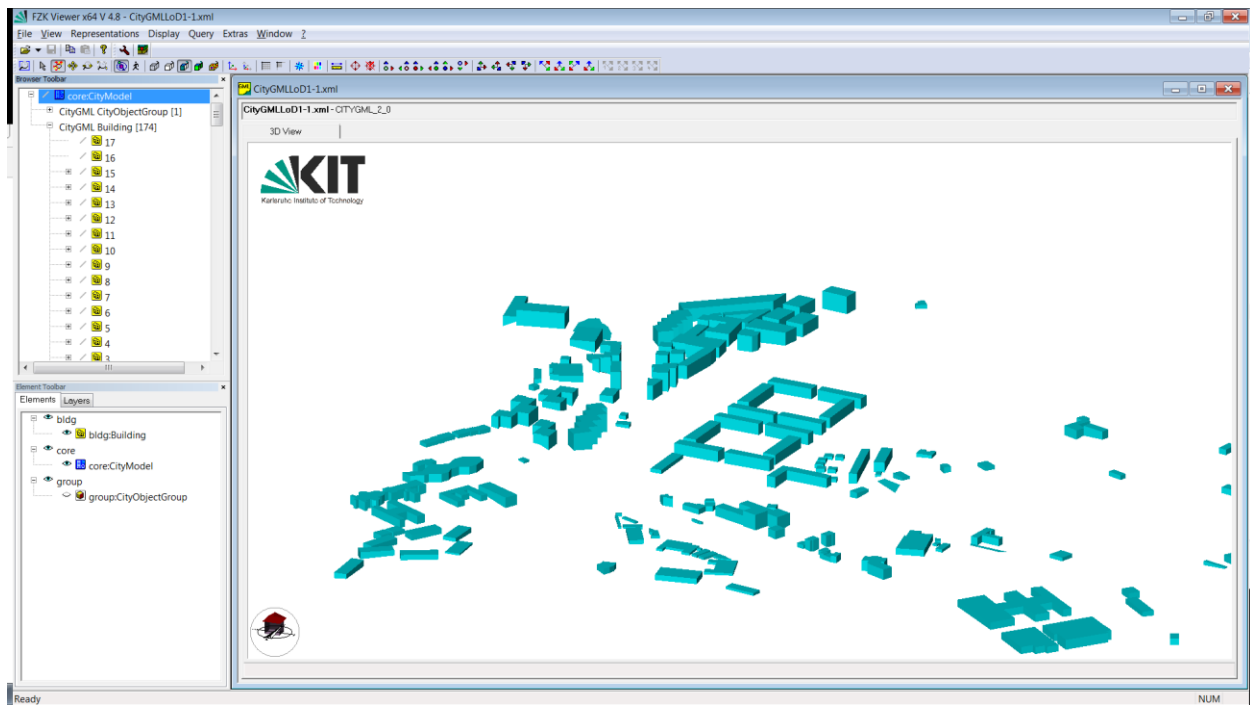
Real   IFC

3.3.2   Buildings must be represented in LoD2

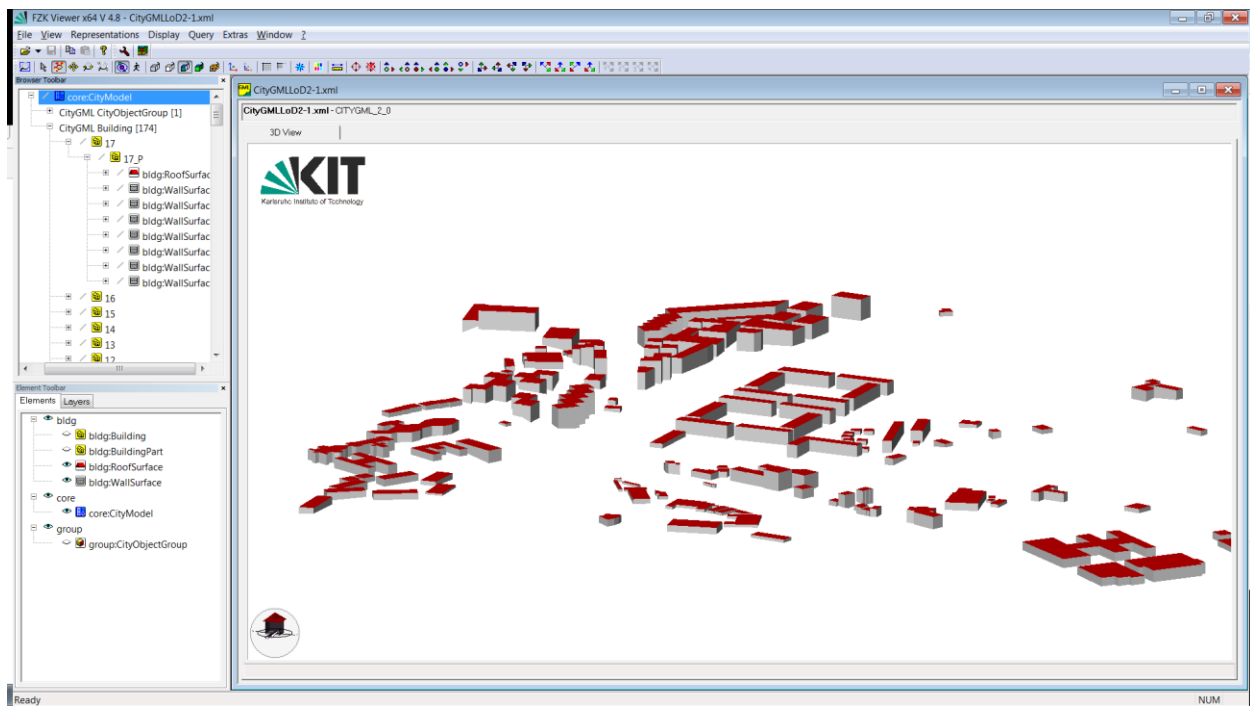All buildings within the CityGML file need to have geometry represented by bldg:lod2Solid or bldg:lod2MultiSurface.

