OGC City Geography Markup Language (CityGML) Part 2: GML Encoding Standard

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i. Abstract

The CityGML 3.0 GML Encoding Standard presents the implementation-dependent, GML encoding of the concepts defined by the CityGML 3.0 Conceptual Model(CM) standard. Those concepts include 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 an implementation of the CityGML 3.0 Conceptual Model Standard. Table 1 maps requirements classes from the CityGML conceptual model into the implementation details documented in this standard.

Table 1. Conceptual Model Mapping

Conceptual Model	Section	GML Schema
ADE	Section 6.2	core.xsd
Appearance	Section 6.3	appearance.xsd
Bridge	Section 6.4	bridge.xsd
Building	Section 6.5	building.xsd
City Furniture	Section 6.6	cityFurniture.xsd
City Object Group	Section 6.7	cityObjectGroup.xsd
Construction	Section 6.8	construction.xsd
Core	Section 6.2	core.xsd
Dynamizer	Section 6.9	dynamizer.xsd
Generics	Section 6.10	generics.xsd
Land Use	Section 6.11	landUse.xsd
Point Cloud	Section 6.12	pointCloud.xsd
Relief	Section 6.13	relief.xsd
Transportation	Section 6.14	transportation.xsd
Tunnel	Section 6.15	tunnel.xsd
Vegetation	Section 6.16	vegetation.xsd
Versioning	Section 6.17	versioning.xsd
Water Body	Section 6.18	waterBody.xsd

ii. Keywords

The following are keywords to be used by search engines and document catalogues.

ogcdoc, OGC document, CityGML, 3D city models, GML, XML

iii. Preface

In order to achieve consensus on the basic entities, attributes, and relations of a 3D city model, a UML Conceptual Model, CityGML 3.0, was approved as an OGC standard in March, 2021. This model provides a unifying conceptual basis for city model encoding standards. This cityGML 3.0 XML Encoding Standard defines how those concepts should be realized using XML and GML technologies.

As an OGC standard, CityGML follows the OGC modular specification standard, OGC 08-131r3. Because of the breadth of CityGML, its conceptual model was divided into separate Requirements Classes, one for each subject area. This CityGML encoding similarly is divided into Requirements Classes which are then grouped into Parts. A Part may address multiple CityGML Requirements Classes but each Requirements Class is addressed in a single part. Because Requirements Classes may depend on other Requirements Classes the reader of this CityGML Part may need to conform to Requirements Classes in other Parts as well.

Note that this CityGML encoding standard is a standardization target of the CityGML 3.0 Conceptual Model Standard. Therefore this standard conforms to the Conformance Classes in that standard. Evidence of that conformance is provided in Appendix D. On the other hand, an application claiming conformance to this CityGML encoding standard must conform to the Requirements Classes contained in this standard.

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iv. Submitting organizations

The following organizations submitted this Document to the Open Geospatial Consortium (OGC):

Table 2. Submitting Organizations

Organization	Points of Contact
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v. Submitters

All questions regarding this submission should be directed to the editor or the submitters:

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Chapter 1. Scope

This Standard documents the OGC GML Implementation Specification (IS) for the CityGML 3.0 Conceptual Model. The CityGML 3.0 conceptual model is a Platform Independent Model (PIM). It defines concepts in a manner which is independent of any implementing technology. As such, the CityGML CM cannot be implemented directly. Rather, it serves as the base for Platform Specific Models (PSM). A PSM adds to the PIM the technology-specific details needed to fully define the CityGML model for use with a specific technology. The PSM can then be used to generate the schema and other artifacts needed to build CityGML 3.0 implementations.

This standard defines the PSMs and schemas for the CityGML 3.0 Implementation Specification (IS) for Geography Markup Language (GML) implemenations.

Chapter 2. Conformance

This standard defines an Implementation Specification which specifies how the CityGML 3.0 Conceptual Model should be implemented using Geography Markup Language (GML). The Standardization Target for this standard is:

1. Implementations of the CityGML 3.0 Conceptual Model using GML encodings.

2.1. Implementation Specifications

Implementation Specifications define how a Conceptual Model should be implemented using a specific technology. Conformant Implementation Specifications provide evidence that they are an accurate representation of the Conceptual Model. This evidence includes data demonstrating that the applicable criteria documented in the CityGML 3.0 CM Abstract Test Suite have been satisfied. That evidence is provided in Appendix D.

2.2. Conformance Classes

This standard identifies seventeen (17) conformance classes. One conformance class is defined for each GML schema. Each conformance class is defined by one requirements class. The tests in Annex A are organized by requirements class. So an implementation of the *Core* conformance class must pass all tests specified in Annex A for the *Core* requirements class.

Of these seventeen conformance classes, only the *Core* conformance class is mandatory. All other conformance classes are optional. In the case where a conformance class has a dependency on another conformance class, that conformance class should also be implemented.

Chapter 3. References

The following normative documents contain provisions that, through reference in this text, constitute provisions of OGC TBD. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of OGC TBD are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

- IETF: RFC 2045 & 2046, Multipurpose Internet Mail Extensions (MIME). (November 1996),

- IETF: RFC 3986, Uniform Resource Identifier (URI): Generic Syntax. (January 2005)

- INSPIRE: D2.8.III.2 Data Specification on Buildings – Technical Guidelines. European Commission Joint Research Centre.

- ISO: ISO 19101-1:2014, Geographic information - Reference model - Part 1: Fundamentals

- ISO: ISO 19103:2015, Geographic Information – Conceptual Schema Language

- ISO: ISO 19105:2000, Geographic information – Conformance and testing

- ISO: ISO 19107:2003, Geographic Information – Spatial Schema

- ISO: ISO 19108:2002/Cor 1:2006, Geographic information – Temporal schema — Technical Corrigendum 1

- ISO: ISO 19109:2015, Geographic Information – Rules for Application Schemas

- ISO: ISO 19111:2019, Geographic information – Referencing by coordinates

- ISO: ISO 19123:2005, Geographic information — Schema for coverage geometry and functions

- ISO: ISO 19156:2011, Geographic information – Observations and measurements

- ISO: ISO/IEC 19505-2:2012, Information technology — Object Management Group Unified Modeling Language (OMG UML) — Part 2: Superstructure

- ISO/IEC 19507:2012, Information technology — Object Management Group Object Constraint Language (OCL)

- ISO: ISO/IEC 19775-1:2013 Information technology — Computer graphics, image processing and environmental data representation — Extensible 3D (X3D) — Part 1: Architecture and base components

- Khronos Group Inc.: COLLADA – Digital Asset Schema Release 1.5.0

- OASIS: Customer Information Quality Specifications - extensible Address Language (xAL), Version v3.0

- OGC: The OpenGIS® Abstract Specification Topic 5: Features, OGC document 08-126

- OGC: The OpenGIS™ Abstract Specification Topic 8: Relationships Between Features, OGC document 99-108r2

- OGC: The OpenGIS™ Abstract Specification Topic 10: Feature Collections, OGC document 99-110

Chapter 4. Terms and Definitions

This document uses the terms defined in Sub-clause 5.3 of [OGC 06-121r8], which is based on the ISO/IEC Directives, Part 2, Rules for the structure and drafting of International Standards. In particular, the word "shall" (not "must") is the verb form used to indicate a requirement to be strictly followed to conform to this Standard.

For the purposes of this document, the following additional terms and definitions apply.

feature
abstraction of real world phenomena
NOTE Features are objects that have an identity that allows for distinguishing features from each other. Features can have spatial and non-spatial properties that describe the features in more detail. Spatial properties are properties that have a geometry from ISO 19107 as data type.
NOTE Features are denoted by the stereotype «FeatureType» in the CityGML 3.0 Conceptual Model.
[ISO 19101-1:2014, 4.1.11]

geometry
an ordered set of n-dimensional points in a given coordinate reference system; can be used to model the spatial extent or shape of a feature
NOTE Geometries are objects that can have an identity that allows for distinguishing geometries from each other. Geometries define the data types of spatial properties of features.
[OGC 15-107, modified]

top-level feature
a feature that represents one of the main components of 3D city models; can be further semantically and spatially decomposed and substructured into parts
NOTE Top-level features are denoted by the stereotype «TopLevelFeatureType» in the CityGML 3.0 Conceptual Model.
[CityGML Conceptual Model]

space
an entity of volumetric extent in the real world
NOTE Spaces can be spatially represented in different LODs and by different types of geometric objects.
NOTE Spaces are represented in the CityGML 3.0 Conceptual Model by those classes that are derived from the class AbstractSpace.
[CityGML Conceptual Model]

space boundary
an entity with areal extent in the real world. Space boundaries are objects that bound a Space. They also realize the contact between adjacent spaces.
NOTE Space boundaries can be spatially represented in different LODs and by different types of geometric objects.
NOTE Space boundaries are represented in the CityGML 3.0 Conceptual Model by those classes that are derived from the class AbstractSpaceBoundary.
[CityGML Conceptual Model]

city-object relation

a specific relation from the city object in which the relation is included to another city object
[CityGML Conceptual Model]

The following definitions were copied from the Conceptual Model specification. We need to decide which of them to keep also in this specification.

2D data
geometry of features is represented in a two-dimensional space
NOTE In other words, the geometry of 2D data is given using (X,Y) coordinates.
[INSPIRE D2.8.III.2, definition 1]

2.5D data
geometry of features is represented in a three-dimensional space with the constraint that, for each (X,Y) position, there is only one Z
[INSPIRE D2.8.III.2, definition 2]

3D data
Geometry of features is represented in a three-dimensional space.
NOTE In other words, the geometry of 2D data is given using (X,Y,Z) coordinates without any constraints.
[INSPIRE D2.8.III.2, definition 3]

application schema
A set of conceptual schema for data required by one or more applications. An application schema contains selected parts of the base schemas presented in the ORM Information Viewpoint. Designers of application schemas may extend or restrict the types defined in the base schemas to define appropriate types for an application domain. Application schemas are information models for a specific information community.
OGC Definitions Register at http://www.opengis.net/def/glossary/term/ApplicationSchema

codelist
A value domain including a code for each permissible value.

conceptual model
model that defines concepts of a universe of discourse
[ISO 19101-1:2014, 4.1.5]

conceptual schema

1. formal description of a conceptual model
   [ISO 19101-1:2014, 4.1.6]

2. base schema. Formal description of the model of any geospatial information. Application schemas are built from conceptual schemas.
   OGC Definitions Register at http://www.opengis.net/def/glossary/term/ConceptualSchema

Implementation Specification
Specified on the OGC Document Types Register at http://www.opengis.net/def/doc-type/is

levels of detail
quantity of information that portrays the real world

NOTE The concept comprises data capturing rules of spatial object types, the accuracy and the types of geometries, and other aspects of a data specification. In particular, it is related to the notions of scale and resolution.
[INSPIRE Glossary]

life-cycle information
set of properties of a spatial object that describe the temporal characteristics of a version of a spatial object or the changes between versions
[INSPIRE Glossary]

Platform (Model Driven Architecture)
the set of resources on which a system is realized.
[Object Management Group, Model Driven Architecture Guide rev. 2.0]

Platform Independent Model
a model that is independent of a spacific platform
[Object Management Group, Model Driven Architecture Guide rev. 2.0]

Platform Specific Model
a model of a system that is defined in terms of a specific platform
[Object Management Group, Model Driven Architecture Guide rev. 2.0]

Chapter 5. Conventions

5.1. Identifiers

The normative provisions in this document are denoted by the URI

http://www.opengis.net/spec/CityGML-2/3.0

All requirements and conformance tests that appear in this document are denoted by partial URIs relative to this base.

5.2. UML Notation

This standard is an implementation of the CityGML Conceptual Model (CM) Standard. The CityGML conceptual model was constructed using the Unified Modeling Language (UML). Exerpts from that model appear in this standard. The UML notations used are described in the diagram in Figure 1.
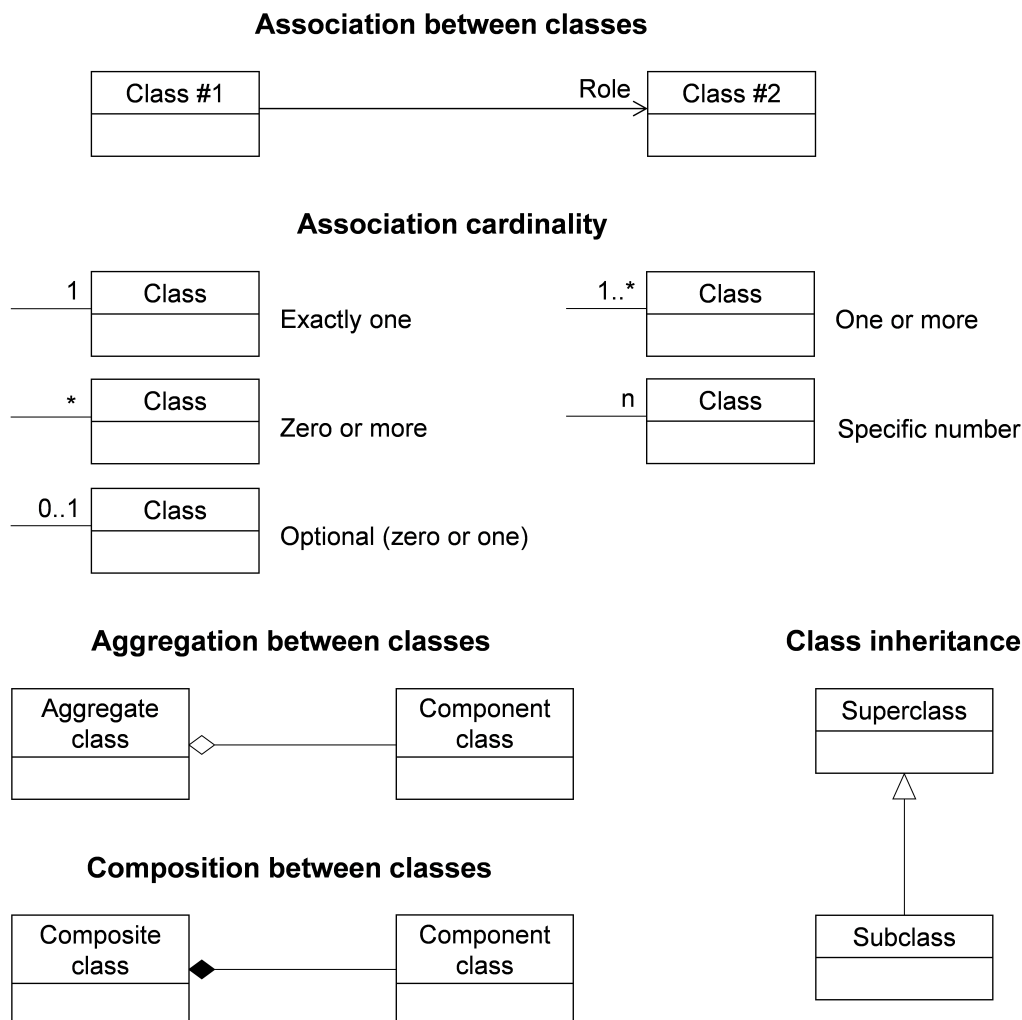
Figure 1. UML notation (see ISO TS 19103, Geographic information - Conceptual schema language).

All associations between model elements in the CityGML Conceptual Model are uni-directional. Thus, associations in the model are navigable in only one direction. The direction of navigation is depicted by an arrowhead. In general, the context an element takes within the association is

indicated by its role. The role is displayed near the target of the association. If the graphical representation is ambiguous though, the position of the role has to be drawn to the element the association points to.

The following stereotypes are used in the model:

- «ApplicationSchema» denotes a conceptual schema for data required by one or more applications. In the CityGML Conceptual Model, every module is defined as a separate application schema to allow for modularization.

- «FeatureType» represents features that are similar and exhibit common characteristics. Features are abstractions of real-world phenomena and have an identity.

- «TopLevelFeatureType» denotes features that represent the main components of the conceptual model. Top-level features may be further semantically and spatially decomposed and substructured into parts.

- «Type» denotes classes that are not directly instantiable, but are used as an abstract collection of operation, attribute and relation signatures. The stereotype is used in the CityGML Conceptual Model only for classes that are imported from the ISO standards 19107, 19109, 19111, and 19123.

- «ObjectType» represents objects that have an identity, but are not features.

- «DataType» defines a set of properties that lack identity. A data type is a classifier with no operations, whose primary purpose is to hold information.

- «Enumeration» enumerates the valid attribute values in a fixed list of named literal values. Enumerations are specified in the CityGML Conceptual Model.

- «BasicType» defines a basic data type.

- «CodeList» enumerates the valid attribute values. In contrast to Enumeration, the list of values is open and, thus, not given inline in the CityGML UML Model. The allowed values can be provided within an external code list.

- «Union» is a list of attributes. The semantics are that only one of the attributes can be present at any time.

- «Property» denotes attributes and association roles. This stereotype does not add further semantics to the conceptual model, but is required to be able to add tagged values to the attributes and association roles that are relevant for the encoding.

- «Version» denotes that the value of an association role that ends at a feature type is a specific version of the feature, not the feature in general.

In order to enhance the readability of the CityGML UML diagrams, classes are depicted in different colors. The following coloring scheme is applied:
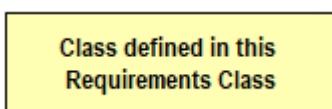
Classes painted in yellow belong to the Requirements Class which is subject of discussion in that clause of the standard in which the UML diagram is given. For example, in the context of [rc_core_section], which introduces the *CityGML Core* module, the yellow color is used to denote

classes that are defined in the *CityGML Core* Requirements Class. Likewise, the yellow classes shown in the UML diagram in [rc_building-model_section] are associated with the *Building* Requirements Class that is subject of discussion in that chapter.

Classes painted in blue belong to a Requirements Class different to that associated with the yellow color. In order to explicitly denote to which Requirements Class these classes belong, their class names are preceded by the UML package name of that Requirements Class. For example, in the context of the *Building* Requirements Class, classes from the *CityGML Core* and the *Construction* Requirements Classes are painted in blue and their class names are preceded by *Core* and *Construction*, respectively.

Classes painted in green are defined in the ISO standards 19107, 19111, or 19123. Their class names are preceded by the UML package name, in which the classes are defined.

Classes painted in grey are defined in the ISO standard 19109. In the context of this standard, this only applies to the class *AnyFeature*. *AnyFeature* is an instance of the metaclass *FeatureType* and acts as super class of all classes in the CityGML UML model with the stereotype «FeatureType». A metaclass is a class whose instances are classes.

The color white is used for notes and Object Constraint Language (OCL) constraints that are provided in the UML diagrams.

The example UML diagram in Figure 2 demonstrates the UML notation and coloring scheme used throughout this standard. In this example, the yellow classes are associated with the *CityGML Building* module, the blue classes are from the *CityGML Core* and *Construction* modules, and the green class depicts a geometry element defined by ISO 19107.
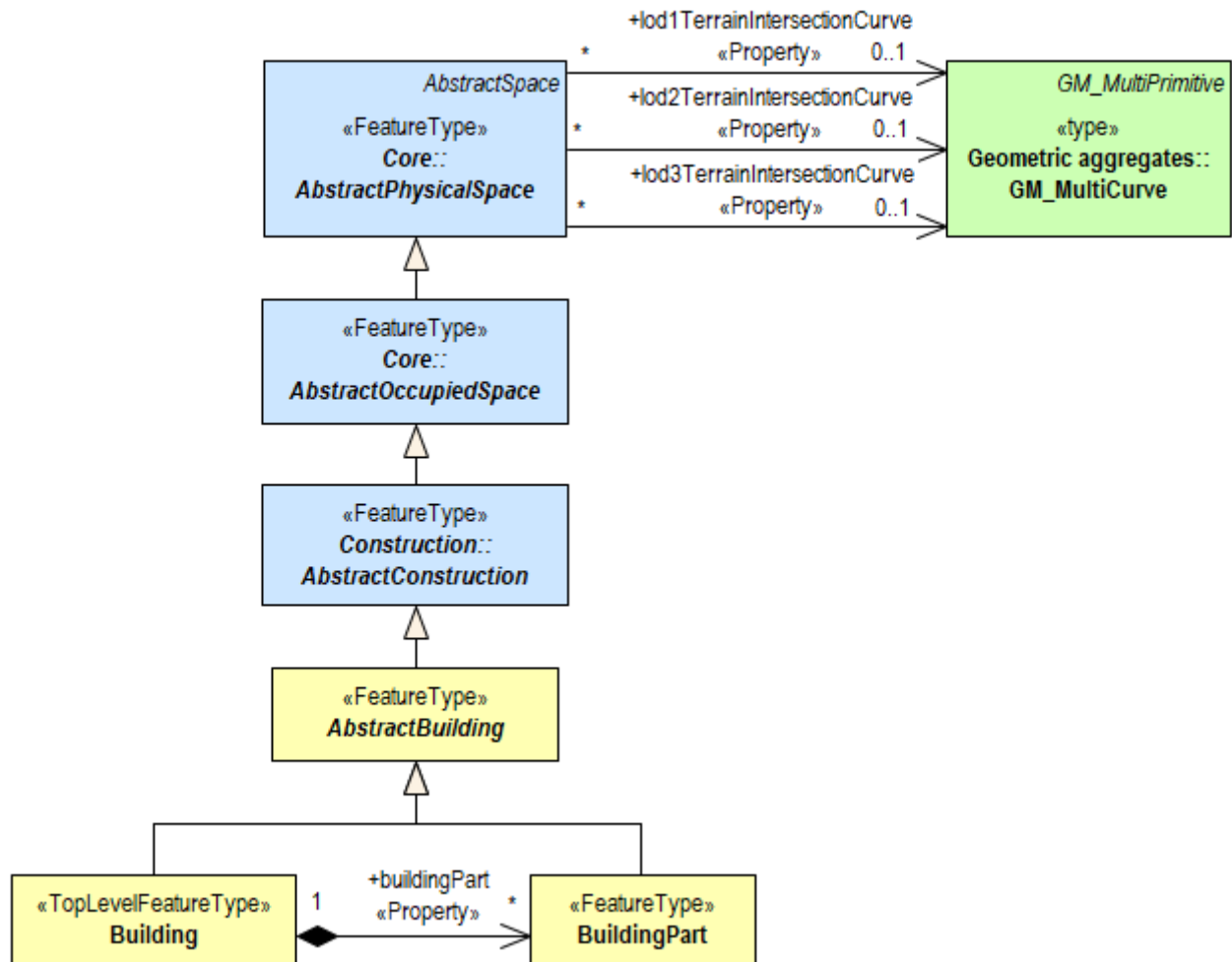
Figure 2. Example UML diagram demonstrating the UML notation and coloring scheme used throughout the CityGML Standard.