In LoD2 boundary surfaces (walls, roofs, ground, etc.) are semantically represented, while in LoD1 is not.

CityGML in LoD1:

CityGML in LoD2:

```
409     <gml:name>8495006a_P</gml:name>
410     <bldg:measuredHeight uom="urn:ogc:def:uom:UCUM::m">14.649200397829162</bldg:measuredHeight>
411     <bldg:lod2Solid>
412     <gml:Solid>
413     <gml:exterior>
414     <gml:CompositeSurface>
415     <gml:surfaceMember xlink:href="PolyID7347_4407_3140_2312"/>
416     <gml:surfaceMember xlink:href="PolyID8509_9515_5735_962"/>
417     <gml:surfaceMember xlink:href="PolyID3765_1824_6149_8362"/>
418     <gml:surfaceMember xlink:href="PolyID3977_4302_1881_9774"/>
419     <gml:surfaceMember xlink:href="PolyID648_8186_6527_3541"/>
420     <gml:surfaceMember xlink:href="PolyID7705_1944_8836_6529"/>
421     <gml:surfaceMember xlink:href="PolyID6859_1608_5801_6158"/>
422     <gml:surfaceMember xlink:href="PolyID5904_7299_7411_4346"/>
423     <gml:surfaceMember xlink:href="PolyID1798_3384_1469_842"/>
424     <gml:surfaceMember xlink:href="PolyID2051_3925_1810_2126"/>
425     <gml:surfaceMember xlink:href="PolyID7797_9077_1102_4788"/>
426     </gml:CompositeSurface>
427     </gml:exterior>
428     </gml:Solid>
429     </bldg:lod2Solid>
430     <bldg:boundedBy>
431     <bldg:WallSurface>
432     <bldg:lod2MultiSurface>
433     <gml:MultiSurface>
434     <gml:surfaceMember>
435     <gml:Polygon gml:id="PolyID7347_4407_3140_2312">
436     <gml:exterior>
437     <gml:LinearRing>
438     <gml:pos>584226.4473299832 4795142.885436246 5.04670290382672</gml:pos>
439     <gml:pos>584226.4473299832 4795142.885436246 18.81930469230769</gml:pos>
440     <gml:pos>584236.400530374 4795138.036266865 18.81930469230769</gml:pos>
441     <gml:pos>584236.400530374 4795138.036266865 4.248805775334477</gml:pos>
442     <gml:pos>584226.4473299832 4795142.885436246 5.04670290382672</gml:pos>
443     </gml:LinearRing>
444     </gml:exterior>
445     </gml:Polygon>
446     </gml:surfaceMember>
```

## 3.4 REQ_04: Avoid representing other city elements than buildings

REQUIREMENT	VALIDATION TEST	ERROR MESSAGE	MANDATORY / OPTIONAL
Only buildings must be represented in the CityGML	NOT IMPLEMENTED		Optional

3.4.1 Only buildings must be represented in the CityGML

Only buildings are used in OPTEEMAL, so other elements, such as roads, green areas or rivers should not be included in the CityGML. The representation of more elements than those required will make the file larger and difficult to manage.

The representation of the terrain (DTM) should not also be included in the CityGML for the same reason.

CityGML file with other city elements than buildings:
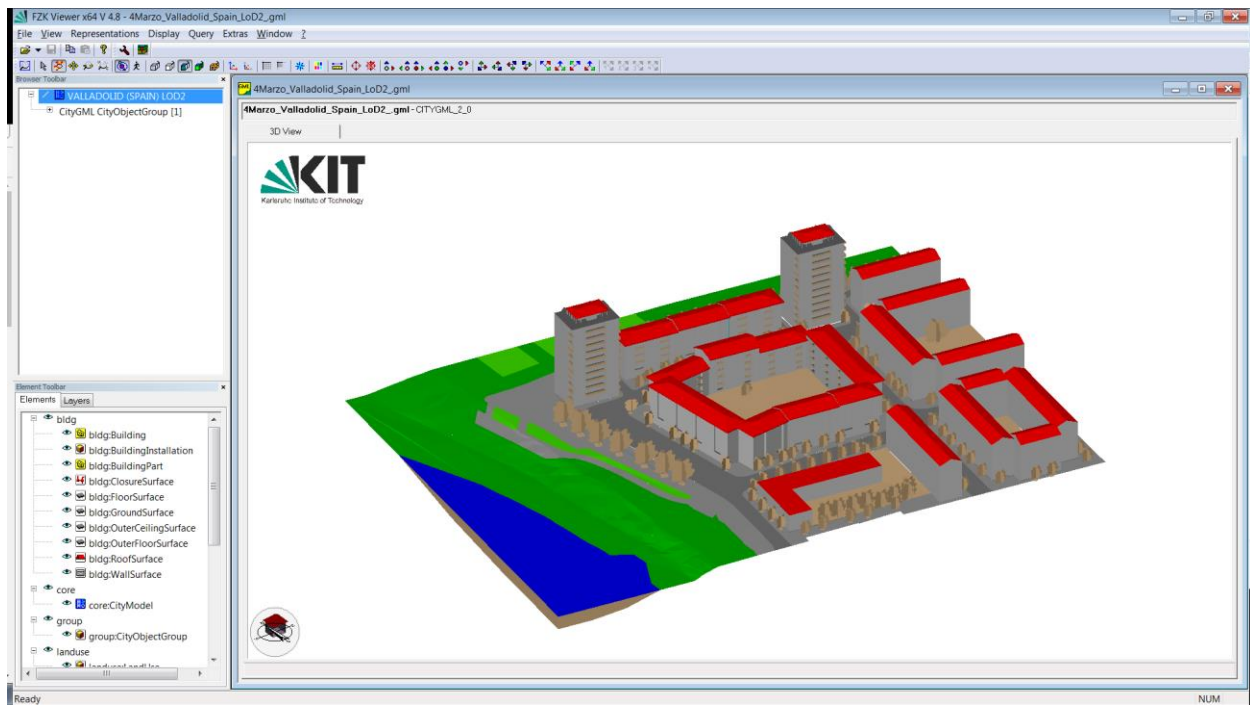
CityGML file with only buildings:
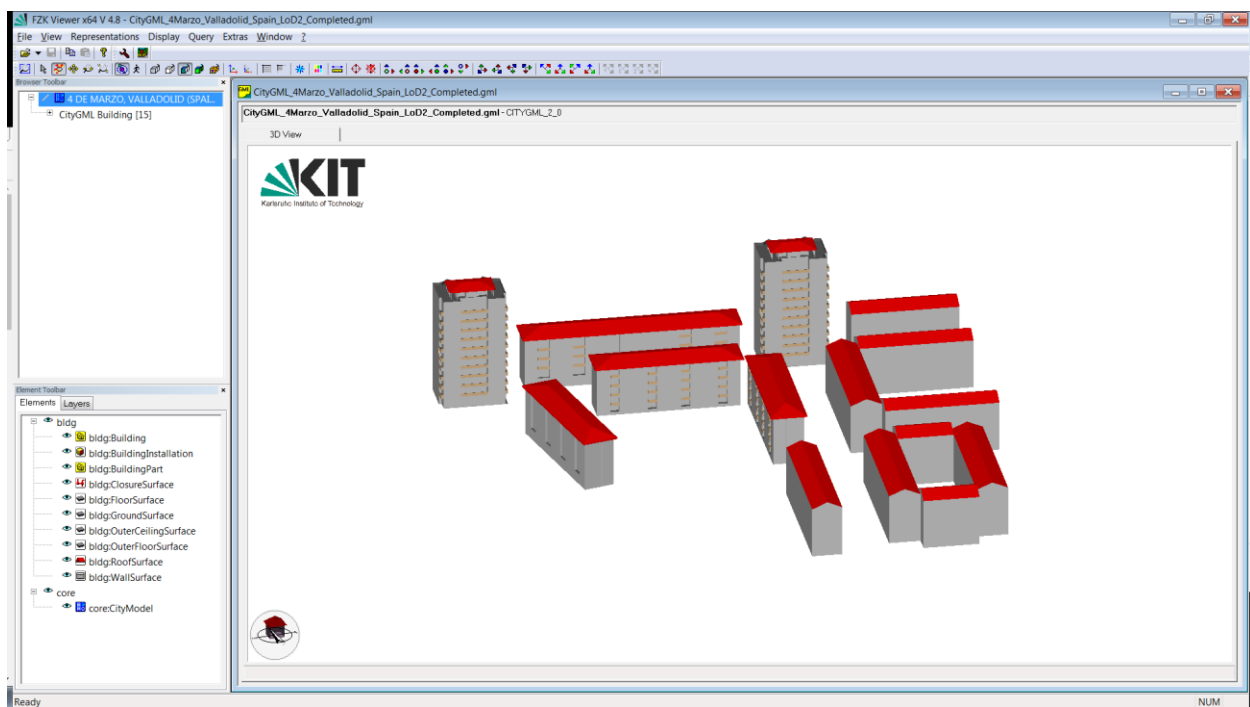
3.5   REQ_05: Avoid geometrical errors