5.3. XML Notation

TBD

Chapter 6. Requirements

6.1. Global requirements

6.1.1. Object identifiers for features and geometries

In the GML encoding of the CityGML 3.0 Conceptual Model, different types of objects exist: *features*, *top-level features*, and *geometries*. All these objects have a unique identity, thus, they can be distinguished from each other and can also be referenced from other objects.

The CityGML 3.0 Conceptual Model introduces two attributes to provide all features and toplevel features with a unique identity: 1) the mandatory *featureID* attribute to distinguish all (top-level) features and possible multiple versions of the same real-world object and 2) an optional *identifier* attribute to reference specific (top-level) features independent from their actual feature version. The featureID attribute value is unique within the same CityGML dataset and also for a specific version of a feature, whereas the identifier attribute has an identical value for all versions of the same real-world object. It is recommended to use globally unique identifiers like UUID values or identifiers maintained by an organization such as a mapping agency for both attributes: for the identifier attribute, as these identifiers should remain stable over the lifetime of the real-world object, and for the featureID attribute, as this ensures that 3D city models which are integrated from different sources into e.g. one GIS or database will not have colliding featureID values and also to be able to uniquely identify a specific version of a feature using these identifiers together with a timestamp and a version number.

The two attributes are defined in the UML class *AbstractFeature* as part of the Core module of the CityGML 3.0 Conceptual Model. The class was introduced to the UML model to be able to define attributes at the conceptual level that are automatically inherited from the class *AbstractGML* in the GML encoding, but not in other encodings. In this way, it will be ensured that these attributes are available in all possible CityGML 3.0 encodings. Since these two attributes originate from the GML specification, they are mapped onto the predefined GML concepts *gml:id* and *gml:identifier* in the GML encoding. Table 4 lists the two identity attributes together with their definition and GML encoding, and the GML code in Listing 1 illustrates the use of the identity attributes to represent the object identity in GML instance documents.

Table 4. Identity attributes used in CityGML 3.

UML attributes to provide (top-level) features with identity	Mapping to corresponding GML concepts	Definition
featureID	XML attribute gml:id	Specifies the unique identifier of the feature that is valid in the instance document within which it occurs.
identifier	XML element gml:identifier	Specifies the unique identifier of the feature that is valid globally.

Listing 1. Use of the identity attributes in CityGML 3 instance documents.

```
<bldg:Building gml:id="B1020_t1">
  <gml:identifier codeSpace="www.xyz.org">B1020</gml:identifier>
  <core:creationDate>2012-08-02T00:00:00</core:creationDate>
  <core:terminationDate>2013-10-09T00:00:00</core:terminationDate>
  <bldg:function>Office</bldg:function>
</bldg:Building>
```

The GML encoding implements the geometry model defined in ISO 19107. This means that all geometries are derived from the class AbstractGML as well and, thus, also geometries exhibit the same unique identity as features do. The fact that geometries also have identifiers is of particular importance for CityGML, since CityGML requires defining references to geometries. One example is the application of textures to surfaces. The textures reference the gml:ids of those LinearRings that describe the boundaries of the surface geometries (e.g. Triangle, Polygon, or a MultiSurface consisting of Polygons) to which the textures are applied. Another example is that the CityGML GML encoding allows for realising topological relationships amongst others through referencing of shared geometries.

6.1.2. Referencing features and geometries

There are two XML concepts that are used to reference objects in GML instance documents: the XML Linking Language (XLink) and the XML Pointer Language (XPointer).

XLink allows for creating links to other documents by providing specific attributes that are added to the element that references the document. The most commonly used attribute is *xlink:href*, the value of the attribute is the URI of the referenced document.

In CityGML, however, we are mainly interested in referencing specific objects (features and geometries) within the same or external GML instance document. For this, XPointer is used. To reference objects by their gml:id, a number sign (#) followed by the gml:id of the object to be referenced is added to the URI of the referenced document. In Listing 2, the element <versionMember> references a <Building> feature. Since the feature is part of the same GML instance document, a relative URI is specified by simply providing the number sign and the gml:id of the building as value of the attribute xlink:href. In the context of version management, referencing features by their gml:id means that a specific feature version of a real-world object is referenced.

Listing 2. Referencing a feature by its gml:id.

```
<core:CityModel gml:id="CM_1">
  <core:versionMember>
    <vers:Version gml:id="V_1">
      <vers:versionMember xlink:href="#BU_234"/>
    </vers:Version>
  </core:versionMember>
  <core:cityObjectMember>
    <bldg:Building gml:id="BU_234"> ... </bldg:Building>
  </core:cityObjectMember>
<core:CityModel>
```

When using references, it is important to keep in mind that many (top-level) features in CityGML have a complex structure. This is shown in Listing 3. In general, features can have spatial and non-spatial properties that describe the features in more detail. Spatial properties are properties that have a geometry from ISO 19107 as data type (<lod2Solid> in the example). Non-spatial properties can either have a simple data type (<function> with Integer value or <creationDate> with Date value), but they can also be further specified by additional attributes, such as the height of the building that is described by further properties (<height> with the additional properties <highReference>, <lowReference>, <status>, and <value>). In addition, they can also be composed of subfeatures that contain spatial and non-spatial properties themselves (<WallSurface> with <lod2MultiSurface> geometry).

The subfeatures can be provided *inline* or *by reference*. Inline means that the subfeatures are provided directly as content of the (top-level) feature as is shown below, where the subfeature <BuildingRoom> is provided as content of the <Building> feature. In contrast, by reference means that the subfeatures are provided elsewhere in the CityGML document and are referenced from the (top-level) feature using an XLink as is described above and illustrated in Listing 2.

Listing 3. Complex structure of CityGML features.

```
<bldg:Building gml:id="BU_234">
  <core:creationDate>2019-09-24T00:00:00</core:creationDate>
  <core:boundary>
    <con:WallSurface gml:id="WS_21">
      <core:lod2MultiSurface>
        <gml:MultiSurface gml:id="MS_21_1">
          ...
        </gml:MultiSurface>
      </core:lod2MultiSurface>
    </con:WallSurface>
  </core:boundary>
  <core:lod2Solid>
    <gml:Solid gml:id="S_1"> ... </gml:Solid>
  </core:lod2Solid>
  <con:height>
    <con:Height>
      <con:highReference>topOfConstruction</con:highReference>
      <con:lowReference>lowestGroundPoint</con:lowReference>
      <con:status>measured</con:status>
      <con:value uom="urn:adv:uom:m">24.709</con:value>
    </con:Height>
  </con:height>
  <bldg:function>1000</bldg:function>
  <bldg:buildingRoom>
    <bldg:BuildingRoom gml:id="BR_3">
      ...
    </bldg:BuildingRoom>
  <bldg:buildingRoom>
</bldg:Building>
```

6.1.3. Rules for linking features and geometries that are shared by multiple (top-level) features

When modelling cities, geometries and features can be integral parts of multiple city objects. To avoid redundant modelling of these geometries and features, CityGML offers the possibility to represent geometries and features only once and to reference them from any other city object to which they belong as well.

This non-redundant representation guarantees that no integrity problems occur, i.e. several differing instances of the same geometry or feature will not exist.

Three different cases for non-redundant representation need to be differentiated:

1. Geometries are represented in different parts within the same top-level feature. An example is the roof surface of a building. The polygon representing the geometry of the RoofSurface feature is at the same time part of the RoofSurface feature and of the Solid geometry of the Building feature.

2. One geometry can be part of the representation of different features. An example is a road across a bridge, the road surface sharing the geometry with the roof surface of the bridge.

3. One and the same feature can belong to different aggregations. Examples are an intersection that belongs to two roads, the intersection being one and the same feature for both roads, or features that belong to a CityObjectGroup and that are already integral part of the city model.

For these cases, different recommendations are provided for how to encode the references in CityGML.

Although these recommendations impose restrictions, they facilitate at the same time reading, storing, processing, and generating of CityGML documents, because they reduce the multiple possibilities of how to represent and link features and geometries in CityGML documents to the most appropriate ones. Furthermore, top-level features can now completely be loaded in the main memory, because links to shared geometries that are part of different top-level features represented further down in the GML document do not need to be resolved any more. This also facilitates querying features and geometries using web services, as up to now queries cannot address specific parts of a geometry. Maintenance becomes easier as well, because links between feature geometries do not need to be maintained and updated any more when a feature changes its geometry or when the feature does not exist anymore.

Referencing geometries using XLinks within the same and from different top-level features

1. XLinks may be used to reference geometries within the same top-level feature in accordance with rules 1 - 5 in Section 6.1.3.2.

2. XLinks shall not be used to reference geometries from another top-level feature.

Referencing geometries of spaces and space boundaries

1. [The geometry describing a space shall be stored with the space or its space boundaries.]

2. Geometries stored inline a space boundary must be referenced from the geometry of the space using XLinks.

3. Space boundaries shall not reference geometries of the space using XLinks.

4. The geometry of a space may contain the geometries of nested spaces.

5. LoDs must be self-contained: Geometries shall not be shared between different LoDs using XLinks.

Here, XLink represents a link at the geometry level ("geometry link"), i.e. a reference to the ID of the geometry to be reused. The link direction is always from the geometry of the space to the geometries of the space boundaries (example 1).

If the space is not bounded by space boundaries (e.g. WallSurface or RoofSurface), then the geometry is stored as a geometry property (e.g. lod2MultiSurface) of the space. No XLinks are required in this case.

Example 1: Building with Solid geometry and boundary surfaces
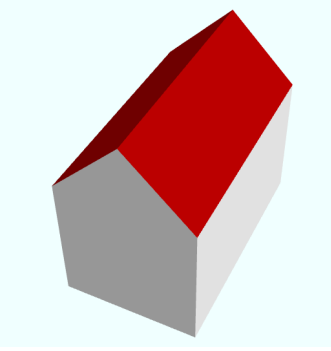
Figure 3. Simple building with solid geometry and boundary surfaces.

The building (=space) in Figure 3 is modelled in LOD2 as Solid geometry and is bounded by four WallSurfaces, one RoofSurface, and one GroundSurface (=space boundaries). All space boundaries are modelled as Polygon geometries. The Solid geometry of the building references the Polygon geometries using XLink.

The GML file is available here: https://github.com/opengeospatial/CityGML-3.0Encodings/tree/xlinks-discussion/CityGML/Examples/Building/XLink_examples/1_SimpleBuilding

The Building from the GML file is illustrated in the object diagram in Figure 4. The XLink relations between the Solid geometry and the Polygon geometries are highlighted in red.
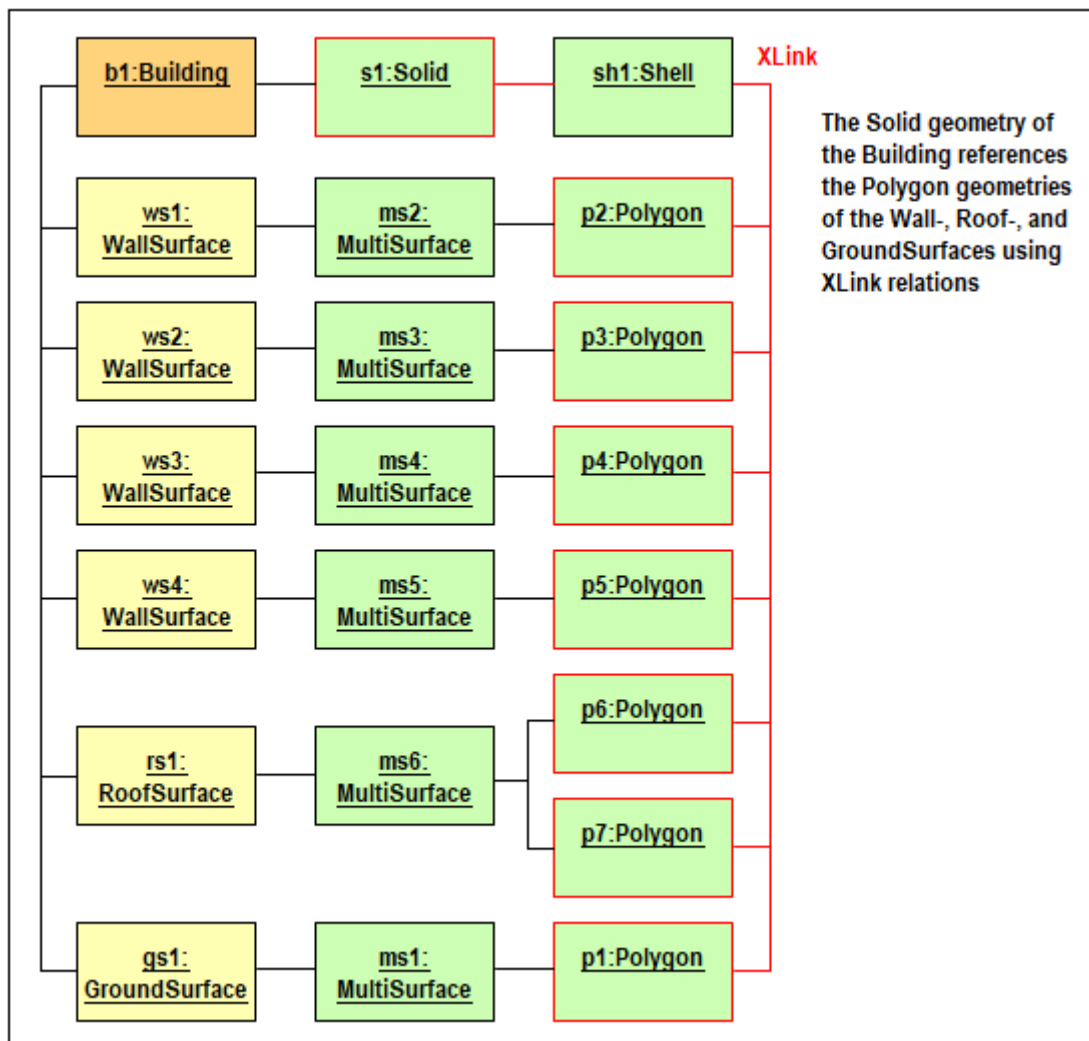
Figure 4. UML object diagram for the building in Figure 3.

Example 2: Building with roof overhangs
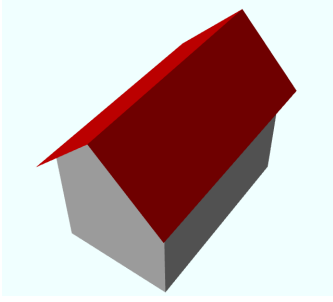
Figure 5. Building with roof overhangs.

The building (=space) in Figure 5 is modelled in LOD2 as Solid geometry and is bounded by four WallSurfaces, one RoofSurface, and one GroundSurface (=space boundaries). All space boundaries are modelled as Polygon geometries. The Solid geometry of the building references the Polygon geometries using XLink.

The RoofSurface contains four Polygon geometries. Two of these Polygons are roof overhangs (i.e. dangling surfaces), and, thus, are not referenced by the Solid geometry of the building, as they would render the solid invalid if referenced. For this reason, an additional MultiSurface geometry is added to the building that references the dangling surfaces.

The GML file is available here: https://github.com/opengeospatial/CityGML-3.0Encodings/tree/xlinks-discussion/CityGML/Examples/Building/XLink_examples/2_SimpleBuilding_Roof_Overhangs

The Building from the GML file is illustrated in the object diagram in Figure 6. The XLink relations between the Solid geometry and the Polygon geometries are highlighted in red, the XLink relations between the MultiSurface geometry and the dangling surfaces in blue.

The Solid geometry of the Building references the Polygon geometries of the Wall-, Roof-, and GroundSurfaces that bound the Building using XLink relations

The two dangling surfaces are referenced from the MultiSurface geometry using XLink relations
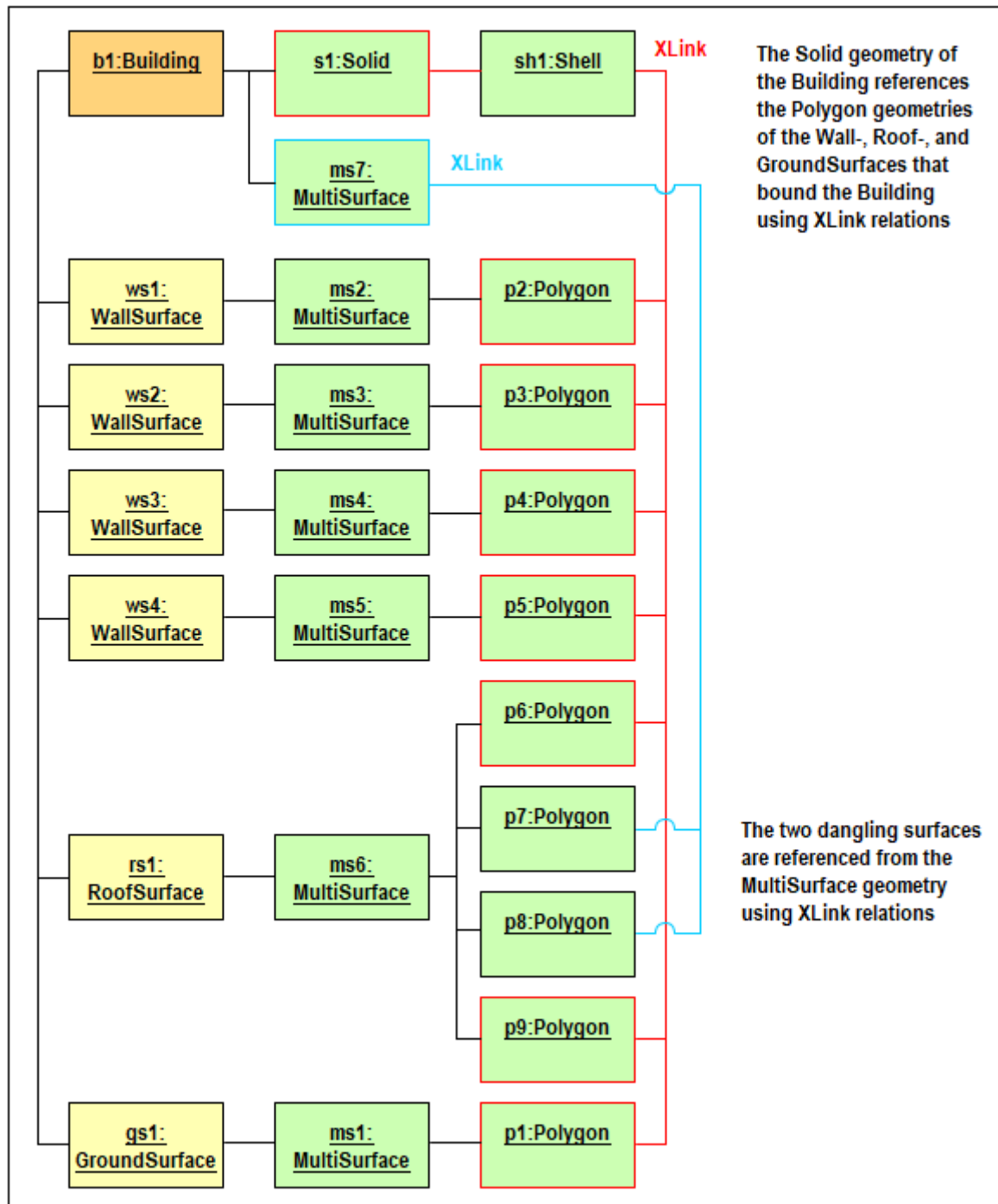
Figure 6. UML object diagram for the building in Figure 5.

Example 3: Building with BuildingInstallation
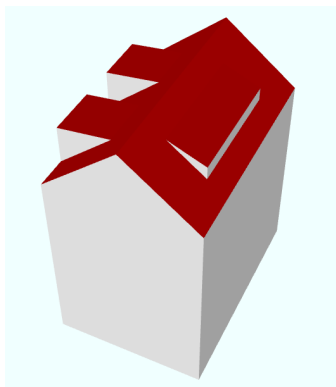
Figure 7. Building with building installation.

The building (=space) in Figure 7 is modelled in LOD2 as Solid geometry and is bounded by eight WallSurfaces, four RoofSurfaces, and one GroundSurface (=space boundaries). In addition, the building has a dormer that is modelled as BuildingInstallation (=space). The building installation is modelled as MultiSurface geometry and is bounded by one RoofSurface and three WallSurfaces (=space boundaries).

The space boundaries of the building and of the building installation are all modelled as Polygon geometries. The Solid geometry of the building references those Polygon geometries that represent the space boundaries of the building space using XLink. The MultiSurface geometry of the building installation references those Polygon geometries that represent the space boundaries of the building installation using XLink. In addition, the Solid geometry may also reference the Polygon geometries that represent the space boundaries of the building installation using XLink.

The GML file is available here: https://github.com/opengeospatial/CityGML-3.0Encodings/tree/xlinks-discussion/CityGML/Examples/Building/XLink_examples/3_Building_With_Nested_Features

The Building from the GML file is illustrated in the object diagram in Figure 8. The XLink relations are highlighted in red.
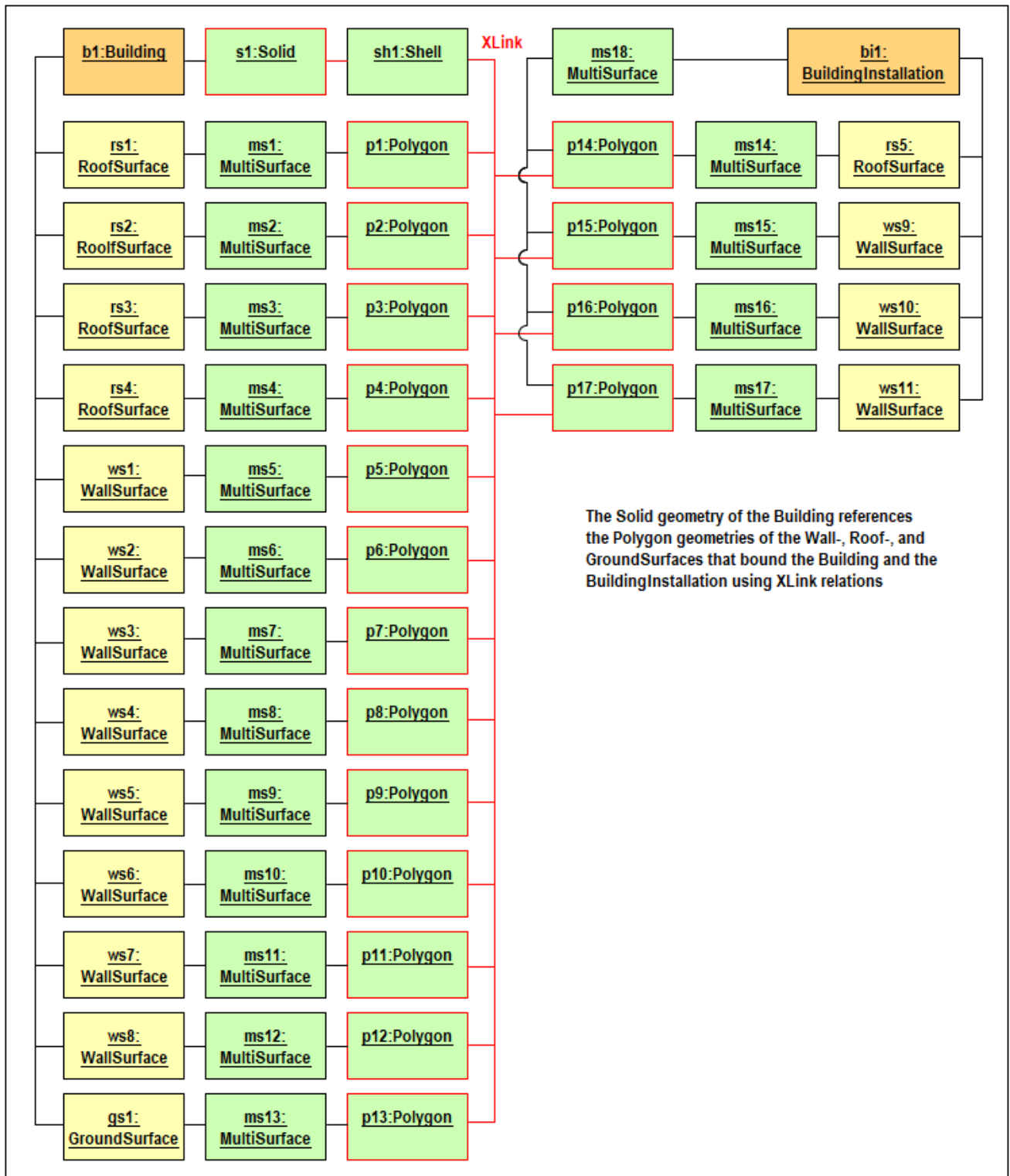
Figure 8. UML object diagram for the building in Figure 7.

Expressing shared geometries between top-level features using CityObjectRelations

1. If two top-level features share a common geometry, the shared geometry must be stored for each top-level feature separately (follows from 4.1.2).

2. A CityObjectRelation may be modelled for the features where the shared geometries are stored (might be the top-level feature itself or one of its nested features).

3. Each CityObjectRelation must be assigned the relation type "shared".

4. Each CityObjectRelation must reference the other feature using an XLink. Thus, the reference

shall be bi-directional.

CityObjectRelation represents a link at the feature level ("feature link") referencing the ID of another feature that contains a shared geometry. The explicit representation of the relation between the features facilitates spatial analyses. For visualisation it would be enough to render only one of the two surfaces (if the viewer is capable of doing so).

Example 1: Two buildings with shared boundary surface
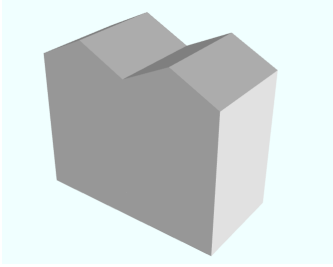
Figure 9. Two buildings with shared boundary surface.

The two buildings (=top-level features) in Figure 9 are modelled in LOD2 as Solid geometry and are bounded by Wall-, Roof-, and GroundSurfaces that are modelled as Polygon geometries. One of the WallSurfaces of the first Building shares the Polygon geometry with one of the WallSurfaces of the second Building. Both WallSurfaces might appear identical, however, the surface normals of the Polygon geometries of the WallSurfaces are pointing in opposite directions.

To express that the WallSurfaces of the two buildings share the Polygon geometry, the WallSurfaces reference each other using a CityObjectRelation with the relation type "shared". Both WallSurfaces contain the Polygon geometry themselves, the second WallSurface, however, in reverse order.

The GML file is available here: https://github.com/opengeospatial/CityGML-3.0Encodings/tree/xlinks-discussion/CityGML/Examples/Building/XLink_examples/4_Cross-Top-Level-XLink

The Buildings from the GML file are illustrated in the object diagram in Figure 10. The CityObjectRelation is highlighted in red.
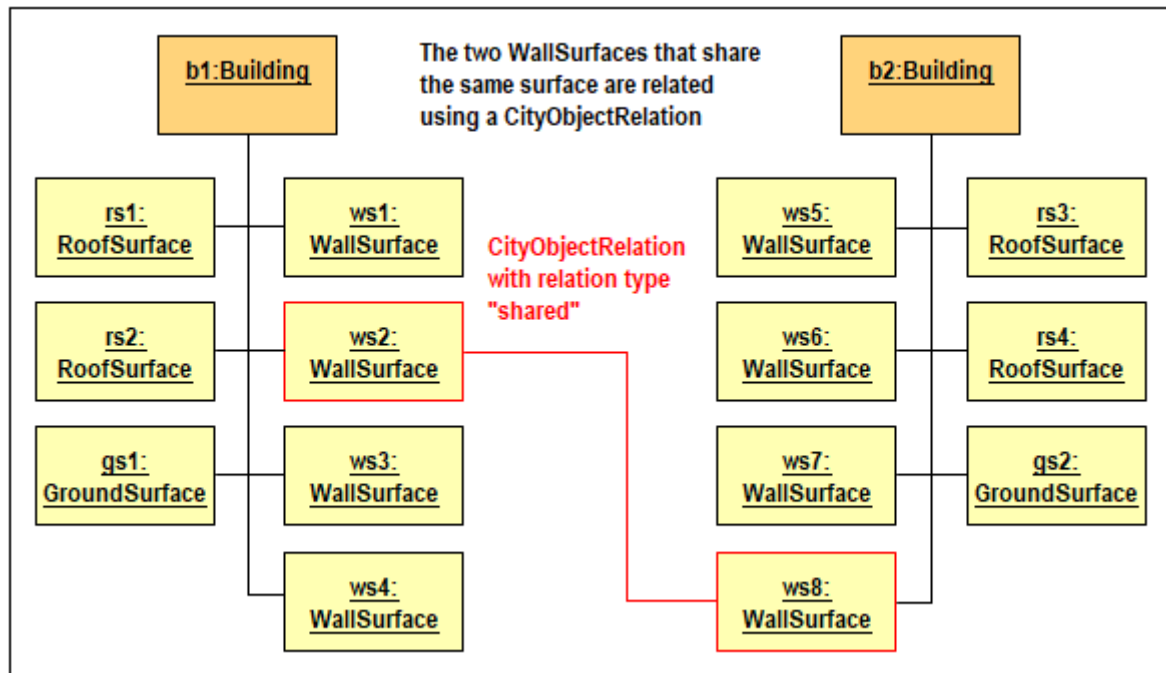
Figure 10. UML object diagram for the building in Figure 9.

Example 2: Road crossing a Bridge

[Example RoadOverBridge] | *images/Example_RoadOverBridge.png*

Figure 11. Shared surfaces between a road and a bridge.

A Road and a Bridge (=top-level features) are modelled in LOD2, as is shown in Figure 11. The Bridge is bounded by Ground-, Roof-, and WallSurfaces that are modelled as MultiSurface geometries. The Road consists of three sections; each section is bounded by two TrafficAreas that are modelled as MultiSurface geometries as well. The RoofSurfaces of the Bridge share MultiSurface geometries with two TrafficAreas of the Road. The RoofSurfaces and the TrafficAreas are geometrically identical, but they differ semantically.

To express that the RoofSurfaces share MultiSurface geometries with two TrafficAreas, they reference each other using CityObjectRelations with the relation type "shared".

The GML file is available here: https://github.com/opengeospatial/CityGML-3.0Encodings/blob/master/CityGML/Examples/Transportation/Basic%20examples/Road_over_Bridge_CityGML3.0_LOD2_with_CityObjectRelations.gml

The Road and Bridge from the GML file are illustrated in the object diagram in Figure 12. The CityObjectRelations are highlighted in red.
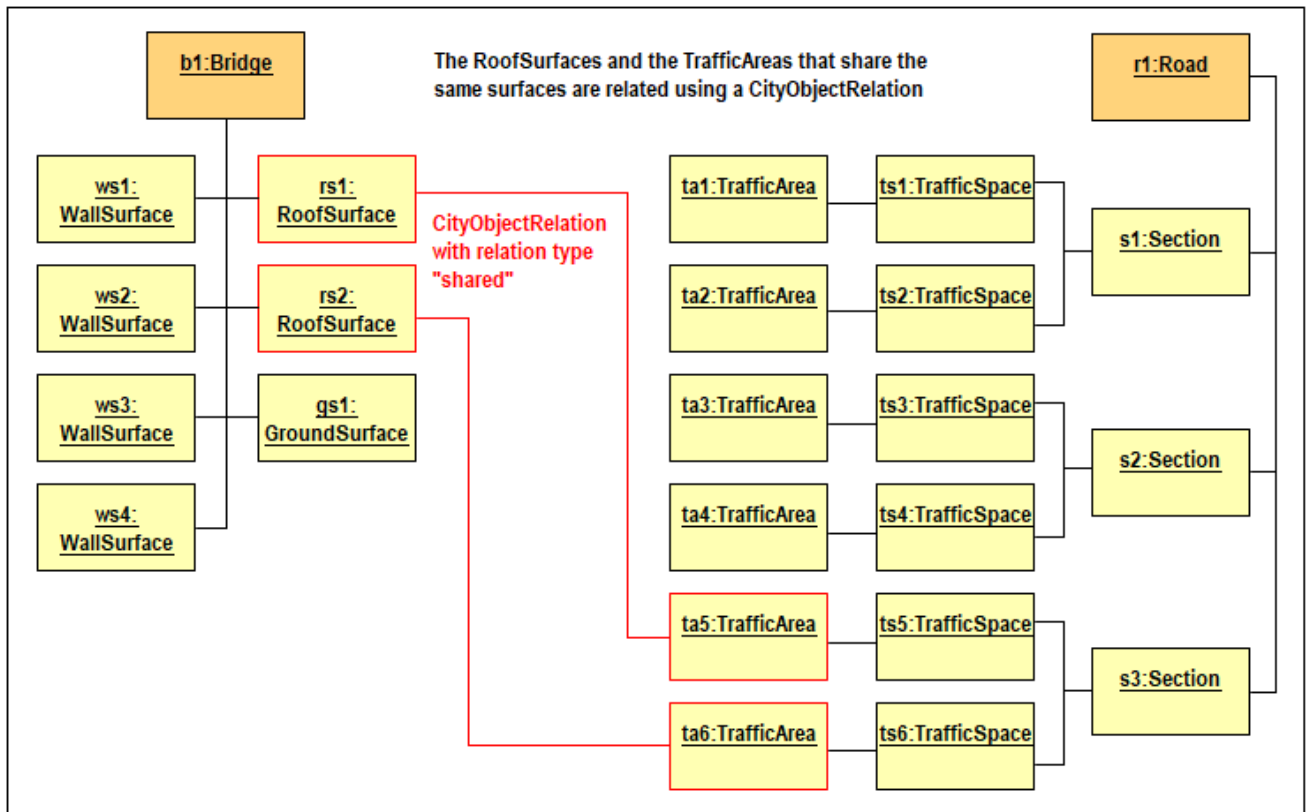
Figure 12. UML object diagram for the building in Figure 11.

Example 3: Parking garage

[Example ParkingGarage] | *images/Example_ParkingGarage.png*

Figure 13. Shared surfaces in a parking garage.

The parking garage in Figure 13 is modelled in LOD2 as a building (=top-level feature) with Floor-, Roof-, and WallSurfaces that are modelled as MultiSurface geometries. The parking garage contains a Road with Sections and TrafficAreas that are modelled as MultiSurface geometries as well. The Floor- and RoofSurface of the Building share MultiSurface geometries with the Sections and TrafficAreas of the Road.

To express the sharing of MultiSurface geometries between the Roof-/WallSurfaces and the Sections/TrafficAreas, they reference each other using CityObjectRelations with the relation type "shared".

The GML file is available here: https://github.com/opengeospatial/CityGML-3.0Encodings/blob/ master/CityGML/Examples/Transportation/Basic%20examples/ Road_over_Bridge_CityGML3.0_LOD2_with_CityObjectRelations.gml

Referencing features from alternative aggregations

1. Each feature belongs to a natural aggregation hierarchy and shall be stored inline in this hierarchy.

2. Alternative aggregations may not contain the feature inline but must use an XLink to reference the feature.

Here, XLink represents a link at the feature level ("feature link"), i.e. a reference to the ID of the

feature being part of the natural aggregation. All features are part of a natural aggregation, i.e. features are typically represented in a data set once in physical form, either directly as part of the city model when they are top-level features (e.g. a Building), or inline as part of other (top-level) features (e.g. a BuildingRoom represented inline as part of the top-level feature Building). At the same time, the features can also occur in alternative aggregations.

Example 1: Intersection as part of two Roads

[Example Intersection] | *images/Example_Intersection.png*

Figure 14. Intersection shared by two roads.

In Figure 14, two roads are shown that each have two Sections and one Intersection. The two roads cross each other at the Intersection. Although the Intersection is shared by the Roads, it exists in reality only once. This is reflected by specifying that the natural aggregation of the Intersection feature is Road 2, whereas Road 3 represents an alternative aggregation of the Intersection. Thus, the Intersection feature is represented inline as part of Road 2, whereas it is referenced by Road 3 using an XLink that references the ID of the Intersection feature.

The GML file is available here: https://github.com/opengeospatial/CityGML-3.0Encodings/blob/master/CityGML/Examples/Transportation/Basic%20examples/ParkingGarage_CityGML3.0_LOD2_with_CityObjectRelations_and_XLinks.gml

The two Roads and the Intersection from the GML file are illustrated in the object diagram in Figure 15. The XLink relation is highlighted in red.
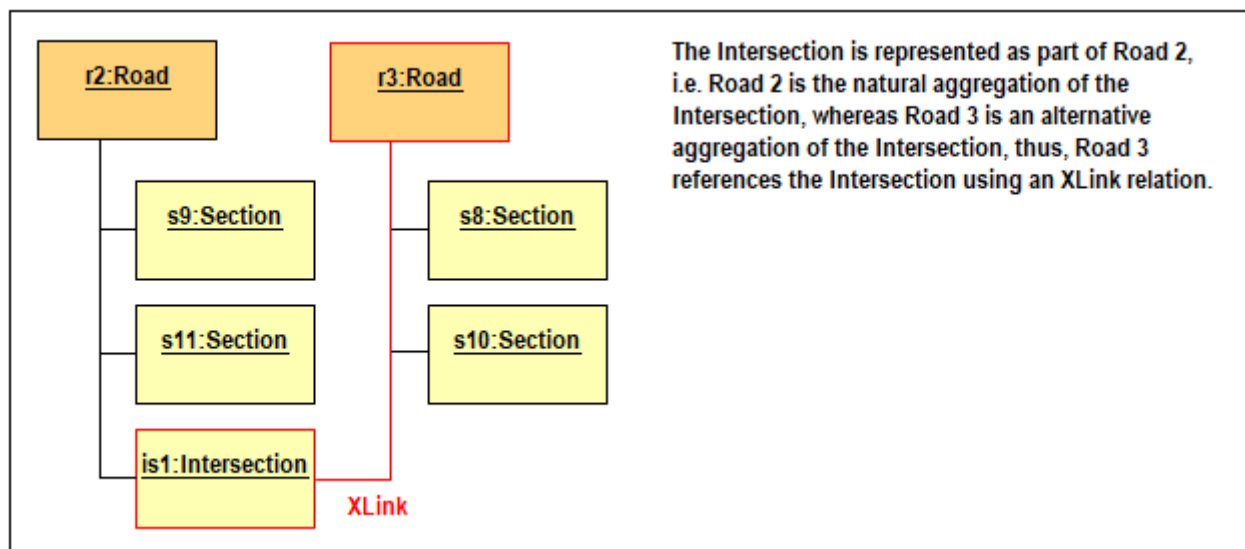
Figure 15. UML object diagram for the building in Figure 14.

Example 2: A specific version of a city model

A Version features groups, for instance, versions of city objects that are valid within a specific time period. The city model represents the natural aggregation of these versioned city objects, whereas the Version feature represents the alternative aggregation. Thus, the versioned city objects are represented inline as part of the city model, whereas they are referenced by the Version feature using XLink relations.

Example 3: Building rooms belonging to a Storey

BuildingRooms are usually represented inline as part of the Building they belong to, thus, the Building represents the natural aggregation. In addition, Storeys can group BuildingRooms to indicate which BuildingRoom belongs to which Storey. This grouping represents an alternative aggregation, thus, the Storeys must reference the BuildingRooms using XLink relations.

Example 4: A Building installation spanning across several Building Parts

This example was discussed in issue https://github.com/opengeospatial/CityGML-3.0CM/issues/8: "Installations that are spanning across several building parts are to be physically modelled as part of one building part, all other building parts reference the installation using XLinks, expressing in this way, that the installation does not exclusively belong to one building part only."

This means, that one of the BuildingParts represents the natural aggregation of the BuildingInstallation (i.e. inline representation), whereas the other BuildingParts represent alternative aggregations (i.e. XLink reference).

Example 5: CityObjectGroups

A CityObjectGroup groups existing city objects that are usually represented inline somewhere else in the data set. Thus, CityObjectGroups represent alternative aggregations and have to use XLink to reference the city objects they are grouping.

6.1.4. Encoding of association classes

GML encoding of association classes according to ISO 19136-2

ISO 19136-2 defines an encoding rule for association classes. The encoding rule comprises several steps for deriving a GML encoding from association classes which will be explain ed in the following based on the UML model provided in Figure 16.

[UML AssociationClass] | *images/UML_AssociationClass.png*

Figure 16. UML object diagram for the building in Figure 14.

The UML model in Figure 16 defines association class X with an association between source class A and target class B. The following steps are defined by the encoding rule, resulting in the UML model shown in Figure 17: - Association class X is converted into intermediate class X. The new intermediate class has the same name, stereotype, tagged values, constraints, attributes, and relationships as the original association class. - The association between source class A and target class B is replaced by two associations, association 1 between the classes A and X, and association 2 between the classes X and B. - The association ends at class X of association 1 and at class B of association 2 receive the role name, navigability, stereotype, and tagged values of the association end at the original target class B. In addition, the association end at class X receives the multiplicity of the association end at the original target class B. The association end at class B receives multiplicity 1. - The association ends at class A of association 1 and at class X of association 2 receive the role name, navigability, stereotype, and tagged values of the association end at the original source class A. In addition, the association end at class X receives the multiplicity of the association end at the original source class A. The association end at class A receives multiplicity 1.

[UML IntermediateClass] | *images/UML_IntermediateClass.png*

Figure 17. UML model resulting from applying the encoding rule.

The encoding rule can be applied to association classes that are defined with unidirectional, bidirectional or unspecified navigability. Correspondingly, the UML model that results from the encoding rule will also have the associations defined unidirectional, bidirectional or unspecified. The examples here focus on unidirectional associations, since all associations in the CityGML 3.0 Conceptual Model are defined with unidirectional navigability.

Encoding of the tagged value "inlineOrByReference" within association classes

The tagged value "inlineOrByReference" from ISO 19136-1 is commonly used for associations to define how a feature (referenced feature) that is referenced by another feature (referencing feature) is to be represented in GML instance documents. Three different values are defined for this tagged value:

- inline: the referenced feature is embedded inside the referencing feature

- byReference: the referenced feature is provided elsewhere in the same or an external GML instance document and is referenced from the referencing feature using XLink

- inlineOrByReference: both representations, i.e. inline and byReference, are possible and, in addition, a mixture of both representations.

When making use of this tagged value in association classes, the encoding rule described above will add this tagged value to the corresponding association ends of association 1 and 2 after having created the intermediate class. Figure 18 and Figure 19 illustrate this. Figure 18 assumes that for the association end at class B the tagged value "inlineOrByReference" is set to the value "inline". After applying the encoding rule, both the association ends at class X and at class B, will exhibit the value "inline" as is shown in Figure 19. Similarly, when the association in Figure 18 will have the value "byReference" or "inlineOrByReference", both associations in Figure 4 will exhibit the value "byReference" or "inlineOrByReference", respectively.

[UML AssociationClass Inline] | *images/UML_AssociationClass_Inline.png*

Figure 18. Association class with the tagged value "inlineOrByReference" set to "inline".

[UML IntermediateClass Inline] | *images/UML_IntermediateClass_Inline.png*

Figure 19. "inlineOrByReference" settings after applying the encoding rule.

Using this tagged value means that three different encodings can be obtained depending on which of the three values is set. These different encodings are illustrated in the following by three different GML instance documents. The source class A, the target class B, and the intermediate class X are represented by corresponding XML elements <A>, <B>, and <X>. The associations between the classes A and X and between X and B are both represented by the property element <role>. For illustration purposes, the GML instance documents do not contain root elements and namespaces.

The first GML instance document (Listing 4) is obtained when setting the tagged value to "inline". Here, element X needs to be provided inline element A and element B inline element X.

Listing 4. GML instance document for the value "inline".

```
<A gml:id="f1">
  <role>
    <X gml:id="f3">
      <role>
        <B gml:id="f2">
        </B>
      </role>
    </X>
  </role>
</A>
```

The second GML instance document (Listing 5) results from setting the tagged value to "byReference". Here, element A references element X and element X references element B using XLink.

Listing 5. GML instance document for the value "byReference".

```
<A gml:id="f1">
  <role xlink:href="#f3"/>
</A>
<X gml:id="f3">
  <role xlink:href="#f2"/>
</X>
<B gml:id="f2">
</B>
```

The third GML instance document (Listing 6) is obtained when the tagged value is set to "inlineOrByReference". Here, the inline and byReference representations are combined, i.e. element X is provided inline element A and element B is referenced by element X using XLink. Alternatively, it is also possible that element X is referenced by element A and element B is provided inline element X. In addition, also the GML instances as shown above for "inline" and "byReference" can be represented with the value "inlineOrByReference".

Listing 6. GML instance document for the value "inlineOrByReference".

```
<A gml:id="f1">
  <role>
    <X gml:id="f3">
      <role xlink:href="f2"/>
    </X>
  </role>
</A>
<B gml:id="f2">
</B>
```

Solutions for restricting the combination of inline and byReference representations in the GML encoding

As described in the previous section, four different instance representations are possible in the case of the "inlineOrByReference" value. This behaviour is not desired in the GML encoding of the CityGML 3.0 Conceptual Model, as it allows for too many possibilities of how to reference features and, thus, needs to be restricted.