REQUIREMENT	VALIDATION TEST	ERROR MESSAGE	MANDATORY / OPTIONAL
The CityGML file must not have two consecutive equal points.	4.6	Two Consecutive equal points + ERROR MESSAGE	Mandatory
The CityGML file must have the first and last points that are equal.	4.7	First and Last points NOT equal + ERROR MESSAGE	Mandatory

Examples of most common geometrical errors are:

3.5.1 The CityGML file must not have two consecutive equal points.

Not valid:

```
27  <gml:Polygon gml:id='_4Marzo_v04_BD.tYJ3Z3Dwbed1xaENEFlY_
28  <gml:exterior>
29  <gml:LinearRing>
30  <gml:posList srsDimension='3'>
31  355007.573 4610894.867 708.3
32  355006.869 4610890.422 706.3
33  355006.869 4610890.422 706.3
34  355040.909 4610885.031 706.3
35  355041.613 4610889.475 708.3
36  355007.573 4610894.867 708.3
37  </gml:posList>
38  </gml:LinearRing>
39  </gml:exterior>
40  </gml:Polygon>
```

Valid:

```
27  <gml:Polygon gml:id='_4Marzo_v04_BD.tYJ3Z3Dwbed1xaENEFlY_BP.C
28  <gml:exterior>
29  <gml:LinearRing>
30  <gml:posList srsDimension='3'>
31  355007.573 4610894.867 708.3
32  355006.869 4610890.422 706.3
33  355040.909 4610885.031 706.3
34  355041.613 4610889.475 708.3
35  355007.573 4610894.867 708.3
36  </gml:posList>
37  </gml:LinearRing>
38  </gml:exterior>
39  </gml:Polygon>
```

3.5.2   The CityGML file must have the first and last points that are equal.

Not valid:

```
27   <gml:Polygon gml:id='_4Marzo_v04_BD.tYJ3Z3DwbedlxaENEFlY_BP
28   <gml:exterior>
29   <gml:LinearRing>
30   <gml:posList srsDimension='3'>
31    355007.573 4610894.867 708.3
32    355006.869 4610890.422 706.3
33    355040.909 4610885.031 706.3
34    355041.613 4610889.475 708.3
35   </gml:posList>
36   </gml:LinearRing>
37   </gml:exterior>
38   </gml:Polygon>
```

Valid:

```
27   <gml:Polygon gml:id='_4Marzo_v04_BD.tYJ3Z3DwbedlxaENEFlY_BP.C
28   <gml:exterior>
29   <gml:LinearRing>
30   <gml:posList srsDimension='3'>
31    355007.573 4610894.867 708.3
32    355006.869 4610890.422 706.3
33    355040.909 4610885.031 706.3
34    355041.613 4610889.475 708.3
35    355007.573 4610894.867 708.3
36   </gml:posList>
37   </gml:LinearRing>
38   </gml:exterior>
39   </gml:Polygon>
```