In the CityGML 3.0 Conceptual Model, this setting affects two association classes, *CityObjectRelation* in the Core module and *Role* in the CityObjectGroup module. For both, the only desired way of representing them in GML instance documents is the structure shown in Listing 6. The CityGML 3.0 Conceptual Model also defines the association class *TextureAssociation* in the Appearance module. This association class, however, is not affected here, because it makes use of the value "inline" for which the encoding is correct.

This structure can be specified in the UML model as shown in Figure 20. After converting the association class into an intermediate class, the tagged value of association 1 receives the value "inline" and the tagged value of association 2 receives the value "byReference".

[UML IntermediateClass Byreference] | *images/UML_IntermediateClass_Byreference.png*

Figure 20. Desired settings for the value "inlineOrByReference" after applying the encoding rule.

The following two solutions for obtaining the restricted structure in GML instance documents are introduced:

1. A new value "inlineThenByReference" is defined. This value informs the encoding rule for association classes that during the encoding all association classes to which the new value is applied are to be converted as shown in Figure 20.

2. A CityGML 3.0 Implementation Model is manually created from the CityGML 3.0 Conceptual Model in which the association classes are represented as shown in Figure 20. With this solution, the encoding rule for association classes does not need to be applied, the encoding is simply performed on the Implementation Model.

Both solutions guarantee for representing references between features according to Listing 6 in GML instance documents. The first solution, however, requires that the semantics of the new value is implemented in ShapeChange or any other conversion tool used for the encoding. The second solution can be applied directly without any changes to the conversion tools. For this reason, the second solution is used for the GML encoding of the CityGML 3.0 Conceptual Model as a simple and fast workaround.

In the following, the solutions will be exemplified based on the association class CityObjectRelation which is shown in Figure 21. This association class can be used to specify relationships between different features, e.g. it can be expressed that the WallSurface of one building shares the Polygon geometry with the WallSurface of a second Building.

[UML CityObjectRelation AssociationClass] | *images/UML_CityObjectRelation_AssociationClass.png*

Figure 21. Association class CityObjectRelation.

By setting the tagged value of the association to "inlineThenByReference", the encoding rule will

convert the UML model into the representation illustrated in Figure 22. The same representation is obtained by manually converting the association class in the Implementation Model.

[UML CityObjectRelation IntermediateClass] |

images/UML_CityObjectRelation_IntermediateClass.png

Figure 22. Association class CityObjectRelation represented as intermediate class.

As shown in Listing 7, a GML instance document would then specify in the following way that the WallSurfaces of two buildings share the same geometry. The source and target classes are represented by two XML elements <WallSurface> and the intermediate class by the element <CityObjectRelation>. The element WallSurface of building 1 provides the element CityObjectRelation inline, whereas the element CityObjectRelation references the WallSurface element of building 2 using XLink. In the same way, building 2 provides the element CityObjectRelation inline its WallSurface, and the CityObjectRelation references the WallSurface of building 1 using Xlink.

Listing 7. GML instance document for the value "inlineThenByReference".

```
<bldg:Building gml:id="bldg_1">
  <boundary>
    <con:WallSurface gml:id="bldg_1_ws_2">
      <relatedTo>
        <CityObjectRelation>
          <relationType>shared</relationType>
          <relatedTo xlink:href="#bldg_2_ws_4"/>
        </CityObjectRelation>
      </relatedTo>
      <lod2MultiSurface> ... </lod2MultiSurface>
    </con:WallSurface>
  </boundary>
</bldg:Building>
<bldg:Building gml:id="bldg_2">
  <boundary>
    <con:WallSurface gml:id="bldg_2_ws_4">
      <relatedTo>
        <CityObjectRelation>
          <relationType>equal</relationType>
          <relatedTo xlink:href="#bldg_1_ws_2"/>
        </CityObjectRelation>
      </relatedTo>
      <lod2MultiSurface> ... </lod2MultiSurface>
    </con:WallSurface>
  </boundary>
</bldg:Building>
```

6.2. Core Conformance Class

The Core Conformance Class implements the following Requirements Classes from the CityGML 3.0 Conceptual Model Standard:

- Core: http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-core

- ADE: http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-ade

The applicable GML schema is core.xsd.

Requirements Class	
http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-core	
Target type	Implementation
Dependency	core.xsd
Dependency	http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-core
Dependency	http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-ade

6.2.1. GML Elements

The CityGML Core XML elements are listed in the GML schema core.xsd.

6.2.2. Implementation Decisions

The following decisions have been made regarding implementation of the CityGML 3.0 Core conformance class in GML.

1. The UML class AnyFeature is an instance of the metaclass FeatureType which is defined in ISO 19109. AnyFeature is the generalization of all feature types and acts as superclass of all classes in the CityGML UML model with the stereotype «FeatureType». A comparable concept is defined in ISO 19136 with the XML element gml:AbstractFeature as the most generic feature in GML and its basic feature model gml:AbstractFeatureType from which all feature defined in GML application schemas and, thus, also in the CityGML application schema, are derived. For this reason, the UML class AnyFeature is not encoded as CityGML-specific XML element, but is simply mapped to gml:AbstractFeature.

2. The UML class AbstractFeature is the abstract superclass of all feature types within the CityGML Conceptual Model. This class defines amongst others the attributes featureID, identifier, name, and description. These attributes represent properties that are predefined in ISO 19136 (i.e. gml:id, gml:identifier, gml:name, and gml:description) and are inherited by all features defined in GML application schemas. The attributes were added to the UML model to guarantee that they are available in all possible CityGML encodings. In the GML schema, these attributes are suppressed from being encoded, as they are already inherited by all CityGML features.

3. The UML class ImplicitGeometry is represented as an object type that defines the attribute objectID. This attribute was added to the UML model to guarantee that it is available in all possible CityGML encodings. This attribute represents the GML property gml:id which all object types automatically inherit in the GML encoding, thus, this attribute is suppressed from being encoded.

4. The UML class XALAddress is a placeholder for representing address details according to the OASIS xAL standard. The class is not encoded in the GML schema, but is simply mapped to xAL:Address, the root element for xAL-based address information.

5. As described in Section 6.1.4, the UML association class CityObjectRelation is modelled as an intermediate class in an Implementation Model before the GML encoding is applied. In this way, a relation between two features A and B can be represented in such a way that feature A provides the element CityObjectRelation inline, whereas the CityObjectRelation references

feature B using XLink. This encoding also ensures that the rule on referencing features from alternative aggregations as described in Section 6.1.3.4 is observed.

6. All associations allow by default that the referenced features can be provided inline or by reference. However, a restriction is defined for the following association, since it represents an alternative aggregation (see rule on referencing features from alternative aggregations in Section 6.1.3.4):

   ◦ The reflexive association generalizesTo of the element AbstractCityObject; here, a city object must reference its generalized city object using XLink.

7. An execption to the rule that XLinks shall not be used to reference geometries from another top-level feature (Rule 2 in Section 6.1.3.1) is defined for the element ImplicitGeometry. The concept of ImplicitGeometry requires that different top-level features can reference the same geometry and appearance; thus, XLinks from different top-level features to the same geometry and appearance are allowed in this case.

6.2.3. Requirements

Requirement 1	/req/core/elements
CityGML XML elements implemented by a conforming instance document shall conform to the GML XML schema in core.xsd.	

6.3. Appearance Conformance Class

Requirements Class	
http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-appearance	
Target type	Implementation
Dependency	appearance.xsd
Dependency	http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-appearance
Dependency	http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-core

The Appearance module supports the modelling of the observable surface properties of CityGML features in the form of textures and material.

The Appearance Conformance Class implements the following Requirements Class from the CityGML 3.0 Conceptual Model Standard:

- Appearance: http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-appearance

The applicable GML schema is appearance.xsd.

6.3.1. Dependencies

The Appearance Requirements Class is dependent on the following Requirements Class from this standard:

- The Core Requirements Class is the only mandatory Requirements Class. This class contains

foundational elements upon which a CityGML dataset is built. The Core Requirements Class also defines XML elements and types reused by other Requirements Classes.

In addition, the Appearance Requirements Class is dependent on the following external OGC and ISO standards:

- GML 3.2 provides most of the geometry types (e.g., Point, LineString, Polygon) used for spatial representations in this standard. Defines Coordinate Reference Systems. Supports the General Feature Model upon which this standard is based.

- GML 3.3 defines the linear referencing concepts (e.g., linear element, distance along, Linear Referencing Methods) used for linearly referenced locations in this standard. Also included are TINs.

6.3.2. GML Elements

The CityGML Appearance XML elements are listed in the GML schema appearance.xsd. In addition, they are provided in the HTML documentation http://…&#8203;

6.3.3. Implementation Decisions

The following decisions have been made regarding implementation of the CityGML 3.0 Appearance conformance class in GML.

1. All associations allow by default that the referenced features can be provided inline or by reference. However, a restriction is defined for following association:

   - The assocation class TextureAssociation which connects ParameterizedTexture with AbstractTextureParameterization; here, AbstractTextureParameterization (or rather of the non-abstract subclasses TexCoordList and TexCoordGen) must be represented inline For the GML encoding this means that the element ParameterizedTexture embeds the element TextureAssociation which, in turn, embeds either the element TexCoordList or TexCoordGen.

6.3.4. Requirements

Requirement 2	/req/appearance/elements
CityGML XML elements implemented by a conforming instance document shall conform to the GML XML schema in appearance.xsd.	

6.4. Bridge Conformance Class

The Bridge Conformance Class implements the following Requirements Class from the CityGML 3.0 Conceptual Model Standard:

- Bridge: http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-bridge

The applicable GML schema is bridge.xsd.

Requirements Class	
http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-bridgee	
Target type	Implementation
Dependency	bridge.xsd
Dependency	http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-bridge
Dependency	http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-core

6.4.1. GML Elements

The CityGML Bridge XML elements are listed in the GML schema bridge.xsd.

6.4.2. Implementation Decisions

The following decisions have been made regarding implementation of the CityGML 3.0 Bridge conformance class in GML.

1. All associations allow by default that the referenced features can be provided inline or by reference.

6.4.3. Requirements

Requirement 3	/req/bridge/elements
CityGML XML elements implemented by a conforming instance document shall conform to the GML XML schema in bridge.xsd.	

6.5. Building Conformance Class

The Building Conformance Class implements the following Requirements Class from the CityGML 3.0 Conceptual Model Standard:

- Building: http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-building

The applicable GML schema is building.xsd.

Requirements Class	
http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-building	
Target type	Implementation
Dependency	building.xsd
Dependency	http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-building
Dependency	http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-core

6.5.1. GML Elements

The CityGML Building XML elements are listed in the GML schema building.xsd.

6.5.2. Implementation Decisions

The following decisions have been made regarding implementation of the CityGML 3.0 Building conformance class in GML.

1. All associations allow by default that the referenced features can be provided inline or by reference.

6.5.3. Requirements

Requirement 4	/req/building/elements
CityGML XML elements implemented by a conforming instance document shall conform to the GML XML schema in bulding.xsd.	

6.6. City Furniture Conformance Class

The City Furniture Conformance Class implements the following Requirements Class from the CityGML 3.0 Conceptual Model Standard:

- CityFurniture: http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-cityfurniture

The applicable GML schema is cityFurniture.xsd.

Requirements Class	
http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-cityfurniture	
Target type	Implementation
Dependency	cityFurniture.xsd
Dependency	http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-cityfurniture
Dependency	http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-core

6.6.1. GML Elements

The CityGML City Furniture XML elements are listed in the GML schema cityFurniture.xsd.

6.6.2. Implementation Decisions

The following decisions have been made regarding implementation of the CityGML 3.0 City Furniture conformance class in GML.

1. All associations allow by default that the referenced features can be provided inline or by reference.

6.6.3. Requirements

Requirement 5	/req/cityfurniture/elements
CityGML XML elements implemented by a conforming instance document shall conform to the GML XML schema in cityFurniture.xsd.	

6.7. City Object Group Conformance Class

The City Object Group Conformance Class implements the following Requirements Class from the CityGML 3.0 Conceptual Model Standard:

- CityObjectGroup: http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-cityobjectgroup

The applicable GML schema is cityObjectGroup.xsd.

Requirements Class	
http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-cityobjectgroup	
Target type	Implementation
Dependency	cityObjectGroup.xsd
Dependency	http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-cityobjectgroup
Dependency	http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-core

6.7.1. GML Elements

The CityGML City Object Group XML elements are listed in the GML schema cityObjectGroup.xsd.

6.7.2. Implementation Decisions

The following decisions have been made regarding implementation of the CityGML 3.0 City Object Group conformance class in GML.

1. As described in Section 6.1.4, the UML association class Role is modelled as an intermediate class in an Implementation Model before the GML encoding is applied. In this way, a relation between a city object group and the features it groups can be represented in such a way that the city object group provides the element Role inline, whereas the Role references the features that belong to the city object group using XLink. This encoding also ensures that the rule on referencing features from alternative aggregations as described in Section 6.1.3.4 is observed.

2. All associations allow by default that the referenced features can be provided inline or by reference. However, a restriction is defined for the following association, since it represents an alternative aggregation (see rule on referencing features from alternative aggregations in Section 6.1.3.4):
   - The association parent which connects CityObjectGroup with AbstractCityObject; here, a city object group must reference its parent city object using XLink.

6.7.3. Requirements

Requirement 6	/req/cityobjectgroup/elements
CityGML XML elements implemented by a conforming instance document shall conform to the GML XML schema in cityObjectGroup.xsd.	

6.8. Construction Conformance Class

The Construction Conformance Class implements the following Requirements Class from the CityGML 3.0 Conceptual Model Standard:

- Construction: http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-construction

The applicable GML schema is construction.xsd.

Requirements Class	
http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-construction	
Target type	Implementation
Dependency	construction.xsd
Dependency	http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-construction
Dependency	http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-core

6.8.1. GML Elements

The CityGML Construction XML elements are listed in the GML schema construction.xsd.

6.8.2. Implementation Decisions

The following decisions have been made regarding implementation of the CityGML 3.0 Construction conformance class in GML.

1. All associations allow by default that the referenced features can be provided inline or by reference.

6.8.3. Requirements

Requirement 7	/req/construction/elements
CityGML XML elements implemented by a conforming instance document shall conform to the GML XML schema in construction.xsd.	

6.9. Dynamizer Conformance Class

The Dynamizer Conformance Class implements the following Requirements Class from the CityGML 3.0 Conceptual Model Standard:

- Dynamizer: http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-dynamizer

The applicable GML schema is dynamizer.xsd.

Requirements Class	
http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-dynamizer	
Target type	Implementation
Dependency	dynamizer.xsd
Dependency	http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-dynamizer
Dependency	http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-core

6.9.1. GML Elements

The CityGML Dynamizer XML elements are listed in the GML schema dynamizer.xsd.

6.9.2. Implementation Decisions

The following decisions have been made regarding implementation of the CityGML 3.0 Dynamizer conformance class in GML.

1. All associations allow by default that the referenced features can be provided inline or by reference. However, a restriction is defined for the following association, since it represents an alternative aggregation (see rule on referencing features from alternative aggregations in Section 6.1.3.4):

   - The association sensorLocation which connects SensorConnection with AbstractCityObject; here, a sensor connection must reference the city object for which it provides sensor information using XLink.

6.9.3. Requirements

Requirement 8	/req/dynamizer/elements
CityGML XML elements implemented by a conforming instance document shall conform to the GML XML schema in dynamizer.xsd.	

6.10. Generics Conformance Class

The Generics Conformance Class implements the following Requirements Class from the CityGML 3.0 Conceptual Model Standard:

- Generics: http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-generics

The applicable GML schema is generics.xsd.

Requirements Class
http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-generics

Target type	Implementation
Dependency	generics.xsd
Dependency	http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-generics
Dependency	http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-core

6.10.1. GML Elements

The CityGML Generics XML elements are listed in the GML schema generics.xsd.

6.10.2. Implementation Decisions

The following decisions have been made regarding implementation of the CityGML 3.0 Generics conformance class in GML.

1. All associations allow by default that the referenced features can be provided inline or by reference.

6.10.3. Requirements

Requirement 9	/req/generics/elements
CityGML XML elements implemented by a conforming instance document shall conform to the GML XML schema in generics.xsd.	

6.11. Land Use Conformance Class

The Land Use Conformance Class implements the following Requirements Class from the CityGML 3.0 Conceptual Model Standard:

- LandUse: http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-landuse

The applicable GML schema is landUse.xsd.

Requirements Class	
http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-landuse	
Target type	Implementation
Dependency	landUse.xsd
Dependency	http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-landuse
Dependency	http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-core

6.11.1. GML Elements

The CityGML Land Use XML elements are listed in the GML schema landUse.xsd.

6.11.2. Implementation Decisions

The following decisions have been made regarding implementation of the CityGML 3.0 Land Use conformance class in GML.

1. All associations allow by default that the referenced features can be provided inline or by reference.

6.11.3. Requirements

Requirement 10	/req/landuse/elements
CityGML XML elements implemented by a conforming instance document shall conform to the GML XML schema in landUse.xsd.	

6.12. Point Cloud Conformance Class

The Point Cloud Conformance Class implements the following Requirements Class from the CityGML 3.0 Conceptual Model Standard:

- Point Cloud: http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-pointcloud

The applicable GML schema is pointCloud.xsd.

Requirements Class	
http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-pointcloud	
Target type	Implementation
Dependency	pointCloud.xsd
Dependency	http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-pointcloud
Dependency	http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-core

6.12.1. GML Elements

The CityGML Point Cloud XML elements are listed in the GML schema pointCloud.xsd.

6.12.2. Implementation Decisions

The following decisions have been made regarding implementation of the CityGML 3.0 Point Cloud conformance class in GML.

1. All associations allow by default that the referenced features can be provided inline or by reference.

6.12.3. Requirements

Requirement 11	/req/pointcloud/elements

> CityGML XML elements implemented by a conforming instance document shall conform to the GML XML schema in pointCloud.xsd.

6.13. Relief Conformance Class

The Relief Conformance Class implements the following Requirements Class from the CityGML 3.0 Conceptual Model Standard:

- Relief: http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-relief

The applicable GML schema is relief.xsd.

Requirements Class	
http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-relief	
Target type	Implementation
Dependency	relief.xsd
Dependency	http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-relief
Dependency	http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-core

6.13.1. GML Elements

The CityGML Relief XML elements are listed in the GML schema relief.xsd.

6.13.2. Implementation Decisions

The following decisions have been made regarding implementation of the CityGML 3.0 Relief conformance class in GML.

1. All associations allow by default that the referenced features can be provided inline or by reference.

6.13.3. Requirements

Requirement 12	/req/relief/elements
CityGML XML elements implemented by a conforming instance document shall conform to the GML XML schema in relief.xsd.	

6.14. Transportation Conformance Class

The Transportation Conformance Class implements the following Requirements Class from the CityGML 3.0 Conceptual Model Standard:

- Transportation: http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-transportation

The applicable GML schema is transportation.xsd.

Requirements Class
http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-transportation

Target type	Implementation
Dependency	transportation.xsd
Dependency	http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-transportation
Dependency	http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-core

6.14.1. GML Elements

The CityGML Transportation XML elements are listed in the GML schema transportation.xsd.

6.14.2. Implementation Decisions

The following decisions have been made regarding implementation of the CityGML 3.0 Transportation conformance class in GML.

1. All associations allow by default that the referenced features can be provided inline or by reference. However, restrictions are defined for the following associations, since they represent alternative aggregations (see rule on referencing features from alternative aggregations in Section 6.1.3.4):

   ◦ The reflexive association successor of TrafficSpace; here, a traffic space must reference its succeeding traffic space using XLink.

   ◦ The reflexive association predecessor of TrafficSpace; here, a traffic space must reference its preceding traffic space using XLink.

6.14.3. Requirements

Requirement 13	/req/transportation/elements
CityGML XML elements implemented by a conforming instance document shall conform to the GML XML schema in transportation.xsd.	

6.15. Tunnel Conformance Class

The Tunnel Conformance Class implements the following Requirements Class from the CityGML 3.0 Conceptual Model Standard:

- Tunnel: http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-tunnel

The applicable GML schema is tunnel.xsd.

Requirements Class
http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-tunnel

Target type	Implementation

Dependency	tunnel.xsd
Dependency	http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-tunnel
Dependency	http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-core

6.15.1. GML Elements

The CityGML Tunnel XML elements are listed in the GML schema tunnel.xsd.

6.15.2. Implementation Decisions

The following decisions have been made regarding implementation of the CityGML 3.0 Tunnel conformance class in GML.

1. All associations allow by default that the referenced features can be provided inline or by reference.

6.15.3. Requirements

Requirement 14	/req/tunnel/elements
CityGML XML elements implemented by a conforming instance document shall conform to the GML XML schema in tunnel.xsd.	

6.16. Vegetation Conformance Class

The Vegetation Conformance Class implements the following Requirements Class from the CityGML 3.0 Conceptual Model Standard:

- Vegetation: http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-vegetation

The applicable GML schema is vegetation.xsd.

Requirements Class	
http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-vegetation	
Target type	Implementation
Dependency	vegetation.xsd
Dependency	http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-vegetation
Dependency	http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-core

6.16.1. GML Elements

The CityGML Vegetation XML elements are listed in the GML schema vegetation.xsd.

6.16.2. Implementation Decisions

The following decisions have been made regarding implementation of the CityGML 3.0 Vegetation

conformance class in GML.

1. All associations allow by default that the referenced features can be provided inline or by reference.

6.16.3. Requirements

Requirement 15	/req/vegetation/elements
CityGML XML elements implemented by a conforming instance document shall conform to the GML XML schema in vegetation.xsd.	

6.17. Versioning Conformance Class

The Versioning Conformance Class implements the following Requirements Class from the CityGML 3.0 Conceptual Model Standard:

- Versioning: http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-versioning

The applicable GML schema is versioning.xsd.

Requirements Class
http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-versioning

Target type	Implementation
Dependency	versioning.xsd
Dependency	http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-versioning
Dependency	http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-core

6.17.1. GML Elements

The CityGML Versioning XML elements are listed in the GML schema versioning.xsd.

6.17.2. Implementation Decisions

The following decisions have been made regarding implementation of the CityGML 3.0 Versioning conformance class in GML.

1. All associations allow by default that the referenced features can be provided inline or by reference. However, restrictions are defined for the following associations, since they represent alternative aggregations (see rule on referencing features from alternative aggregations in Section 6.1.3.4):

   ◦ The association oldFeature which connects Transaction with AbstractFeatureWithLifespan; here, a transaction must reference the version of the city object prior to the transaction using XLink.

   ◦ The association newFeature which connects Transaction with AbstractFeatureWithLifespan; here, a transaction must reference the version of the city object subsequent to the

transaction using XLink.

- ◦ The association from which connects VersionTransition with Version; here, a version transition must reference the predecessor version of the VersionTransition using XLink.

- ◦ The association to which connects VersionTransition with Version; here, a version transition must reference the successor version of the VersionTransition using XLink.

- ◦ The association versionMember which connects Version with AbstractFeatureWithLifespan; here, a version must reference the features that are part of this version using XLink.

6.17.3. Requirements

Requirement 16	/req/versioning/elements
CityGML XML elements implemented by a conforming instance document shall conform to the GML XML schema in versioning.xsd.	

6.18. Water Body Conformance Class

The Water Body Conformance Class implements the following Requirements Class from the CityGML 3.0 Conceptual Model Standard:

- WaterBody: http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-waterbody

The applicable GML schema is waterBody.xsd.

Requirements Class	
http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-waterbody	
Target type	Implementation
Dependency	waterBody.xsd
Dependency	http://www.opengis.net/spec/CityGML-1/3.0/req/req-class-waterbody
Dependency	http://www.opengis.net/spec/CityGML-2/3.0/req/req-class-core

6.18.1. GML Elements

The CityGML Water Body XML elements are listed in the GML schema waterBody.xsd.

6.18.2. Implementation Decisions

The following decisions have been made regarding implementation of the CityGML 3.0 Water Body conformance class in GML.

1. All associations allow by default that the referenced features can be provided inline or by reference.

6.18.3. Requirements

Requirement 17	/req/waterbody/elements
CityGML XML elements implemented by a conforming instance document shall conform to the GML XML schema in waterBody.xsd.	

Chapter 7. Media Types

Data for all Parts of the CityGML 3.0 GML encoding standard is encoded in GML-conformant XML documents. The standard MIME-type and sub-type for GML data should be used to indicate the encoding in internet exchange.

The registered MIME Media Type for GML documents is `application/gml+xml`.

Annex A: Conformance Class Abstract Test Suite (Normative)

NOTE   Ensure that there is a conformance class for each requirements class and a test for each requirement (identified by requirement name and number)

A.1. Conformance Class A

A.1.1. Requirement 1

Test id:	/conf/conf-class-a/req-name-1
Requirement:	/req/req-class-a/req-name-1
Test purpose:	Verify that…
Test method:	Inspect…

A.1.2. Requirement 2

Annex B: Examples (Informative)

NOTE | This is where any examples will live. For ease of maintenance, each example should be created in its' own asccidoc file and then imported using an "include" statement.

Annex C: XML Schema (Normative)

NOTE This is where any XML or JSON schema reside. Conformance is defined, in part, by conformance to these schemas.

C.1. Core module

The CityGML Core module is defined in the XML Schema Definition file *core.xsd* (Listing 8). The target namespace http://www.opengis.net/citygml/3.0 is associated with this module.

Listing 8. core.xsd

```
<?xml version="1.0" encoding="UTF-8"?><schema xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:core="http://www.opengis.net/citygml/3.0"
xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:xAL="urn:oasis:names:tc:ciq:xal:3"
elementFormDefault="qualified" targetNamespace="http://www.opengis.net/citygml/3.0"
version="3.0.0">
  <annotation>
    <documentation>The Core module defines the basic components of the CityGML
conceptual model. This includes abstract base classes that define the core properties
of more specialized thematic classes defined in other modules as well as concrete
classes that are common to other modules, for example basic data
types.</documentation>
  </annotation>
  <import namespace="http://www.opengis.net/gml/3.2"
schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd"/>
  <import namespace="urn:oasis:names:tc:ciq:xal:3" schemaLocation="http://docs.oasis-
open.org/ciq/v3.0/cs02/xsd/default/xsd/xAL.xsd"/>
  <!--XML Schema document created by ShapeChange - http://shapechange.net/-->
  <element abstract="true" name="ADEOfAbstractAppearance"
substitutionGroup="gml:AbstractObject" type="core:ADEOfAbstractAppearanceType">
    <annotation>
      <documentation>ADEOfAbstractAppearance acts as a hook to define properties
within an ADE that are to be added to AbstractAppearance.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAbstractAppearanceType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfAbstractAppearancePropertyType">
    <sequence>
      <element ref="core:ADEOfAbstractAppearance"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfAbstractCityObject"
substitutionGroup="gml:AbstractObject" type="core:ADEOfAbstractCityObjectType">
    <annotation>
      <documentation>ADEOfAbstractCityObject acts as a hook to define properties
within an ADE that are to be added to AbstractCityObject.</documentation>
```

```xml
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfAbstractCityObjectType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfAbstractCityObjectPropertyType">
      <sequence>
        <element ref="core:ADEOfAbstractCityObject"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfAbstractDynamizer"
substitutionGroup="gml:AbstractObject" type="core:ADEOfAbstractDynamizerType">
      <annotation>
        <documentation>ADEOfAbstractDynamizer acts as a hook to define properties within
an ADE that are to be added to AbstractDynamizer.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfAbstractDynamizerType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfAbstractDynamizerPropertyType">
      <sequence>
        <element ref="core:ADEOfAbstractDynamizer"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfAbstractFeature"
substitutionGroup="gml:AbstractObject" type="core:ADEOfAbstractFeatureType">
      <annotation>
        <documentation>ADEOfAbstractFeature acts as a hook to define properties within
an ADE that are to be added to AbstractFeature.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfAbstractFeatureType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfAbstractFeaturePropertyType">
      <sequence>
        <element ref="core:ADEOfAbstractFeature"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfAbstractFeatureWithLifespan"
substitutionGroup="gml:AbstractObject"
type="core:ADEOfAbstractFeatureWithLifespanType">
      <annotation>
        <documentation>ADEOfAbstractFeatureWithLifespan acts as a hook to define
properties within an ADE that are to be added to
AbstractFeatureWithLifespan.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfAbstractFeatureWithLifespanType">
      <sequence/>
```

```xml
    </complexType>
    <complexType name="ADEOfAbstractFeatureWithLifespanPropertyType">
      <sequence>
        <element ref="core:ADEOfAbstractFeatureWithLifespan"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfAbstractLogicalSpace"
substitutionGroup="gml:AbstractObject" type="core:ADEOfAbstractLogicalSpaceType">
      <annotation>
        <documentation>ADEOfAbstractLogicalSpace acts as a hook to define properties
within an ADE that are to be added to AbstractLogicalSpace.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfAbstractLogicalSpaceType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfAbstractLogicalSpacePropertyType">
      <sequence>
        <element ref="core:ADEOfAbstractLogicalSpace"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfAbstractOccupiedSpace"
substitutionGroup="gml:AbstractObject" type="core:ADEOfAbstractOccupiedSpaceType">
      <annotation>
        <documentation>ADEOfAbstractOccupiedSpace acts as a hook to define properties
within an ADE that are to be added to AbstractOccupiedSpace.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfAbstractOccupiedSpaceType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfAbstractOccupiedSpacePropertyType">
      <sequence>
        <element ref="core:ADEOfAbstractOccupiedSpace"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfAbstractPhysicalSpace"
substitutionGroup="gml:AbstractObject" type="core:ADEOfAbstractPhysicalSpaceType">
      <annotation>
        <documentation>ADEOfAbstractPhysicalSpace acts as a hook to define properties
within an ADE that are to be added to AbstractPhysicalSpace.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfAbstractPhysicalSpaceType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfAbstractPhysicalSpacePropertyType">
      <sequence>
        <element ref="core:ADEOfAbstractPhysicalSpace"/>
      </sequence>
    </complexType>
```

```
<element abstract="true" name="ADEOfAbstractPointCloud"
substitutionGroup="gml:AbstractObject" type="core:ADEOfAbstractPointCloudType">
    <annotation>
      <documentation>ADEOfAbstractPointCloud acts as a hook to define properties
within an ADE that are to be added to AbstractPointCloud.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAbstractPointCloudType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfAbstractPointCloudPropertyType">
    <sequence>
      <element ref="core:ADEOfAbstractPointCloud"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfAbstractSpace"
substitutionGroup="gml:AbstractObject" type="core:ADEOfAbstractSpaceType">
    <annotation>
      <documentation>ADEOfAbstractSpace acts as a hook to define properties within an
ADE that are to be added to AbstractSpace.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAbstractSpaceType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfAbstractSpacePropertyType">
    <sequence>
      <element ref="core:ADEOfAbstractSpace"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfAbstractSpaceBoundary"
substitutionGroup="gml:AbstractObject" type="core:ADEOfAbstractSpaceBoundaryType">
    <annotation>
      <documentation>ADEOfAbstractSpaceBoundary acts as a hook to define properties
within an ADE that are to be added to AbstractSpaceBoundary.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAbstractSpaceBoundaryType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfAbstractSpaceBoundaryPropertyType">
    <sequence>
      <element ref="core:ADEOfAbstractSpaceBoundary"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfAbstractThematicSurface"
substitutionGroup="gml:AbstractObject" type="core:ADEOfAbstractThematicSurfaceType">
    <annotation>
      <documentation>ADEOfAbstractThematicSurface acts as a hook to define properties
within an ADE that are to be added to AbstractThematicSurface.</documentation>
    </annotation>
```

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    </element>
    <complexType abstract="true" name="ADEOfAbstractThematicSurfaceType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfAbstractThematicSurfacePropertyType">
      <sequence>
        <element ref="core:ADEOfAbstractThematicSurface"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfAbstractUnoccupiedSpace"
substitutionGroup="gml:AbstractObject" type="core:ADEOfAbstractUnoccupiedSpaceType">
      <annotation>
        <documentation>ADEOfAbstractUnoccupiedSpace acts as a hook to define properties
within an ADE that are to be added to AbstractUnoccupiedSpace.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfAbstractUnoccupiedSpaceType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfAbstractUnoccupiedSpacePropertyType">
      <sequence>
        <element ref="core:ADEOfAbstractUnoccupiedSpace"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfAbstractVersion"
substitutionGroup="gml:AbstractObject" type="core:ADEOfAbstractVersionType">
      <annotation>
        <documentation>ADEOfAbstractVersion acts as a hook to define properties within
an ADE that are to be added to AbstractVersion.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfAbstractVersionType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfAbstractVersionPropertyType">
      <sequence>
        <element ref="core:ADEOfAbstractVersion"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfAbstractVersionTransition"
substitutionGroup="gml:AbstractObject" type="core:ADEOfAbstractVersionTransitionType">
      <annotation>
        <documentation>ADEOfAbstractVersionTransition acts as a hook to define
properties within an ADE that are to be added to
AbstractVersionTransition.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfAbstractVersionTransitionType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfAbstractVersionTransitionPropertyType">
```

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    <sequence>
      <element ref="core:ADEOfAbstractVersionTransition"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfAddress" substitutionGroup="gml:AbstractObject"
type="core:ADEOfAddressType">
    <annotation>
      <documentation>ADEOfAddress acts as a hook to define properties within an ADE
that are to be added to an Address.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAddressType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfAddressPropertyType">
    <sequence>
      <element ref="core:ADEOfAddress"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfCityModel"
substitutionGroup="gml:AbstractObject" type="core:ADEOfCityModelType">
    <annotation>
      <documentation>ADEOfCityModel acts as a hook to define properties within an ADE
that are to be added to a CityModel.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfCityModelType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfCityModelPropertyType">
    <sequence>
      <element ref="core:ADEOfCityModel"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfClosureSurface"
substitutionGroup="gml:AbstractObject" type="core:ADEOfClosureSurfaceType">
    <annotation>
      <documentation>ADEOfClosureSurface acts as a hook to define properties within an
ADE that are to be added to a ClosureSurface.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfClosureSurfaceType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfClosureSurfacePropertyType">
    <sequence>
      <element ref="core:ADEOfClosureSurface"/>
    </sequence>
  </complexType>
  <element abstract="true" name="AbstractAppearance"
substitutionGroup="core:AbstractFeatureWithLifespan"
```

```xml
type="core:AbstractAppearanceType">
    <annotation>
      <documentation>AbstractAppearance is the abstract superclass to represent any
kind of appearance objects.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="AbstractAppearanceType">
    <complexContent>
      <extension base="core:AbstractFeatureWithLifespanType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfAbstractAppearance"
type="core:ADEOfAbstractAppearancePropertyType">
            <annotation>
              <documentation>Augments AbstractAppearance with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="AbstractAppearancePropertyType">
    <sequence minOccurs="0">
      <element ref="core:AbstractAppearance"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element abstract="true" name="AbstractCityObject"
substitutionGroup="core:AbstractFeatureWithLifespan"
type="core:AbstractCityObjectType">
    <annotation>
      <documentation>AbstractCityObject is the abstract superclass of all thematic
classes within the CityGML Conceptual Model.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="AbstractCityObjectType">
    <complexContent>
      <extension base="core:AbstractFeatureWithLifespanType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="externalReference"
type="core:ExternalReferencePropertyType">
            <annotation>
              <documentation>References external objects in other information systems
that have a relation to the city object.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="generalizesTo"
type="gml:ReferenceType">
            <annotation>
              <documentation>Relates generalized representations of the same real-
```

world object in different Levels of Detail to the city object. The direction of this relation is from the city object to the corresponding generalized city objects.</documentation>
                <appinfo>
                  <targetElement
xmlns="http://www.opengis.net/gml/3.2">core:AbstractCityObject</targetElement>
                </appinfo>
              </annotation>
            </element>
            <element minOccurs="0" name="relativeToTerrain"
type="core:RelativeToTerrainType">
              <annotation>
                <documentation>Describes the vertical position of the city object
relative to the surrounding terrain.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="relativeToWater"
type="core:RelativeToWaterType">
              <annotation>
                <documentation>Describes the vertical position of the city object
relative to the surrounding water surface.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="relatedTo">
              <complexType>
                <sequence>
                  <element ref="core:CityObjectRelation"/>
                </sequence>
                <attributeGroup ref="gml:OwnershipAttributeGroup"/>
              </complexType>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="appearance">
              <annotation>
                <documentation>Relates appearances to the city object.</documentation>
              </annotation>
              <complexType>
                <complexContent>
                  <extension base="gml:AbstractFeatureMemberType">
                    <sequence minOccurs="0">
                      <element ref="core:AbstractAppearance"/>
                    </sequence>
                    <attributeGroup ref="gml:AssociationAttributeGroup"/>
                  </extension>
                </complexContent>
              </complexType>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="genericAttribute"
type="core:AbstractGenericAttributePropertyType">
              <annotation>
                <documentation>Relates generic attributes to the city
object.</documentation>

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          </annotation>
        </element>
        <element maxOccurs="unbounded" minOccurs="0" name="dynamizer"
type="core:AbstractDynamizerPropertyType">
          <annotation>
            <documentation>Relates Dynamizer objects to the city object. These allow
timeseries data to override static attribute values of the city
object.</documentation>
          </annotation>
        </element>
        <element maxOccurs="unbounded" minOccurs="0" name="adeOfAbstractCityObject"
type="core:ADEOfAbstractCityObjectPropertyType">
          <annotation>
            <documentation>Augments AbstractCityObject with properties defined in an
ADE.</documentation>
          </annotation>
        </element>
      </sequence>
    </extension>
  </complexContent>
</complexType>
<complexType name="AbstractCityObjectPropertyType">
  <sequence minOccurs="0">
    <element ref="core:AbstractCityObject"/>
  </sequence>
  <attributeGroup ref="gml:AssociationAttributeGroup"/>
  <attributeGroup ref="gml:OwnershipAttributeGroup"/>
</complexType>
<element abstract="true" name="AbstractDynamizer"
substitutionGroup="core:AbstractFeatureWithLifespan"
type="core:AbstractDynamizerType">
  <annotation>
    <documentation>AbstractDynamizer is the abstract superclass to represent
Dynamizer objects.</documentation>
  </annotation>
</element>
<complexType abstract="true" name="AbstractDynamizerType">
  <complexContent>
    <extension base="core:AbstractFeatureWithLifespanType">
      <sequence>
        <element maxOccurs="unbounded" minOccurs="0" name="adeOfAbstractDynamizer"
type="core:ADEOfAbstractDynamizerPropertyType">
          <annotation>
            <documentation>Augments AbstractDynamizer with properties defined in an
ADE.</documentation>
          </annotation>
        </element>
      </sequence>
    </extension>
  </complexContent>
</complexType>
```

```xml
  <complexType name="AbstractDynamizerPropertyType">
    <sequence minOccurs="0">
      <element ref="core:AbstractDynamizer"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element abstract="true" name="AbstractFeature"
substitutionGroup="gml:AbstractFeature" type="core:AbstractFeatureType">
    <annotation>
      <documentation>AbstractFeature is the abstract superclass of all feature types
within the CityGML Conceptual Model.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="AbstractFeatureType">
    <complexContent>
      <extension base="gml:AbstractFeatureType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfAbstractFeature"
type="core:ADEOfAbstractFeaturePropertyType">
            <annotation>
              <documentation>Augments AbstractFeature with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="AbstractFeaturePropertyType">
    <sequence minOccurs="0">
      <element ref="core:AbstractFeature"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element abstract="true" name="AbstractFeatureWithLifespan"
substitutionGroup="core:AbstractFeature" type="core:AbstractFeatureWithLifespanType">
    <annotation>
      <documentation>AbstractFeatureWithLifespan is the base class for all CityGML
features. This class allows the optional specification of the real-world and database
times for the existence of each feature.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="AbstractFeatureWithLifespanType">
    <complexContent>
      <extension base="core:AbstractFeatureType">
        <sequence>
          <element minOccurs="0" name="creationDate" type="dateTime">
            <annotation>
              <documentation>Indicates the date at which a CityGML feature was added
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              to the CityModel.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="terminationDate" type="dateTime">
              <annotation>
                <documentation>Indicates the date at which a CityGML feature was removed
from the CityModel.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="validFrom" type="dateTime">
              <annotation>
                <documentation>Indicates the date at which a CityGML feature started to
exist in the real world.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="validTo" type="dateTime">
              <annotation>
                <documentation>Indicates the date at which a CityGML feature ended to
exist in the real world.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0"
name="adeOfAbstractFeatureWithLifespan"
type="core:ADEOfAbstractFeatureWithLifespanPropertyType">
              <annotation>
                <documentation>Augments AbstractFeatureWithLifespan with properties
defined in an ADE.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
    </complexType>
    <complexType name="AbstractFeatureWithLifespanPropertyType">
      <sequence minOccurs="0">
        <element ref="core:AbstractFeatureWithLifespan"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <element abstract="true" name="AbstractGenericAttribute"
substitutionGroup="gml:AbstractObject" type="core:AbstractGenericAttributeType">
      <annotation>
        <documentation>AbstractGenericAttribute is the abstract superclass for all types
of generic attributes.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="AbstractGenericAttributeType">
      <sequence/>
    </complexType>
    <complexType name="AbstractGenericAttributePropertyType">
```

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        <sequence>
          <element ref="core:AbstractGenericAttribute"/>
        </sequence>
      </complexType>
      <element abstract="true" name="AbstractLogicalSpace"
substitutionGroup="core:AbstractSpace" type="core:AbstractLogicalSpaceType">
        <annotation>
          <documentation>AbstractLogicalSpace is the abstract superclass for all types of
logical spaces. Logical space refers to spaces that are not bounded by physical
surfaces but are defined according to thematic considerations.</documentation>
        </annotation>
      </element>
      <complexType abstract="true" name="AbstractLogicalSpaceType">
        <complexContent>
          <extension base="core:AbstractSpaceType">
            <sequence>
              <element maxOccurs="unbounded" minOccurs="0"
name="adeOfAbstractLogicalSpace" type="core:ADEOfAbstractLogicalSpacePropertyType">
                <annotation>
                  <documentation>Augments AbstractLogicalSpace with properties defined in
an ADE.</documentation>
                </annotation>
              </element>
            </sequence>
          </extension>
        </complexContent>
      </complexType>
      <complexType name="AbstractLogicalSpacePropertyType">
        <sequence minOccurs="0">
          <element ref="core:AbstractLogicalSpace"/>
        </sequence>
        <attributeGroup ref="gml:AssociationAttributeGroup"/>
        <attributeGroup ref="gml:OwnershipAttributeGroup"/>
      </complexType>
      <element abstract="true" name="AbstractOccupiedSpace"
substitutionGroup="core:AbstractPhysicalSpace" type="core:AbstractOccupiedSpaceType">
        <annotation>
          <documentation>AbstractOccupiedSpace is the abstract superclass for all types of
physically occupied spaces. Occupied space refers to spaces that are partially or
entirely filled with matter.</documentation>
        </annotation>
      </element>
      <complexType abstract="true" name="AbstractOccupiedSpaceType">
        <complexContent>
          <extension base="core:AbstractPhysicalSpaceType">
            <sequence>
              <element minOccurs="0" name="lod1ImplicitRepresentation"
type="core:ImplicitGeometryPropertyType">
                <annotation>
                  <documentation>Relates to an implicit geometry that represents the
occupied space in Level of Detail 1.</documentation>
```