3.6   REQ_06: Simple geometry representation

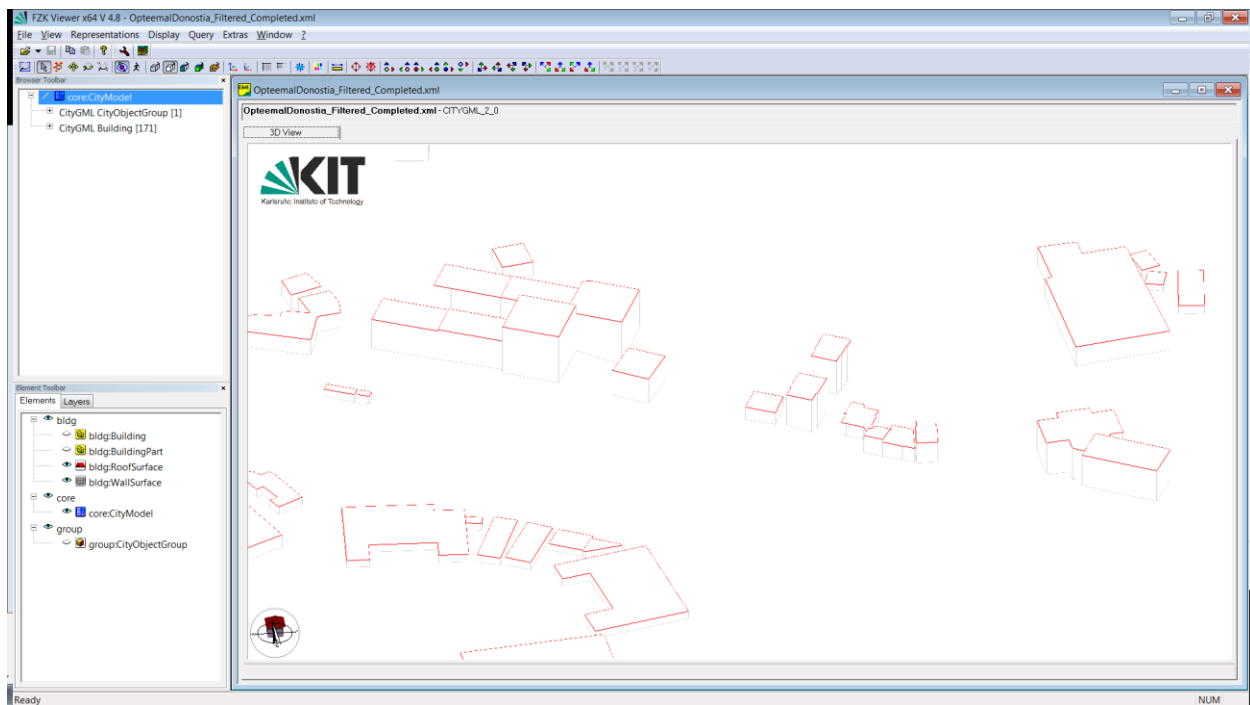| REQUIREMENT	VALIDATION TEST	ERROR MESSAGE	MANDATORY / OPTIONAL
Simple geometry representation in CityGML	NOT IMPLEMENTED		Optional

3.6.1   Simple geometry representation in CityGML

Details in geometrical representation should be avoided. The number of polygons used to represent elements in CityGML should be minimized.

CityGML file with too much geometrical detail:
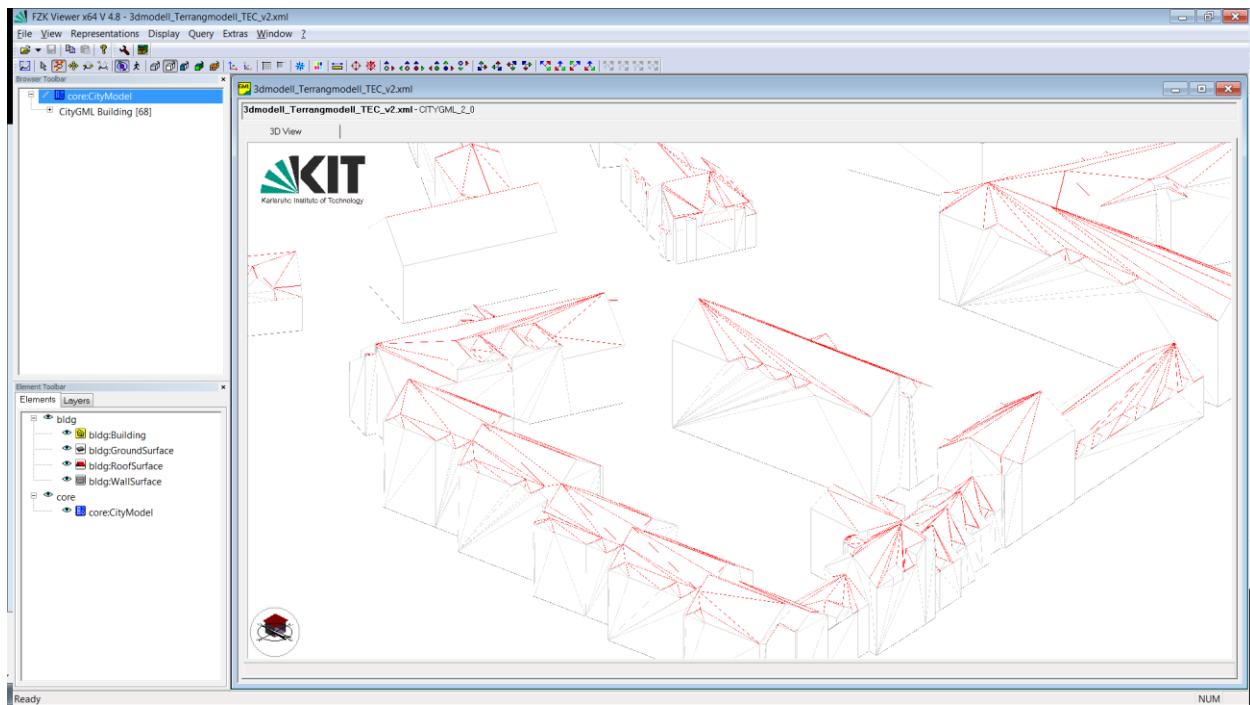
CityGML file with less geometrical detail:

3.7   REQ_07: Use codetypes defined or define new ones

REQUIREMENT	VALIDATION	ERROR MESSAGE	MANDATORY /

	TEST	OPTIONAL
Validate codetypes in CityGML	4.8	Not valid codetypes + Mandatory ERROR MESSAGE

3.7.1 Validate codetypes in CityGML

The codetypes of the parameters function, use and class within buildings must be valid. The codetypes can be found in https://www.sig3d.org/codelists/standard/building/2.0/ or in the CityGML 2.0 specification in page 244.

CityGML XSD schema codetypes:

CityGML file with NOT valid codetypes

```
11  <bldg:Building gml:id='_4Marzo_v04_BD.tYJ3Z3Dwbed1xaENEFlY_BP.OfRQPXbXeNg
12   <gml:description>Subtype 1: Linear block with North-South orientation</gm
13   <gml:name>Building_3-5Turina St.</gml:name>
14   <bldg:function>8000</bldg:function>
15   <bldg:usage>4321</bldg:usage>
16   <bldg:yearOfConstruction>1960</bldg:yearOfConstruction>
17   <bldg:roofType>1234</bldg:roofType>
18   <bldg:measuredHeight uom='m'>17.3</bldg:measuredHeight>
19   <bldg:storeysAboveGround>5</bldg:storeysAboveGround>
20   <bldg:storeysBelowGround>0</bldg:storeysBelowGround>
21   <bldg:storeyHeightsAboveGround uom='m'>3</bldg:storeyHeightsAboveGround>
```

CityGML file with valid codetypes

```
11  <bldg:Building gml:id='_4Marzo_v04_BD.tYJ3Z3Dwbed1xaENEF1Y_BP.OfRQPXbXeNq3
12    <gml:description>Subtype 1: Linear block with North-South orientation</gml
13    <gml:name>Building_3-5Turina St.</gml:name>
14    <bldg:function>1000</bldg:function>
15    <bldg:usage>1000</bldg:usage>
16    <bldg:yearOfConstruction>1960</bldg:yearOfConstruction>
17    <bldg:roofType>1030</bldg:roofType>
18    <bldg:measuredHeight uom='m'>17.3</bldg:measuredHeight>
19    <bldg:storeysAboveGround>5</bldg:storeysAboveGround>
20    <bldg:storeysBelowGround>0</bldg:storeysBelowGround>
21    <bldg:storeyHeightsAboveGround uom='m'>3</bldg:storeyHeightsAboveGround>
```

3.8 REQ_08: CityGML file must be correctly georeferenced

REQUIREMENT	VALIDATION TEST	ERROR MESSAGE	MANDATORY / OPTIONAL
CityGML file georeferenced	User Acceptance Test (UAT)		Mandatory

3.8.1 CityGML file georeferenced

CityGML file must be correctly georeferenced, it cannot be represented in local coordinates as CAD or BIM tools do.