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              </annotation>
            </element>
            <element minOccurs="0" name="lod2ImplicitRepresentation"
type="core:ImplicitGeometryPropertyType">
              <annotation>
                <documentation>Relates to an implicit geometry that represents the
occupied space in Level of Detail 2.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="lod3ImplicitRepresentation"
type="core:ImplicitGeometryPropertyType">
              <annotation>
                <documentation>Relates to an implicit geometry that represents the
occupied space in Level of Detail 3.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0"
name="adeOfAbstractOccupiedSpace" type="core:ADEOfAbstractOccupiedSpacePropertyType">
              <annotation>
                <documentation>Augments AbstractOccupiedSpace with properties defined in
an ADE.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
    </complexType>
    <complexType name="AbstractOccupiedSpacePropertyType">
      <sequence minOccurs="0">
        <element ref="core:AbstractOccupiedSpace"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <element abstract="true" name="AbstractPhysicalSpace"
substitutionGroup="core:AbstractSpace" type="core:AbstractPhysicalSpaceType">
      <annotation>
        <documentation>AbstractPhysicalSpace is the abstract superclass for all types of
physical spaces. Physical space refers to spaces that are fully or partially bounded
by physical objects.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="AbstractPhysicalSpaceType">
      <complexContent>
        <extension base="core:AbstractSpaceType">
          <sequence>
            <element minOccurs="0" name="lod1TerrainIntersectionCurve"
type="gml:MultiCurvePropertyType">
              <annotation>
                <documentation>Relates to a 3D MultiCurve geometry that represents the
terrain intersection curve of the physical space in Level of Detail 1.</documentation>
```

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            </annotation>
          </element>
          <element minOccurs="0" name="lod2TerrainIntersectionCurve"
type="gml:MultiCurvePropertyType">
            <annotation>
              <documentation>Relates to a 3D MultiCurve geometry that represents the
terrain intersection curve of the physical space in Level of Detail 2.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="lod3TerrainIntersectionCurve"
type="gml:MultiCurvePropertyType">
            <annotation>
              <documentation>Relates to a 3D MultiCurve geometry that represents the
terrain intersection curve of the physical space in Level of Detail 3.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="pointCloud"
type="core:AbstractPointCloudPropertyType">
            <annotation>
              <documentation>Relates to a 3D PointCloud that represents the physical
space.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0"
name="adeOfAbstractPhysicalSpace" type="core:ADEOfAbstractPhysicalSpacePropertyType">
            <annotation>
              <documentation>Augments AbstractPhysicalSpace with properties defined in
an ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="AbstractPhysicalSpacePropertyType">
    <sequence minOccurs="0">
      <element ref="core:AbstractPhysicalSpace"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element abstract="true" name="AbstractPointCloud"
substitutionGroup="core:AbstractFeature" type="core:AbstractPointCloudType">
    <annotation>
      <documentation>AbstractPointCloud is the abstract superclass to represent
PointCloud objects.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="AbstractPointCloudType">
    <complexContent>
      <extension base="core:AbstractFeatureType">
```

```
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfAbstractPointCloud"
type="core:ADEOfAbstractPointCloudPropertyType">
            <annotation>
              <documentation>Augments AbstractPointCloud with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="AbstractPointCloudPropertyType">
    <sequence minOccurs="0">
      <element ref="core:AbstractPointCloud"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element abstract="true" name="AbstractSpace"
substitutionGroup="core:AbstractCityObject" type="core:AbstractSpaceType">
    <annotation>
      <documentation>AbstractSpace is the abstract superclass for all types of spaces.
A space is an entity of volumetric extent in the real world.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="AbstractSpaceType">
    <complexContent>
      <extension base="core:AbstractCityObjectType">
        <sequence>
          <element minOccurs="0" name="spaceType" type="core:SpaceTypeType">
            <annotation>
              <documentation>Specifies the degree of openness of a
space.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="volume"
type="core:QualifiedVolumePropertyType">
            <annotation>
              <documentation>Specifies qualified volumes related to the
space.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="area"
type="core:QualifiedAreaPropertyType">
            <annotation>
              <documentation>Specifies qualified areas related to the
space.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="boundary"
```

```
type="core:AbstractSpaceBoundaryPropertyType">
              <annotation>
                <documentation>Relates to surfaces that bound the space.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="lod0Point" type="gml:PointPropertyType">
              <annotation>
                <documentation>Relates to a 3D Point geometry that represents the space
in Level of Detail 0.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="lod0MultiSurface"
type="gml:MultiSurfacePropertyType">
              <annotation>
                <documentation>Relates to a 3D MultiSurface geometry that represents the
space in Level of Detail 0.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="lod0MultiCurve"
type="gml:MultiCurvePropertyType">
              <annotation>
                <documentation>Relates to a 3D MultiCurve geometry that represents the
space in Level of Detail 0.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="lod1Solid" type="gml:SolidPropertyType">
              <annotation>
                <documentation>Relates to a 3D Solid geometry that represents the space
in Level of Detail 1.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="lod2Solid" type="gml:SolidPropertyType">
              <annotation>
                <documentation>Relates to a 3D Solid geometry that represents the space
in Level of Detail 2.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="lod2MultiSurface"
type="gml:MultiSurfacePropertyType">
              <annotation>
                <documentation>Relates to a 3D MultiSurface geometry that represents the
space in Level of Detail 2.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="lod2MultiCurve"
type="gml:MultiCurvePropertyType">
              <annotation>
                <documentation>Relates to a 3D MultiCurve geometry that represents the
space in Level of Detail 2.</documentation>
              </annotation>
            </element>
```

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          <element minOccurs="0" name="lod3Solid" type="gml:SolidPropertyType">
            <annotation>
              <documentation>Relates to a 3D Solid geometry that represents the space
in Level of Detail 3.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="lod3MultiSurface"
type="gml:MultiSurfacePropertyType">
            <annotation>
              <documentation>Relates to a 3D MultiSurface geometry that represents the
space in Level of Detail 3.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="lod3MultiCurve"
type="gml:MultiCurvePropertyType">
            <annotation>
              <documentation>Relates to a 3D MultiCurve geometry that represents the
space in Level of Detail 3.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfAbstractSpace"
type="core:ADEOfAbstractSpacePropertyType">
            <annotation>
              <documentation>Augments AbstractSpace with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="AbstractSpacePropertyType">
    <sequence minOccurs="0">
      <element ref="core:AbstractSpace"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element abstract="true" name="AbstractSpaceBoundary"
substitutionGroup="core:AbstractCityObject" type="core:AbstractSpaceBoundaryType">
    <annotation>
      <documentation>AbstractSpaceBoundary is the abstract superclass for all types of
space boundaries. A space boundary is an entity with areal extent in the real world.
Space boundaries are objects that bound a Space. They also realize the contact between
adjacent spaces.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="AbstractSpaceBoundaryType">
    <complexContent>
      <extension base="core:AbstractCityObjectType">
        <sequence>
```

```xml
            <element maxOccurs="unbounded" minOccurs="0"
name="adeOfAbstractSpaceBoundary" type="core:ADEOfAbstractSpaceBoundaryPropertyType">
              <annotation>
                <documentation>Augments AbstractSpaceBoundary with properties defined in
an ADE.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
    </complexType>
    <complexType name="AbstractSpaceBoundaryPropertyType">
      <sequence minOccurs="0">
        <element ref="core:AbstractSpaceBoundary"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <element abstract="true" name="AbstractThematicSurface"
substitutionGroup="core:AbstractSpaceBoundary"
type="core:AbstractThematicSurfaceType">
      <annotation>
        <documentation>AbstractThematicSurface is the abstract superclass for all types
of thematic surfaces.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="AbstractThematicSurfaceType">
      <complexContent>
        <extension base="core:AbstractSpaceBoundaryType">
          <sequence>
            <element maxOccurs="unbounded" minOccurs="0" name="area"
type="core:QualifiedAreaPropertyType">
              <annotation>
                <documentation>Specifies qualified areas related to the thematic
surface.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="lod0MultiCurve"
type="gml:MultiCurvePropertyType">
              <annotation>
                <documentation>Relates to a 3D MultiCurve geometry that represents the
thematic surface in Level of Detail 0.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="lod0MultiSurface"
type="gml:MultiSurfacePropertyType">
              <annotation>
                <documentation>Relates to a 3D MultiSurface geometry that represents the
thematic surface in Level of Detail 0.</documentation>
              </annotation>
            </element>
```

```xml
            <element minOccurs="0" name="lod1MultiSurface"
type="gml:MultiSurfacePropertyType">
              <annotation>
                <documentation>Relates to a 3D MultiSurface geometry that represents the
thematic surface in Level of Detail 1.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="lod2MultiSurface"
type="gml:MultiSurfacePropertyType">
              <annotation>
                <documentation>Relates to a 3D MultiSurface geometry that represents the
thematic surface in Level of Detail 2.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="lod3MultiSurface"
type="gml:MultiSurfacePropertyType">
              <annotation>
                <documentation>Relates to a 3D MultiSurface geometry that represents the
thematic surface in Level of Detail 3.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="pointCloud"
type="core:AbstractPointCloudPropertyType">
              <annotation>
                <documentation>Relates to a 3D PointCloud that represents the thematic
surface.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0"
name="adeOfAbstractThematicSurface"
type="core:ADEOfAbstractThematicSurfacePropertyType">
              <annotation>
                <documentation>Augments AbstractThematicSurface with properties defined
in an ADE.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
    </complexType>
    <complexType name="AbstractThematicSurfacePropertyType">
      <sequence minOccurs="0">
        <element ref="core:AbstractThematicSurface"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <element abstract="true" name="AbstractUnoccupiedSpace"
substitutionGroup="core:AbstractPhysicalSpace"
type="core:AbstractUnoccupiedSpaceType">
    <annotation>
```

```xml
      <documentation>AbstractUnoccupiedSpace is the abstract superclass for all types
of physically unoccupied spaces. Unoccupied space refers to spaces that are entirely
or mostly free of matter.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="AbstractUnoccupiedSpaceType">
    <complexContent>
      <extension base="core:AbstractPhysicalSpaceType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0"
name="adeOfAbstractUnoccupiedSpace"
type="core:ADEOfAbstractUnoccupiedSpacePropertyType">
            <annotation>
              <documentation>Augments AbstractUnoccupiedSpace with properties defined
in an ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="AbstractUnoccupiedSpacePropertyType">
    <sequence minOccurs="0">
      <element ref="core:AbstractUnoccupiedSpace"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element abstract="true" name="AbstractVersion"
substitutionGroup="core:AbstractFeatureWithLifespan" type="core:AbstractVersionType">
    <annotation>
      <documentation>AbstractVersion is the abstract superclass to represent Version
objects.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="AbstractVersionType">
    <complexContent>
      <extension base="core:AbstractFeatureWithLifespanType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfAbstractVersion"
type="core:ADEOfAbstractVersionPropertyType">
            <annotation>
              <documentation>Augments AbstractVersion with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="AbstractVersionPropertyType">
```

```
    <sequence minOccurs="0">
      <element ref="core:AbstractVersion"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element abstract="true" name="AbstractVersionTransition"
substitutionGroup="core:AbstractFeatureWithLifespan"
type="core:AbstractVersionTransitionType">
    <annotation>
      <documentation>AbstractVersionTransition is the abstract superclass to represent
VersionTransition objects.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="AbstractVersionTransitionType">
    <complexContent>
      <extension base="core:AbstractFeatureWithLifespanType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0"
name="adeOfAbstractVersionTransition"
type="core:ADEOfAbstractVersionTransitionPropertyType">
            <annotation>
              <documentation>Augments AbstractVersionTransition with properties
defined in an ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="AbstractVersionTransitionPropertyType">
    <sequence minOccurs="0">
      <element ref="core:AbstractVersionTransition"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="Address" substitutionGroup="core:AbstractFeature"
type="core:AddressType">
    <annotation>
      <documentation>Address represents an address of a city object.</documentation>
    </annotation>
  </element>
  <complexType name="AddressType">
    <complexContent>
      <extension base="core:AbstractFeatureType">
        <sequence>
          <element name="xalAddress">
            <annotation>
              <documentation>Relates an OASIS address object to the
Address.</documentation>
```

```xml
          </annotation>
          <complexType>
            <sequence>
              <element ref="xAL:Address"/>
            </sequence>
          </complexType>
        </element>
        <element minOccurs="0" name="multiPoint" type="gml:MultiPointPropertyType">
          <annotation>
            <documentation>Relates to the MultiPoint geometry of the Address. The
geometry relates the address spatially to a city object.</documentation>
          </annotation>
        </element>
        <element maxOccurs="unbounded" minOccurs="0" name="adeOfAddress"
type="core:ADEOfAddressPropertyType">
          <annotation>
            <documentation>Augments the Address with properties defined in an
ADE.</documentation>
          </annotation>
        </element>
      </sequence>
    </extension>
  </complexContent>
</complexType>
<complexType name="AddressPropertyType">
  <sequence minOccurs="0">
    <element ref="core:Address"/>
  </sequence>
  <attributeGroup ref="gml:AssociationAttributeGroup"/>
  <attributeGroup ref="gml:OwnershipAttributeGroup"/>
</complexType>
<element name="CityModel" substitutionGroup="core:AbstractFeatureWithLifespan"
type="core:CityModelType">
  <annotation>
    <documentation>CityModel is the container for all objects belonging to a city
model.</documentation>
  </annotation>
</element>
<complexType name="CityModelType">
  <complexContent>
    <extension base="core:AbstractFeatureWithLifespanType">
      <sequence>
        <element minOccurs="0" name="engineeringCRS">
          <annotation>
            <documentation>Specifies the local engineering coordinate reference
system of the CityModel that can be provided inline the CityModel instead of
referencing a well-known CRS definition. The definition of an engineering CRS requires
an anchor point which relates the origin of the local coordinate system to a point on
the earth□s surface in order to facilitate the transformation of coordinates from the
local engineering CRS.</documentation>
          </annotation>
```

```xml
            <complexType>
              <complexContent>
                <extension base="gml:AbstractMetadataPropertyType">
                  <sequence minOccurs="0">
                    <element ref="gml:EngineeringCRS"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
          </element>
          <group maxOccurs="unbounded" minOccurs="0" ref="core:CityModelMemberGroup">
            <annotation>
              <documentation>Relates to all objects that are part of the
CityModel.</documentation>
            </annotation>
          </group>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfCityModel"
type="core:ADEOfCityModelPropertyType">
            <annotation>
              <documentation>Augments the CityModel with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="CityModelPropertyType">
    <sequence minOccurs="0">
      <element ref="core:CityModel"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <group name="CityModelMemberGroup">
    <annotation>
      <documentation>CityModelMember is a union type that enumerates the different
types of objects that can occur as members of a city model.</documentation>
    </annotation>
    <choice>
      <element name="cityObjectMember">
        <annotation>
          <documentation>Specifies the city objects that are part of the
CityModel.</documentation>
        </annotation>
        <complexType>
          <complexContent>
            <extension base="gml:AbstractFeatureMemberType">
              <sequence minOccurs="0">
                <element ref="core:AbstractCityObject"/>
```

```
          </sequence>
          <attributeGroup ref="gml:AssociationAttributeGroup"/>
        </extension>
      </complexContent>
    </complexType>
  </element>
  <element name="appearanceMember">
    <annotation>
      <documentation>Specifies the appearances of the CityModel.</documentation>
    </annotation>
    <complexType>
      <complexContent>
        <extension base="gml:AbstractFeatureMemberType">
          <sequence minOccurs="0">
            <element ref="core:AbstractAppearance"/>
          </sequence>
          <attributeGroup ref="gml:AssociationAttributeGroup"/>
        </extension>
      </complexContent>
    </complexType>
  </element>
  <element name="versionMember">
    <annotation>
      <documentation>Specifies the different versions of the
CityModel.</documentation>
    </annotation>
    <complexType>
      <complexContent>
        <extension base="gml:AbstractFeatureMemberType">
          <sequence minOccurs="0">
            <element ref="core:AbstractVersion"/>
          </sequence>
          <attributeGroup ref="gml:AssociationAttributeGroup"/>
        </extension>
      </complexContent>
    </complexType>
  </element>
  <element name="versionTransitionMember">
    <annotation>
      <documentation>Specifies the transitions between the different versions of
the CityModel.</documentation>
    </annotation>
    <complexType>
      <complexContent>
        <extension base="gml:AbstractFeatureMemberType">
          <sequence minOccurs="0">
            <element ref="core:AbstractVersionTransition"/>
          </sequence>
          <attributeGroup ref="gml:AssociationAttributeGroup"/>
        </extension>
      </complexContent>
```

```xml
          </complexType>
        </element>
        <element name="featureMember">
          <annotation>
            <documentation>Specifies the feature objects that are part of the CityModel.
It allows to include objects that are not derived from a class defined in the CityGML
conceptual model, but from the ISO 19109 class AnyFeature.</documentation>
          </annotation>
          <complexType>
            <complexContent>
              <extension base="gml:AbstractFeatureMemberType">
                <sequence minOccurs="0">
                  <element ref="core:AbstractFeature"/>
                </sequence>
                <attributeGroup ref="gml:AssociationAttributeGroup"/>
              </extension>
            </complexContent>
          </complexType>
        </element>
      </choice>
    </group>
    <element name="CityObjectRelation" substitutionGroup="gml:AbstractGML"
type="core:CityObjectRelationType">
      <annotation>
        <documentation>CityObjectRelation represents a specific relation from the city
object in which the relation is included to another city object.</documentation>
      </annotation>
    </element>
    <complexType name="CityObjectRelationType">
      <complexContent>
        <extension base="gml:AbstractGMLType">
          <sequence>
            <element maxOccurs="unbounded" minOccurs="0" name="genericAttribute"
type="core:AbstractGenericAttributePropertyType">
              <annotation>
                <documentation>Relates generic attributes to the
CityObjectRelation.</documentation>
              </annotation>
            </element>
            <element name="relationType" type="gml:CodeType"/>
            <element name="relatedTo" type="gml:ReferenceType">
              <annotation>
                <appinfo>
                  <targetElement
xmlns="http://www.opengis.net/gml/3.2">core:AbstractCityObject</targetElement>
                </appinfo>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
```

```xml
      </complexType>
      <complexType name="CityObjectRelationPropertyType">
        <sequence minOccurs="0">
          <element ref="core:CityObjectRelation"/>
        </sequence>
        <attributeGroup ref="gml:AssociationAttributeGroup"/>
        <attributeGroup ref="gml:OwnershipAttributeGroup"/>
      </complexType>
      <element name="ClosureSurface" substitutionGroup="core:AbstractThematicSurface"
type="core:ClosureSurfaceType">
        <annotation>
          <documentation>ClosureSurface is a special type of thematic surface used to
close holes in volumetric objects. Closure surfaces are virtual (non-physical)
surfaces.</documentation>
        </annotation>
      </element>
      <complexType name="ClosureSurfaceType">
        <complexContent>
          <extension base="core:AbstractThematicSurfaceType">
            <sequence>
              <element maxOccurs="unbounded" minOccurs="0" name="adeOfClosureSurface"
type="core:ADEOfClosureSurfacePropertyType">
                <annotation>
                  <documentation>Augments the ClosureSurface with properties defined in an
ADE.</documentation>
                </annotation>
              </element>
            </sequence>
          </extension>
        </complexContent>
      </complexType>
      <complexType name="ClosureSurfacePropertyType">
        <sequence minOccurs="0">
          <element ref="core:ClosureSurface"/>
        </sequence>
        <attributeGroup ref="gml:AssociationAttributeGroup"/>
        <attributeGroup ref="gml:OwnershipAttributeGroup"/>
      </complexType>
      <simpleType name="DoubleBetween0and1Type">
        <annotation>
          <documentation>DoubleBetween0and1 is a basic type for values, which are greater
or equal than 0 and less or equal than 1. The type is used for color encoding, for
example.</documentation>
        </annotation>
        <restriction base="double">
          <minInclusive value="0"/>
          <maxInclusive value="1"/>
        </restriction>
      </simpleType>
      <simpleType name="DoubleBetween0and1ListType">
        <annotation>
```

```
      <documentation>DoubleBetween0and1List is a basic type that represents a list of
double values greater or equal than 0 and less or equal than 1. The type is used for
color encoding, for example.</documentation>
    </annotation>
    <list itemType="core:DoubleBetween0and1Type"/>
  </simpleType>
  <element name="ExternalReference" substitutionGroup="gml:AbstractObject"
type="core:ExternalReferenceType">
    <annotation>
      <documentation>ExternalReference is a reference to a corresponding object in
another information system, for example in the German cadastre (ALKIS), the German
topographic information system (ATKIS), or the OS UK MasterMap®.</documentation>
    </annotation>
  </element>
  <complexType name="ExternalReferenceType">
    <sequence>
      <element name="targetResource" type="anyURI">
        <annotation>
          <documentation>Specifies the URI that points to the object in the external
information system.</documentation>
        </annotation>
      </element>
      <element minOccurs="0" name="informationSystem" type="anyURI">
        <annotation>
          <documentation>Specifies the URI that points to the external information
system.</documentation>
        </annotation>
      </element>
      <element minOccurs="0" name="relationType" type="anyURI">
        <annotation>
          <documentation>Specifies a URI that additionally qualifies the
ExternalReference. The URI can point to a definition from an external ontology (e.g.
the sameAs relation from OWL) and allows for mapping the ExternalReference to RDF
triples.</documentation>
        </annotation>
      </element>
    </sequence>
  </complexType>
  <complexType name="ExternalReferencePropertyType">
    <sequence>
      <element ref="core:ExternalReference"/>
    </sequence>
  </complexType>
  <element name="ImplicitGeometry" substitutionGroup="gml:AbstractGML"
type="core:ImplicitGeometryType">
    <annotation>
      <documentation>ImplicitGeometry is a geometry representation where the shape is
stored only once as a prototypical geometry. Examples are a tree or other vegetation
object, a traffic light or a traffic sign. This prototypic geometry object can be re-
used or referenced many times, wherever the corresponding feature occurs in the 3D
city model.</documentation>
```

```xml
          </annotation>
        </element>
        <complexType name="ImplicitGeometryType">
          <complexContent>
            <extension base="gml:AbstractGMLType">
              <sequence>
                <element name="transformationMatrix"
type="core:TransformationMatrix4x4Type">
                  <annotation>
                    <documentation>Specifies the mathematical transformation (translation,
rotation, and scaling) between the prototypical geometry and the actual spatial
position of the object.</documentation>
                  </annotation>
                </element>
                <element minOccurs="0" name="mimeType" type="gml:CodeType">
                  <annotation>
                    <documentation>Specifies the MIME type of the external file that stores
the prototypical geometry.</documentation>
                  </annotation>
                </element>
                <element minOccurs="0" name="libraryObject" type="anyURI">
                  <annotation>
                    <documentation>Specifies the URI that points to the prototypical
geometry stored in an external file.</documentation>
                  </annotation>
                </element>
                <element name="referencePoint" type="gml:PointPropertyType">
                  <annotation>
                    <documentation>Relates to a 3D Point geometry that represents the base
point of the object in the world coordinate system.</documentation>
                  </annotation>
                </element>
                <element minOccurs="0" name="relativeGeometry"
type="gml:GeometryPropertyType">
                  <annotation>
                    <documentation>Relates to a prototypical geometry in a local coordinate
system stored inline with the city model.</documentation>
                  </annotation>
                </element>
                <element maxOccurs="unbounded" minOccurs="0" name="appearance"
type="core:AbstractAppearancePropertyType">
                  <annotation>
                    <documentation>Relates appearances to the
ImplicitGeometry.</documentation>
                  </annotation>
                </element>
              </sequence>
            </extension>
          </complexContent>
        </complexType>
        <complexType name="ImplicitGeometryPropertyType">
```