In the previous version of the CityGML file of 4 de Marzo, the model wasn't georeferenced.

```
102  <bldg:Building gml:id="_Prueba58_BD.R1MmiKAkPrPDMisLYpG4_BP.5cFavKhrUdduOFEmuens">
103    <gml:description>Subtype 1: Linear block with North-South orientation</gml:description>
104    <gml:name>Building_3-5Turina St.</gml:name>
105    <gen:stringAttribute name="@cityeditor:layer"><gen:value>3D_Building</gen:value></gen:stringAttribute>
106    <bldg:function>1000</bldg:function>
107    <bldg:usage>1000</bldg:usage>
108    <bldg:yearOfConstruction>1960</bldg:yearOfConstruction>
109    <bldg:roofType>1030</bldg:roofType>
110    <bldg:measuredHeight uom="m">17.3</bldg:measuredHeight>
111    <bldg:storeysAboveGround>5</bldg:storeysAboveGround>
112    <bldg:storeysBelowGround>0</bldg:storeysBelowGround>
113    <bldg:storeyHeightsAboveGround uom="m">3</bldg:storeyHeightsAboveGround>
114    <bldg:boundedBy>
115    <bldg:RoofSurface>
116    <bldg:lod2MultiSurface>
117    <gml:MultiSurface>
118    <gml:surfaceMember>
119    <gml:Polygon gml:id="_Prueba58_BD.R1MmiKAkPrPDMisLYpG4_BP.5cFavKhrUdduOFEmuens_PG.kUIsstJADZa7gjOHIWSZ">
120    <gml:exterior>
121    <gml:LinearRing>
122    <gml:posList srsDimension="3">
123    60.001 1.788 18.3
124    59.297 -2.657 16.3
125    93.337 -8.048 16.3
126    94.041 -3.604 18.3
127    60.001 1.788 18.3
128    </gml:posList>
129    </gml:LinearRing>
130    </gml:exterior>
131    </gml:Polygon>
132    </gml:surfaceMember>
133    </gml:MultiSurface>
134    </bldg:lod2MultiSurface>
```

3.9 REQ_09: The Envelope which bounds the urban area must be defined

REQUIREMENT	VALIDATION TEST	ERROR MESSAGE	MANDATORY / OPTIONAL
Envelope is defined in the CityGML	4.3	Envelope is NOT defined + ERROR MESSAGE	Mandatory

3.9.1   Envelope is defined in the CityGML

The CityGML file must contain a gml:Envelope tag indicating which is the coordinate reference system of the model.

```
<gml:boundedBy>
   <gml:Envelope srsName='urn:ogc:def:crs:EPSG::25830' srsDimension='3'>
      <gml:lowerCorner>354754.791 4610767.765 680.66</gml:lowerCorner>
      <gml:upperCorner>355140.377 4611018.055 728.36</gml:upperCorner>
   </gml:Envelope>
</gml:boundedBy>
```

4   Validations
4.1   XML valid document

The CityGML file must be XML valid.

XML validation			
URL	http://3dcity-test.tecnalia.com/TecnaliaTesting/rest/Servicios/CityGMLValidateXMLFromURI		
Method	POST		
Input		Output	
CityGML	URI to the CityGML file	XML	Output CORRECT: <RESULT>XML File is VALID</RESULT>
			Output ERROR: <ERROR>[ErrorMessage]</ERROR>

Test page: http://3dcity-test.tecnalia.com/TecnaliaTesting/CityGMLValidateXMLFromURI.html

4.2   Validate against XSD schema

The CityGML file must be validated against the XSD schema: http://schemas.opengis.net/citygml/

XSD validation			
URL	http://3dcity-test.tecnalia.com/TecnaliaTesting/rest/Servicios/CityGMLValidateXSDFromURI		
Method	POST		
Input		Output	
CityGML	URI to the CityGML file	XML	CORRECT: <RESULT>File is XSD scheme VALID</RESULT>
			ERROR: <ERROR>[ErrorMessage]</ERROR>

Test page: http://3dcity-test.tecnalia.com/TecnaliaTesting/CityGMLValidateXSDFromURI.html

4.3   The CityGML must have an Envelope tag indicating the coordinate reference system

The CityGML file must contain a gml:Envelope tag indicating which is the coordinate reference system of the model.

```
<gml:boundedBy>
   <gml:Envelope srsName='urn:ogc:def:crs:EPSG::25830' srsDimension='3'>
      <gml:lowerCorner>354754.791 4610767.765 680.66</gml:lowerCorner>
      <gml:upperCorner>355140.377 4611018.055 728.36</gml:upperCorner>
   </gml:Envelope>
</gml:boundedBy>
```

ValidationEnvelopeAndCRSExistFromURI			
URL	http://3dcity-test.tecnalia.com/TecnaliaTesting/rest/Servicios/ValidationEnvelopeAndCRSExistFromURI		
Method	POST		
	Input		Output
CityGML	URI to the CityGML file	XML	CORRECT: <RESULT>Envelope tag exit and CRS is defined</RESULT>
			ERROR: <ERROR>[ErrorMessage]</ERROR>

Test page: http://3dcity-test.tecnalia.com/TecnaliaTesting/ValidationEnvelopeAndCRSExistFromURI.html

4.4   CityGML version 2.0

The CityGML file must be version 2.0.