```xml
      <sequence minOccurs="0">
        <element ref="core:ImplicitGeometry"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <simpleType name="IntegerBetween0and3Type">
      <annotation>
        <documentation>IntegerBetween0and3 is a basic type for integer values, which are
greater or equal than 0 and less or equal than 3. The type is used for encoding the
LOD number.</documentation>
      </annotation>
      <restriction base="integer">
        <minInclusive value="0"/>
        <maxInclusive value="3"/>
      </restriction>
    </simpleType>
    <element name="Occupancy" substitutionGroup="gml:AbstractObject"
type="core:OccupancyType">
      <annotation>
        <documentation>Occupancy is an application-dependent indication of what is
contained by a feature.</documentation>
      </annotation>
    </element>
    <complexType name="OccupancyType">
      <sequence>
        <element name="numberOfOccupants" type="integer">
          <annotation>
            <documentation>Indicates the number of occupants contained by a
feature.</documentation>
          </annotation>
        </element>
        <element minOccurs="0" name="interval" type="gml:CodeType">
          <annotation>
            <documentation>Indicates the time period the occupants are contained by a
feature.</documentation>
          </annotation>
        </element>
        <element minOccurs="0" name="occupantType" type="gml:CodeType">
          <annotation>
            <documentation>Indicates the specific type of the occupants that are
contained by a feature.</documentation>
          </annotation>
        </element>
      </sequence>
    </complexType>
    <complexType name="OccupancyPropertyType">
      <sequence>
        <element ref="core:Occupancy"/>
      </sequence>
    </complexType>
```

```xml
    <element name="QualifiedArea" substitutionGroup="gml:AbstractObject"
type="core:QualifiedAreaType">
    <annotation>
      <documentation>QualifiedArea is an application-dependent measure of the area of
a space or of a thematic surface.</documentation>
    </annotation>
  </element>
  <complexType name="QualifiedAreaType">
    <sequence>
      <element name="area" type="gml:AreaType">
        <annotation>
          <documentation>Specifies the value of the QualifiedArea.</documentation>
        </annotation>
      </element>
      <element name="typeOfArea" type="gml:CodeType">
        <annotation>
          <documentation>Indicates the specific type of the
QualifiedArea.</documentation>
        </annotation>
      </element>
    </sequence>
  </complexType>
  <complexType name="QualifiedAreaPropertyType">
    <sequence>
      <element ref="core:QualifiedArea"/>
    </sequence>
  </complexType>
  <element name="QualifiedVolume" substitutionGroup="gml:AbstractObject"
type="core:QualifiedVolumeType">
    <annotation>
      <documentation>QualifiedVolume is an application-dependent measure of the volume
of a space.</documentation>
    </annotation>
  </element>
  <complexType name="QualifiedVolumeType">
    <sequence>
      <element name="volume" type="gml:VolumeType">
        <annotation>
          <documentation>Specifies the value of the QualifiedVolume.</documentation>
        </annotation>
      </element>
      <element name="typeOfVolume" type="gml:CodeType">
        <annotation>
          <documentation>Indicates the specific type of the
QualifiedVolume.</documentation>
        </annotation>
      </element>
    </sequence>
  </complexType>
  <complexType name="QualifiedVolumePropertyType">
    <sequence>
```

```xml
      <element ref="core:QualifiedVolume"/>
    </sequence>
  </complexType>
  <simpleType name="RelativeToTerrainType">
    <annotation>
      <documentation>RelativeToTerrain enumerates the spatial relations of a city
object relative to terrain in a qualitative way.</documentation>
    </annotation>
    <restriction base="string">
      <enumeration value="entirelyAboveTerrain">
        <annotation>
          <documentation>Indicates that the city object is located entirely above the
terrain.</documentation>
        </annotation>
      </enumeration>
      <enumeration value="substantiallyAboveTerrain">
        <annotation>
          <documentation>Indicates that the city object is for the most part located
above the terrain.</documentation>
        </annotation>
      </enumeration>
      <enumeration value="substantiallyAboveAndBelowTerrain">
        <annotation>
          <documentation>Indicates that the city object is located half above the
terrain and half below the terrain.</documentation>
        </annotation>
      </enumeration>
      <enumeration value="substantiallyBelowTerrain">
        <annotation>
          <documentation>Indicates that the city object is for the most part located
below the terrain.</documentation>
        </annotation>
      </enumeration>
      <enumeration value="entirelyBelowTerrain">
        <annotation>
          <documentation>Indicates that the city object is located entirely below the
terrain.</documentation>
        </annotation>
      </enumeration>
    </restriction>
  </simpleType>
  <simpleType name="RelativeToWaterType">
    <annotation>
      <documentation>RelativeToWater enumerates the spatial relations of a city object
relative to the water surface in a qualitative way.</documentation>
    </annotation>
    <restriction base="string">
      <enumeration value="entirelyAboveWaterSurface">
        <annotation>
          <documentation>Indicates that the city object is located entirely above the
water surface.</documentation>
```

```xml
          </annotation>
        </enumeration>
        <enumeration value="substantiallyAboveWaterSurface">
          <annotation>
            <documentation>Indicates that the city object is for the most part located
above the water surface.</documentation>
          </annotation>
        </enumeration>
        <enumeration value="substantiallyAboveAndBelowWaterSurface">
          <annotation>
            <documentation>Indicates that the city object is located half above the
water surface and half below the water surface.</documentation>
          </annotation>
        </enumeration>
        <enumeration value="substantiallyBelowWaterSurface">
          <annotation>
            <documentation>Indicates that the city object is for the most part located
below the water surface.</documentation>
          </annotation>
        </enumeration>
        <enumeration value="entirelyBelowWaterSurface">
          <annotation>
            <documentation>Indicates that the city object is located entirely below the
water surface.</documentation>
          </annotation>
        </enumeration>
        <enumeration value="temporarilyAboveAndBelowWaterSurface">
          <annotation>
            <documentation>Indicates that the city object is temporarily located above
or below the water level, because the height of the water surface is
varying.</documentation>
          </annotation>
        </enumeration>
      </restriction>
  </simpleType>
  <simpleType name="SpaceTypeType">
    <annotation>
      <documentation>SpaceType is an enumeration that characterises a space according
to its closure properties.</documentation>
    </annotation>
    <restriction base="string">
      <enumeration value="closed">
        <annotation>
          <documentation>Indicates that the space has boundaries at the bottom, at the
top, and on all sides.</documentation>
        </annotation>
      </enumeration>
      <enumeration value="open">
        <annotation>
          <documentation>Indicates that the space has at maximum a boundary at the
bottom.</documentation>
```

```
        </annotation>
      </enumeration>
      <enumeration value="semiOpen">
        <annotation>
          <documentation>Indicates that the space has a boundary at the bottom and on
at least one side.</documentation>
        </annotation>
      </enumeration>
    </restriction>
  </simpleType>
  <simpleType name="TransformationMatrix2x2Type">
    <annotation>
      <documentation>TransformationMatrix2x2 is a 2 by 2 matrix represented as a list
of four double values in row major order.</documentation>
    </annotation>
    <restriction base="gml:doubleList">
      <length value="4"/>
    </restriction>
  </simpleType>
  <simpleType name="TransformationMatrix3x4Type">
    <annotation>
      <documentation>TransformationMatrix3x4 is a 3 by 4 matrix represented as a list
of twelve double values in row major order.</documentation>
    </annotation>
    <restriction base="gml:doubleList">
      <length value="12"/>
    </restriction>
  </simpleType>
  <simpleType name="TransformationMatrix4x4Type">
    <annotation>
      <documentation>TransformationMatrix4x4 is a 4 by 4 matrix represented as a list
of sixteen double values in row major order.</documentation>
    </annotation>
    <restriction base="gml:doubleList">
      <length value="16"/>
    </restriction>
  </simpleType>
</schema>
```

C.2. Appearance module

The CityGML Appearance module is defined in the XML Schema Definition file *appearance.xsd* (Listing 9). The target namespace http://www.opengis.net/citygml/appearance/3.0 is associated with this module.

Listing 9. appearance.xsd

```
<?xml version="1.0" encoding="UTF-8"?><schema xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:app="http://www.opengis.net/citygml/appearance/3.0"
xmlns:core="http://www.opengis.net/citygml/3.0"
```

```xml
xmlns:gml="http://www.opengis.net/gml/3.2" elementFormDefault="qualified"
targetNamespace="http://www.opengis.net/citygml/appearance/3.0" version="3.0.0">
  <annotation>
    <documentation>The Appearance module supports the modelling of the observable
surface properties of CityGML features in the form of textures and
material.</documentation>
  </annotation>
  <import namespace="http://www.opengis.net/citygml/3.0" schemaLocation="./core.xsd"/>
  <import namespace="http://www.opengis.net/gml/3.2"
schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd"/>
  <!--XML Schema document created by ShapeChange - http://shapechange.net/-->
  <element abstract="true" name="ADEOfAbstractSurfaceData"
substitutionGroup="gml:AbstractObject" type="app:ADEOfAbstractSurfaceDataType">
    <annotation>
      <documentation>ADEOfAbstractSurfaceData acts as a hook to define properties
within an ADE that are to be added to AbstractSurfaceData.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAbstractSurfaceDataType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfAbstractSurfaceDataPropertyType">
    <sequence>
      <element ref="app:ADEOfAbstractSurfaceData"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfAbstractTexture"
substitutionGroup="gml:AbstractObject" type="app:ADEOfAbstractTextureType">
    <annotation>
      <documentation>ADEOfAbstractTexture acts as a hook to define properties within
an ADE that are to be added to AbstractTexture.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAbstractTextureType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfAbstractTexturePropertyType">
    <sequence>
      <element ref="app:ADEOfAbstractTexture"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfAppearance"
substitutionGroup="gml:AbstractObject" type="app:ADEOfAppearanceType">
    <annotation>
      <documentation>ADEOfAppearance acts as a hook to define properties within an ADE
that are to be added to an Appearance.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAppearanceType">
    <sequence/>
  </complexType>
```

```xml
<complexType name="ADEOfAppearancePropertyType">
  <sequence>
    <element ref="app:ADEOfAppearance"/>
  </sequence>
</complexType>
<element abstract="true" name="ADEOfGeoreferencedTexture"
  substitutionGroup="gml:AbstractObject" type="app:ADEOfGeoreferencedTextureType">
  <annotation>
    <documentation>ADEOfGeoreferencedTexture acts as a hook to define properties
within an ADE that are to be added to a GeoreferencedTexture.</documentation>
  </annotation>
</element>
<complexType abstract="true" name="ADEOfGeoreferencedTextureType">
  <sequence/>
</complexType>
<complexType name="ADEOfGeoreferencedTexturePropertyType">
  <sequence>
    <element ref="app:ADEOfGeoreferencedTexture"/>
  </sequence>
</complexType>
<element abstract="true" name="ADEOfParameterizedTexture"
  substitutionGroup="gml:AbstractObject" type="app:ADEOfParameterizedTextureType">
  <annotation>
    <documentation>ADEOfParameterizedTexture acts as a hook to define properties
within an ADE that are to be added to a ParameterizedTexture.</documentation>
  </annotation>
</element>
<complexType abstract="true" name="ADEOfParameterizedTextureType">
  <sequence/>
</complexType>
<complexType name="ADEOfParameterizedTexturePropertyType">
  <sequence>
    <element ref="app:ADEOfParameterizedTexture"/>
  </sequence>
</complexType>
<element abstract="true" name="ADEOfX3DMaterial"
  substitutionGroup="gml:AbstractObject" type="app:ADEOfX3DMaterialType">
  <annotation>
    <documentation>ADEOfX3DMaterial acts as a hook to define properties within an
ADE that are to be added to an X3DMaterial.</documentation>
  </annotation>
</element>
<complexType abstract="true" name="ADEOfX3DMaterialType">
  <sequence/>
</complexType>
<complexType name="ADEOfX3DMaterialPropertyType">
  <sequence>
    <element ref="app:ADEOfX3DMaterial"/>
  </sequence>
</complexType>
<element abstract="true" name="AbstractSurfaceData"
```

```xml
      substitutionGroup="core:AbstractFeature" type="app:AbstractSurfaceDataType">
    <annotation>
      <documentation>AbstractSurfaceData is the abstract superclass for different
kinds of textures and material.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="AbstractSurfaceDataType">
    <complexContent>
      <extension base="core:AbstractFeatureType">
        <sequence>
          <element default="true" minOccurs="0" name="isFront" type="boolean">
            <annotation>
              <documentation>Indicates whether the texture or material is assigned to
the front side or the back side of the surface geometry object.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfAbstractSurfaceData"
type="app:ADEOfAbstractSurfaceDataPropertyType">
            <annotation>
              <documentation>Augments AbstractSurfaceData with properties defined in
an ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="AbstractSurfaceDataPropertyType">
    <sequence minOccurs="0">
      <element ref="app:AbstractSurfaceData"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element abstract="true" name="AbstractTexture"
substitutionGroup="app:AbstractSurfaceData" type="app:AbstractTextureType">
    <annotation>
      <documentation>AbstractTexture is the abstract superclass to represent the
common attributes of the classes ParameterizedTexture and
GeoreferencedTexture.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="AbstractTextureType">
    <complexContent>
      <extension base="app:AbstractSurfaceDataType">
        <sequence>
          <element name="imageURI" type="anyURI">
            <annotation>
              <documentation>Specifies the URI that points to the external image data
file.</documentation>
            </annotation>
```

```xml
            </element>
            <element minOccurs="0" name="mimeType" type="gml:CodeType">
              <annotation>
                <documentation>Specifies the MIME type of the external point cloud
file.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="textureType" type="app:TextureTypeType">
              <annotation>
                <documentation>Indicates the specific type of the
texture.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="wrapMode" type="app:WrapModeType">
              <annotation>
                <documentation>Specifies the behaviour of the texture when the texture
is smaller than the surface to which it is applied.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="borderColor" type="app:ColorPlusOpacityType">
              <annotation>
                <documentation>Specifies the color of that part of the surface that is
not covered by the texture.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="adeOfAbstractTexture"
type="app:ADEOfAbstractTexturePropertyType">
              <annotation>
                <documentation>Augments AbstractTexture with properties defined in an
ADE.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
  </complexType>
  <complexType name="AbstractTexturePropertyType">
    <sequence minOccurs="0">
      <element ref="app:AbstractTexture"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element abstract="true" name="AbstractTextureParameterization"
substitutionGroup="gml:AbstractObject" type="app:AbstractTextureParameterizationType">
    <annotation>
      <documentation>AbstractTextureParameterization is the abstract superclass for
different kinds of texture parameterizations.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="AbstractTextureParameterizationType">
```

```xml
        <sequence/>
      </complexType>
      <complexType name="AbstractTextureParameterizationPropertyType">
        <sequence>
          <element ref="app:AbstractTextureParameterization"/>
        </sequence>
      </complexType>
      <element name="Appearance" substitutionGroup="core:AbstractAppearance"
type="app:AppearanceType">
        <annotation>
          <documentation>An Appearance is a collection of surface data, i.e. observable
properties for surface geometry objects in the form of textures and
material.</documentation>
        </annotation>
      </element>
      <complexType name="AppearanceType">
        <complexContent>
          <extension base="core:AbstractAppearanceType">
            <sequence>
              <element minOccurs="0" name="theme" type="string">
                <annotation>
                  <documentation>Specifies the topic of the Appearance. Each Appearance
contains surface data for one theme only. Examples of themes are infrared radiation,
noise pollution, or earthquake-induced structural stress.</documentation>
                </annotation>
              </element>
              <element maxOccurs="unbounded" minOccurs="0" name="surfaceData">
                <annotation>
                  <documentation>Relates to the surface data that are part of the
Appearance.</documentation>
                </annotation>
                <complexType>
                  <complexContent>
                    <extension base="gml:AbstractFeatureMemberType">
                      <sequence minOccurs="0">
                        <element ref="app:AbstractSurfaceData"/>
                      </sequence>
                      <attributeGroup ref="gml:AssociationAttributeGroup"/>
                    </extension>
                  </complexContent>
                </complexType>
              </element>
              <element maxOccurs="unbounded" minOccurs="0" name="adeOfAppearance"
type="app:ADEOfAppearancePropertyType">
                <annotation>
                  <documentation>Augments the Appearance with properties defined in an
ADE.</documentation>
                </annotation>
              </element>
            </sequence>
          </extension>
```

```
          </complexContent>
        </complexType>
        <complexType name="AppearancePropertyType">
          <sequence minOccurs="0">
            <element ref="app:Appearance"/>
          </sequence>
          <attributeGroup ref="gml:AssociationAttributeGroup"/>
          <attributeGroup ref="gml:OwnershipAttributeGroup"/>
        </complexType>
        <simpleType name="ColorType">
          <annotation>
            <documentation>Color is a list of three double values between 0 and 1 defining
an RGB color value.</documentation>
          </annotation>
          <restriction base="core:DoubleBetween0and1ListType">
            <length value="3"/>
          </restriction>
        </simpleType>
        <simpleType name="ColorPlusOpacityType">
          <annotation>
            <documentation>Color is a list of four double values between 0 and 1 defining an
RGBA color value. Opacity value of 0 means transparent.</documentation>
          </annotation>
          <restriction base="core:DoubleBetween0and1ListType">
            <minLength value="3"/>
            <maxLength value="4"/>
          </restriction>
        </simpleType>
        <element name="GeoreferencedTexture" substitutionGroup="app:AbstractTexture"
type="app:GeoreferencedTextureType">
          <annotation>
            <documentation>A GeoreferencedTexture is a texture that uses a planimetric
projection. It contains an implicit parameterization that is either stored within the
image file, an accompanying world file or specified using the orientation and
referencePoint elements.</documentation>
          </annotation>
        </element>
        <complexType name="GeoreferencedTextureType">
          <complexContent>
            <extension base="app:AbstractTextureType">
              <sequence>
                <element default="true" minOccurs="0" name="preferWorldFile" type="boolean">
                  <annotation>
                    <documentation>Indicates whether the georeference from the image file or
the accompanying world file should be preferred.</documentation>
                  </annotation>
                </element>
                <element minOccurs="0" name="referencePoint" type="gml:PointPropertyType">
                  <annotation>
                    <documentation>Relates to the 2D Point geometry that represents the
center of the upper left image pixel in world space.</documentation>
```

```xml
            </annotation>
          </element>
          <element minOccurs="0" name="orientation"
type="core:TransformationMatrix2x2Type">
            <annotation>
              <documentation>Specifies the rotation and scaling of the image in form
of a 2x2 matrix.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="target" type="anyURI">
            <annotation>
              <documentation>Specifies the URI that points to the surface geometry
objects to which the texture is applied.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0"
name="adeOfGeoreferencedTexture" type="app:ADEOfGeoreferencedTexturePropertyType">
            <annotation>
              <documentation>Augments the GeoreferencedTexture with properties defined
in an ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="GeoreferencedTexturePropertyType">
    <sequence minOccurs="0">
      <element ref="app:GeoreferencedTexture"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="ParameterizedTexture" substitutionGroup="app:AbstractTexture"
type="app:ParameterizedTextureType">
    <annotation>
      <documentation>A ParameterizedTexture is a texture that uses texture coordinates
or a transformation matrix for parameterization.</documentation>
    </annotation>
  </element>
  <complexType name="ParameterizedTextureType">
    <complexContent>
      <extension base="app:AbstractTextureType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="textureParameterization">
            <annotation>
              <documentation>Relates to the texture coordinates or transformation
matrices used for parameterization.</documentation>
            </annotation>
            <complexType>
              <sequence>
```

```xml
                <element ref="app:TextureAssociation"/>
              </sequence>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0"
name="adeOfParameterizedTexture" type="app:ADEOfParameterizedTexturePropertyType">
            <annotation>
              <documentation>Augments the ParameterizedTexture with properties defined
in an ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="ParameterizedTexturePropertyType">
    <sequence minOccurs="0">
      <element ref="app:ParameterizedTexture"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="TexCoordGen" substitutionGroup="app:AbstractTextureParameterization"
type="app:TexCoordGenType">
    <annotation>
      <documentation>TexCoordGen defines texture parameterization using a
transformation matrix.</documentation>
    </annotation>
  </element>
  <complexType name="TexCoordGenType">
    <complexContent>
      <extension base="app:AbstractTextureParameterizationType">
        <sequence>
          <element name="worldToTexture" type="core:TransformationMatrix3x4Type">
            <annotation>
              <documentation>Specifies the 3x4 transformation matrix that defines the
transformation between world coordinates and texture coordinates.</documentation>
            </annotation>
          </element>
        </sequence>
        <attributeGroup ref="gml:SRSReferenceGroup"/>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="TexCoordGenPropertyType">
    <sequence>
      <element ref="app:TexCoordGen"/>
    </sequence>
  </complexType>
  <element name="TexCoordList" substitutionGroup="app:AbstractTextureParameterization"
type="app:TexCoordListType">
```

```xml
    <annotation>
      <documentation>TexCoordList defines texture parameterization using texture
coordinates.</documentation>
    </annotation>
  </element>
  <complexType name="TexCoordListType">
    <complexContent>
      <extension base="app:AbstractTextureParameterizationType">
        <sequence>
          <element maxOccurs="unbounded" name="textureCoordinates"
type="gml:doubleList">
            <annotation>
              <documentation>Specifies the coordinates of texture used for
parameterization. The texture coordinates are provided separately for each LinearRing
of the surface geometry object.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" name="ring" type="anyURI">
            <annotation>
              <documentation>Specifies the URIs that point to the LinearRings that are
parameterized using the given texture coordinates.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="TexCoordListPropertyType">
    <sequence>
      <element ref="app:TexCoordList"/>
    </sequence>
  </complexType>
  <element name="TextureAssociation" substitutionGroup="gml:AbstractGML"
type="app:TextureAssociationType">
    <annotation>
      <documentation>TextureAssociation denotes the relation of a texture to a surface
geometry object.</documentation>
    </annotation>
  </element>
  <complexType name="TextureAssociationType">
    <complexContent>
      <extension base="gml:AbstractGMLType">
        <sequence>
          <element name="target" type="anyURI">
            <annotation>
              <documentation>Specifies the URI that points to the surface geometry
object to which the texture is applied.</documentation>
            </annotation>
          </element>
          <element name="textureParameterization"
type="app:AbstractTextureParameterizationPropertyType">
```

```xml
            <annotation>
              <documentation>Relates to the texture coordinates or transformation
matrices used for parameterization.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="TextureAssociationPropertyType">
    <sequence minOccurs="0">
      <element ref="app:TextureAssociation"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <simpleType name="TextureTypeType">
    <annotation>
      <documentation>TextureType enumerates the different texture
types.</documentation>
    </annotation>
    <restriction base="string">
      <enumeration value="specific">
        <annotation>
          <documentation>Indicates that the texture is specific to a single
surface.</documentation>
        </annotation>
      </enumeration>
      <enumeration value="typical">
        <annotation>
          <documentation>Indicates that the texture is characteristic of a surface and
can be used repeatedly.</documentation>
        </annotation>
      </enumeration>
      <enumeration value="unknown">
        <annotation>
          <documentation>Indicates that the texture type is not known.</documentation>
        </annotation>
      </enumeration>
    </restriction>
  </simpleType>
  <simpleType name="WrapModeType">
    <annotation>
      <documentation>WrapMode enumerates the different fill modes for
textures.</documentation>
    </annotation>
    <restriction base="string">
      <enumeration value="none">
        <annotation>
          <documentation>Indicates that the texture is applied to the surface "as is".
The part of the surface that is not covered by the texture is shown fully transparent.
```