4.5   All building must have LoD2

All buildings within the CityGML file need to have geometry represented by bldg:lod2Solid or bldg:lod2MultiSurface.

ValidationLoD2ExistFromURI			
URL	http://3dcity-test.tecnalia.com/TecnaliaTesting/rest/Servicios/ValidationLoD2ExistFromURI		
Method	POST		
	Input		Output
CityGML	URI to the CityGML file	XML	CORRECT: <RESULT>LoD2 exist for all buildings</RESULT>
			ERROR: <ERROR>[ErrorMessage]</ERROR>

Test page: http://3dcity-test.tecnalia.com/TecnaliaTesting/ValidationLoD2ExistFromURI.html

4.6   Validate there are not two consecutive equal points

The CityGML file must not have two consecutive equal points.

ValidationTwoConsecutiveEqualFromURI			
URL	http://3dcity-test.tecnalia.com/TecnaliaTesting/rest/Servicios/ValidationTwoConsecutiveEqualFromURI		
Method	POST		
	Input		Output
CityGML	URI to the CityGML file	XML	CORRECT: CityGML file with all consecutive points different
			ERROR: <ERROR>[ErrorMessage]</ERROR>

Test page: http://3dcity-test.tecnalia.com/TecnaliaTesting/ValidationGeometryFirstAndLastEqualFromURI.html

4.7 The first and last points in the geometries must be equal

The CityGML file must have the first and last points that are equal.

ValidationGeometryFirstAndLastEqual			
URL	http://3dcity-test.tecnalia.com/TecnaliaTesting/rest/Servicios/ValidationGeometryFirstAndLastEqualFromURI		
Method	POST		
Input		Output	
CityGML	URI to the CityGML file	XML	CORRECT: CityGML file with all first and last points equal
			ERROR: <ERROR>[ErrorMessage]</ERROR>

Test page: http://3dcity-test.tecnalia.com/TecnaliaTesting/ValidationTwoConsecutiveEqualFromURI.html

4.8 Validate the building function, use and class codetypes

The codetypes of the parameters function, use and class within buildings must be valid.

ValidateCodetype			
URL	http://3dcity-test.tecnalia.com/TecnaliaTesting/rest/Servicios/ValidateCodetypeFromURI		
Method	POST		
Input		Output	
CityGML	URI to the CityGML file	XML	CORRECT: <RESULT>CityGML file Codetypes are VALID </RESULT>
			ERROR: <ERROR>[ErrorMessage]</ERROR>

Test page: http://3dcity-test.tecnalia.com/TecnaliaTesting/ValidateCodetypeFromURI.html

4.9 No empty lines

The CityGML file must not contain empty lines

4.10 Each building needs to have an independent geometry

All buildings in the reality must have an independent building within the CityGML file.

5 Other Services

5.1 Statistics of the CityGML file

Analyses the CityGML in order to know: the number of buildings, buildings with parameters, number of building parts and building parts with parameters.

Statistics of CityGML file			
URL	http://3dcity-test.tecnalia.com/TecnaliaTesting/rest/Servicios/CityGMLStatisticsFromURI		
Method	POST		
Input		Output	
CityGML	URI to the CityGML file	XML	CORRECT: <RESULT>.....</RESULT>
			ERROR: <ERROR>[ErrorMessage]</ERROR>

Test page: http://3dcity-test.tecnalia.com/TecnaliaTesting/CityGMLStatisticsFromURI.html

5.2   Create KML from CityGML file

Exports the geometry of the CityGML file to KML.

Create KML from CityGML			
URL	http://3dcity.tecnalia.com/TecnaliaTesting/rest/Servicios/CreateKML		
Method			
Input		Output	
CityGML	URI to the CityGML file	XML	CORRECT: <RESULT>.....</RESULT>
project	Project Name		ERROR: <ERROR>[ErrorMessage]</ERROR>
srs	Reference System		
outputFileName	Output File Name		

Test page: http://3dcity-test.tecnalia.com/TecnaliaTesting/CreateKMLFromURIOpteemal.html

5.3   Obtain building footprints from CityGML file

Obtains the geometry of the buildings footprint from the CityGML file

Obtain building footprints from CityGML file			
URL	http://3dcity-test.tecnalia.com/OpteemalFootprints/rest/Servicios/CityGMLBuildingFootprints		
Method			
Input		Output	
CityGML	URI to the CityGML file	XML	CORRECT: <BuildingsFootprints>.....</BuildingsFootprints>
			ERROR: <ERROR>[ErrorMessage]</ERROR>

Test page: http://3dcity-test.tecnalia.com/OpteemalFootprints/CityGMLBuildingFootprintsFromURI.html