```
[cf. COLLADA]</documentation>
        </annotation>
      </enumeration>
      <enumeration value="wrap">
        <annotation>
          <documentation>Indicates that the texture is repeated until the surface is
fully covered. [cf. COLLADA]</documentation>
        </annotation>
      </enumeration>
      <enumeration value="mirror">
        <annotation>
          <documentation>Indicates that the texture is repeated and mirrored. [cf.
COLLADA]</documentation>
        </annotation>
      </enumeration>
      <enumeration value="clamp">
        <annotation>
          <documentation>Indicates that the texture is stretched to the edges of the
surface. [cf. COLLADA]</documentation>
        </annotation>
      </enumeration>
      <enumeration value="border">
        <annotation>
          <documentation>Indicates that the texture is applied to the surface "as is".
The part of the surface that is not covered by the texture is filled with the RGBA
color that is specified in the attribute borderColor.  [cf. COLLADA]</documentation>
        </annotation>
      </enumeration>
    </restriction>
  </simpleType>
  <element name="X3DMaterial" substitutionGroup="app:AbstractSurfaceData"
type="app:X3DMaterialType">
    <annotation>
      <documentation>X3DMaterial defines properties for surface geometry objects based
on the material definitions from the X3D and COLLADA standards.</documentation>
    </annotation>
  </element>
  <complexType name="X3DMaterialType">
    <complexContent>
      <extension base="app:AbstractSurfaceDataType">
        <sequence>
          <element default="0.2" minOccurs="0" name="ambientIntensity"
type="core:DoubleBetween0and1Type">
            <annotation>
              <documentation>Specifies the minimum percentage of diffuseColor that is
visible regardless of light sources.</documentation>
            </annotation>
          </element>
          <element default="0.8 0.8 0.8" minOccurs="0" name="diffuseColor"
type="app:ColorType">
            <annotation>
```

```
                  <documentation>Specifies the color of the light diffusely reflected by
the surface geometry object.</documentation>
                </annotation>
            </element>
            <element default="0.0 0.0 0.0" minOccurs="0" name="emissiveColor"
type="app:ColorType">
                <annotation>
                  <documentation>Specifies the color of the light emitted by the surface
geometry object.</documentation>
                </annotation>
            </element>
            <element default="1.0 1.0 1.0" minOccurs="0" name="specularColor"
type="app:ColorType">
                <annotation>
                  <documentation>Specifies the color of the light directly reflected by
the surface geometry object.</documentation>
                </annotation>
            </element>
            <element default="0.2" minOccurs="0" name="shininess"
type="core:DoubleBetween0and1Type">
                <annotation>
                  <documentation>Specifies the sharpness of the specular
highlight.</documentation>
                </annotation>
            </element>
            <element default="0.0" minOccurs="0" name="transparency"
type="core:DoubleBetween0and1Type">
                <annotation>
                  <documentation>Specifies the degree of transparency of the surface
geometry object.</documentation>
                </annotation>
            </element>
            <element default="false" minOccurs="0" name="isSmooth" type="boolean">
                <annotation>
                  <documentation>Specifies which interpolation method is used for the
shading of the surface geometry object. If the attribute is set to true, vertex
normals should be used for shading (Gouraud shading). Otherwise, normals should be
constant for a surface patch (flat shading).</documentation>
                </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="target" type="anyURI">
                <annotation>
                  <documentation>Specifies the URI that points to the surface geometry
objects to which the material is applied.</documentation>
                </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="adeOfX3DMaterial"
type="app:ADEOfX3DMaterialPropertyType">
                <annotation>
                  <documentation>Augments the X3DMaterial with properties defined in an
ADE.</documentation>
```

```
        </annotation>
      </element>
    </sequence>
  </extension>
</complexContent>
  </complexType>
  <complexType name="X3DMaterialPropertyType">
    <sequence minOccurs="0">
      <element ref="app:X3DMaterial"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
</schema>
```

C.3. Bridge module

The CityGML Bridge module is defined in the XML Schema Definition file *bridge.xsd* (Listing 10).
The target namespace http://www.opengis.net/citygml/bridge/3.0 is associated with this module.

Listing 10. bridge.xsd

```
<?xml version="1.0" encoding="UTF-8"?><schema xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:brid="http://www.opengis.net/citygml/bridge/3.0"
xmlns:con="http://www.opengis.net/citygml/construction/3.0"
xmlns:core="http://www.opengis.net/citygml/3.0"
xmlns:gml="http://www.opengis.net/gml/3.2" elementFormDefault="qualified"
targetNamespace="http://www.opengis.net/citygml/bridge/3.0" version="3.0.0">
  <annotation>
    <documentation>The Bridge module supports representation of thematic and spatial
aspects of bridges, bridge parts, bridge installations, and interior bridge
structures.</documentation>
  </annotation>
  <import namespace="http://www.opengis.net/citygml/3.0" schemaLocation="./core.xsd"/>
  <import namespace="http://www.opengis.net/citygml/construction/3.0"
schemaLocation="./construction.xsd"/>
  <import namespace="http://www.opengis.net/gml/3.2"
schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd"/>
  <!--XML Schema document created by ShapeChange - http://shapechange.net/-->
  <element abstract="true" name="ADEOfAbstractBridge"
substitutionGroup="gml:AbstractObject" type="brid:ADEOfAbstractBridgeType">
    <annotation>
      <documentation>ADEOfAbstractBridge acts as a hook to define properties within an
ADE that are to be added to AbstractBridge.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAbstractBridgeType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfAbstractBridgePropertyType">
```

```xml
      <sequence>
        <element ref="brid:ADEOfAbstractBridge"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfBridge" substitutionGroup="gml:AbstractObject"
type="brid:ADEOfBridgeType">
      <annotation>
        <documentation>ADEOfBridge acts as a hook to define properties within an ADE
that are to be added to a Bridge.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfBridgeType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfBridgePropertyType">
      <sequence>
        <element ref="brid:ADEOfBridge"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfBridgeConstructiveElement"
substitutionGroup="gml:AbstractObject" type="brid:ADEOfBridgeConstructiveElementType">
      <annotation>
        <documentation>ADEOfBridgeConstructiveElement acts as a hook to define
properties within an ADE that are to be added to a
BridgeConstructiveElement.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfBridgeConstructiveElementType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfBridgeConstructiveElementPropertyType">
      <sequence>
        <element ref="brid:ADEOfBridgeConstructiveElement"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfBridgeFurniture"
substitutionGroup="gml:AbstractObject" type="brid:ADEOfBridgeFurnitureType">
      <annotation>
        <documentation>ADEOfBridgeFurniture acts as a hook to define properties within
an ADE that are to be added to a BridgeFurniture.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfBridgeFurnitureType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfBridgeFurniturePropertyType">
      <sequence>
        <element ref="brid:ADEOfBridgeFurniture"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfBridgeInstallation"
```

```
  substitutionGroup="gml:AbstractObject" type="brid:ADEOfBridgeInstallationType">
    <annotation>
      <documentation>ADEOfBridgeInstallation acts as a hook to define properties
within an ADE that are to be added to a BridgeInstallation.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfBridgeInstallationType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfBridgeInstallationPropertyType">
    <sequence>
      <element ref="brid:ADEOfBridgeInstallation"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfBridgePart"
substitutionGroup="gml:AbstractObject" type="brid:ADEOfBridgePartType">
    <annotation>
      <documentation>ADEOfBridgePart acts as a hook to define properties within an ADE
that are to be added to a BridgePart.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfBridgePartType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfBridgePartPropertyType">
    <sequence>
      <element ref="brid:ADEOfBridgePart"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfBridgeRoom"
substitutionGroup="gml:AbstractObject" type="brid:ADEOfBridgeRoomType">
    <annotation>
      <documentation>ADEOfBridgeRoom acts as a hook to define properties within an ADE
that are to be added to a BridgeRoom.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfBridgeRoomType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfBridgeRoomPropertyType">
    <sequence>
      <element ref="brid:ADEOfBridgeRoom"/>
    </sequence>
  </complexType>
  <element abstract="true" name="AbstractBridge"
substitutionGroup="con:AbstractConstruction" type="brid:AbstractBridgeType">
    <annotation>
      <documentation>AbstractBridge is an abstract superclass representing the common
attributes and associations of the classes Bridge and BridgePart.</documentation>
    </annotation>
  </element>
```

```xml
  <complexType abstract="true" name="AbstractBridgeType">
    <complexContent>
      <extension base="con:AbstractConstructionType">
        <sequence>
          <element minOccurs="0" name="class" type="gml:CodeType">
            <annotation>
              <documentation>Indicates the specific type of the Bridge or
BridgePart.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the intended purposes of the Bridge or
BridgePart.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the actual uses of the Bridge or
BridgePart.</documentation>
            </annotation>
          </element>
          <element default="false" minOccurs="0" name="isMovable" type="boolean">
            <annotation>
              <documentation>Indicates whether the Bridge or BridgePart can be moved
to allow for watercraft to pass.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0"
name="bridgeConstructiveElement">
            <annotation>
              <documentation>Relates the constructive elements to the Bridge or
BridgePart.</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
                    <element ref="brid:BridgeConstructiveElement"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="bridgeInstallation">
            <annotation>
              <documentation>Relates the installation objects to the Bridge or
BridgePart.</documentation>
```

```
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
                    <element ref="brid:BridgeInstallation"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="bridgeRoom">
            <annotation>
              <documentation>Relates the rooms to the Bridge or
BridgePart.</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
                    <element ref="brid:BridgeRoom"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="bridgeFurniture">
            <annotation>
              <documentation>Relates the furniture objects to the Bridge or
BridgePart.</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
                    <element ref="brid:BridgeFurniture"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="address"
type="core:AddressPropertyType">
            <annotation>
              <documentation>Relates the addresses to the Bridge or
BridgePart.</documentation>
            </annotation>
          </element>
```

```xml
              <element maxOccurs="unbounded" minOccurs="0" name="adeOfAbstractBridge"
type="brid:ADEOfAbstractBridgePropertyType">
                <annotation>
                  <documentation>Augments AbstractBridge with properties defined in an
ADE.</documentation>
                </annotation>
              </element>
            </sequence>
          </extension>
        </complexContent>
      </complexType>
      <complexType name="AbstractBridgePropertyType">
        <sequence minOccurs="0">
          <element ref="brid:AbstractBridge"/>
        </sequence>
        <attributeGroup ref="gml:AssociationAttributeGroup"/>
        <attributeGroup ref="gml:OwnershipAttributeGroup"/>
      </complexType>
      <element name="Bridge" substitutionGroup="brid:AbstractBridge"
type="brid:BridgeType">
        <annotation>
          <documentation>A Bridge represents a structure that affords the passage of
pedestrians, animals, vehicles, and service(s) above obstacles or between two points
at a height above ground. [cf. ISO 6707-1]</documentation>
        </annotation>
      </element>
      <complexType name="BridgeType">
        <complexContent>
          <extension base="brid:AbstractBridgeType">
            <sequence>
              <element maxOccurs="unbounded" minOccurs="0" name="bridgePart">
                <annotation>
                  <documentation>Relates the bridge parts to the Bridge.</documentation>
                </annotation>
                <complexType>
                  <complexContent>
                    <extension base="gml:AbstractFeatureMemberType">
                      <sequence minOccurs="0">
                        <element ref="brid:BridgePart"/>
                      </sequence>
                      <attributeGroup ref="gml:AssociationAttributeGroup"/>
                    </extension>
                  </complexContent>
                </complexType>
              </element>
              <element maxOccurs="unbounded" minOccurs="0" name="adeOfBridge"
type="brid:ADEOfBridgePropertyType">
                <annotation>
                  <documentation>Augments the Bridge with properties defined in an
ADE.</documentation>
                </annotation>
```

```
        </element>
      </sequence>
    </extension>
  </complexContent>
</complexType>
<complexType name="BridgePropertyType">
  <sequence minOccurs="0">
    <element ref="brid:Bridge"/>
  </sequence>
  <attributeGroup ref="gml:AssociationAttributeGroup"/>
  <attributeGroup ref="gml:OwnershipAttributeGroup"/>
</complexType>
<element name="BridgeConstructiveElement"
substitutionGroup="con:AbstractConstructiveElement"
type="brid:BridgeConstructiveElementType">
  <annotation>
    <documentation>A BridgeConstructiveElement is an element of a bridge which is
essential from a structural point of view. Examples are pylons, anchorages, slabs,
beams.</documentation>
  </annotation>
</element>
<complexType name="BridgeConstructiveElementType">
  <complexContent>
    <extension base="con:AbstractConstructiveElementType">
      <sequence>
        <element minOccurs="0" name="class" type="gml:CodeType">
          <annotation>
            <documentation>Indicates the specific type of the
BridgeConstructiveElement.</documentation>
          </annotation>
        </element>
        <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
          <annotation>
            <documentation>Specifies the intended purposes of the
BridgeConstructiveElement.</documentation>
          </annotation>
        </element>
        <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
          <annotation>
            <documentation>Specifies the actual uses of the
BridgeConstructiveElement.</documentation>
          </annotation>
        </element>
        <element maxOccurs="unbounded" minOccurs="0"
name="adeOfBridgeConstructiveElement"
type="brid:ADEOfBridgeConstructiveElementPropertyType">
          <annotation>
            <documentation>Augments the BridgeConstructiveElement with properties
defined in an ADE.</documentation>
```

```xml
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="BridgeConstructiveElementPropertyType">
    <sequence minOccurs="0">
      <element ref="brid:BridgeConstructiveElement"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="BridgeFurniture" substitutionGroup="con:AbstractFurniture"
type="brid:BridgeFurnitureType">
    <annotation>
      <documentation>A BridgeFurniture is an equipment for occupant use, usually not
fixed to the bridge. [cf. ISO 6707-1]</documentation>
    </annotation>
  </element>
  <complexType name="BridgeFurnitureType">
    <complexContent>
      <extension base="con:AbstractFurnitureType">
        <sequence>
          <element minOccurs="0" name="class" type="gml:CodeType">
            <annotation>
              <documentation>Indicates the specific type of the
BridgeFurniture.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the intended purposes of the
BridgeFurniture.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the actual uses of the
BridgeFurniture.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfBridgeFurniture"
type="brid:ADEOfBridgeFurniturePropertyType">
            <annotation>
              <documentation>Augments the BridgeFurniture with properties defined in
an ADE.</documentation>
            </annotation>
          </element>
```

```
          </sequence>
        </extension>
      </complexContent>
    </complexType>
    <complexType name="BridgeFurniturePropertyType">
      <sequence minOccurs="0">
        <element ref="brid:BridgeFurniture"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <element name="BridgeInstallation" substitutionGroup="con:AbstractInstallation"
type="brid:BridgeInstallationType">
      <annotation>
        <documentation>A BridgeInstallation is a permanent part of a Bridge (inside
and/or outside) which does not have the significance of a BridgePart. In contrast to
BridgeConstructiveElements, a BridgeInstallation is not essential from a structural
point of view. Examples are stairs, antennas or railways.</documentation>
      </annotation>
    </element>
    <complexType name="BridgeInstallationType">
      <complexContent>
        <extension base="con:AbstractInstallationType">
          <sequence>
            <element minOccurs="0" name="class" type="gml:CodeType">
              <annotation>
                <documentation>Indicates the specific type of the
BridgeInstallation.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the intended purposes of the
BridgeInstallation.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the actual uses of the
BridgeInstallation.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="adeOfBridgeInstallation"
type="brid:ADEOfBridgeInstallationPropertyType">
              <annotation>
                <documentation>Augments the BridgeInstallation with properties defined
in an ADE.</documentation>
              </annotation>
            </element>
```

```
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="BridgeInstallationPropertyType">
    <sequence minOccurs="0">
      <element ref="brid:BridgeInstallation"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="BridgePart" substitutionGroup="brid:AbstractBridge"
type="brid:BridgePartType">
    <annotation>
      <documentation>A BridgePart is a physical or functional subdivision of a Bridge.
It would be considered a Bridge, if it were not part of a collection of other
BridgeParts.</documentation>
    </annotation>
  </element>
  <complexType name="BridgePartType">
    <complexContent>
      <extension base="brid:AbstractBridgeType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfBridgePart"
type="brid:ADEOfBridgePartPropertyType">
            <annotation>
              <documentation>Augments the BridgePart with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="BridgePartPropertyType">
    <sequence minOccurs="0">
      <element ref="brid:BridgePart"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="BridgeRoom" substitutionGroup="core:AbstractUnoccupiedSpace"
type="brid:BridgeRoomType">
    <annotation>
      <documentation>A BridgeRoom is a space within a Bridge or BridgePart intended
for human occupancy (e.g. a place of work or recreation) and/or containment (storage)
of animals or things. A BridgeRoom is bounded physically and/or virtually (e.g. by
ClosureSurfaces or GenericSurfaces).</documentation>
    </annotation>
  </element>
  <complexType name="BridgeRoomType">
```

```xml
      <complexContent>
        <extension base="core:AbstractUnoccupiedSpaceType">
          <sequence>
            <element minOccurs="0" name="class" type="gml:CodeType">
              <annotation>
                <documentation>Indicates the specific type of the
BridgeRoom.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the intended purposes of the
BridgeRoom.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the actual uses of the
BridgeRoom.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="bridgeFurniture">
              <annotation>
                <documentation>Relates the furniture objects to the
BridgeRoom.</documentation>
              </annotation>
              <complexType>
                <complexContent>
                  <extension base="gml:AbstractFeatureMemberType">
                    <sequence minOccurs="0">
                      <element ref="brid:BridgeFurniture"/>
                    </sequence>
                    <attributeGroup ref="gml:AssociationAttributeGroup"/>
                  </extension>
                </complexContent>
              </complexType>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="bridgeInstallation">
              <annotation>
                <documentation>Relates to the installation objects to the
BridgeRoom.</documentation>
              </annotation>
              <complexType>
                <complexContent>
                  <extension base="gml:AbstractFeatureMemberType">
                    <sequence minOccurs="0">
                      <element ref="brid:BridgeInstallation"/>
                    </sequence>
                    <attributeGroup ref="gml:AssociationAttributeGroup"/>
```

```
                </extension>
              </complexContent>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfBridgeRoom"
type="brid:ADEOfBridgeRoomPropertyType">
              <annotation>
                <documentation>Augments the BridgeRoom with properties defined in an
ADE.</documentation>
              </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="BridgeRoomPropertyType">
    <sequence minOccurs="0">
      <element ref="brid:BridgeRoom"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
</schema>
```

C.4. Building module

The CityGML Building module is defined in the XML Schema Definition file *building.xsd* (Listing 11). The target namespace http://www.opengis.net/citygml/building/3.0 is associated with this module.

Listing 11. building.xsd

```
<?xml version="1.0" encoding="UTF-8"?><schema xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:bldg="http://www.opengis.net/citygml/building/3.0"
xmlns:con="http://www.opengis.net/citygml/construction/3.0"
xmlns:core="http://www.opengis.net/citygml/3.0"
xmlns:gml="http://www.opengis.net/gml/3.2" elementFormDefault="qualified"
targetNamespace="http://www.opengis.net/citygml/building/3.0" version="3.0.0">
  <annotation>
    <documentation>The Building module supports representation of thematic and spatial
aspects of buildings, building parts, building installations, building subdivisions,
and interior building structures.</documentation>
  </annotation>
  <import namespace="http://www.opengis.net/citygml/3.0" schemaLocation="./core.xsd"/>
  <import namespace="http://www.opengis.net/citygml/construction/3.0"
schemaLocation="./construction.xsd"/>
  <import namespace="http://www.opengis.net/gml/3.2"
schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd"/>
  <!--XML Schema document created by ShapeChange - http://shapechange.net/-->
  <element abstract="true" name="ADEOfAbstractBuilding"
substitutionGroup="gml:AbstractObject" type="bldg:ADEOfAbstractBuildingType">
```

```xml
    <annotation>
      <documentation>ADEOfAbstractBuilding acts as a hook to define properties within
an ADE that are to be added to AbstractBuilding.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAbstractBuildingType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfAbstractBuildingPropertyType">
    <sequence>
      <element ref="bldg:ADEOfAbstractBuilding"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfAbstractBuildingSubdivision"
substitutionGroup="gml:AbstractObject"
type="bldg:ADEOfAbstractBuildingSubdivisionType">
    <annotation>
      <documentation>ADEOfAbstractBuildingSubdivision acts as a hook to define
properties within an ADE that are to be added to
AbstractBuildingSubdivision.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAbstractBuildingSubdivisionType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfAbstractBuildingSubdivisionPropertyType">
    <sequence>
      <element ref="bldg:ADEOfAbstractBuildingSubdivision"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfBuilding" substitutionGroup="gml:AbstractObject"
type="bldg:ADEOfBuildingType">
    <annotation>
      <documentation>ADEOfBuilding acts as a hook to define properties within an ADE
that are to be added to a Building.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfBuildingType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfBuildingPropertyType">
    <sequence>
      <element ref="bldg:ADEOfBuilding"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfBuildingConstructiveElement"
substitutionGroup="gml:AbstractObject"
type="bldg:ADEOfBuildingConstructiveElementType">
    <annotation>
      <documentation>ADEOfBuildingConstructiveElement acts as a hook to define
properties within an ADE that are to be added to a
```

```
BuildingConstructiveElement.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfBuildingConstructiveElementType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfBuildingConstructiveElementPropertyType">
    <sequence>
      <element ref="bldg:ADEOfBuildingConstructiveElement"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfBuildingFurniture"
substitutionGroup="gml:AbstractObject" type="bldg:ADEOfBuildingFurnitureType">
    <annotation>
      <documentation>ADEOfBuildingFurniture acts as a hook to define properties within
an ADE that are to be added to a BuildingFurniture.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfBuildingFurnitureType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfBuildingFurniturePropertyType">
    <sequence>
      <element ref="bldg:ADEOfBuildingFurniture"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfBuildingInstallation"
substitutionGroup="gml:AbstractObject" type="bldg:ADEOfBuildingInstallationType">
    <annotation>
      <documentation>ADEOfBuildingInstallation acts as a hook to define properties
within an ADE that are to be added to a BuildingInstallation.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfBuildingInstallationType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfBuildingInstallationPropertyType">
    <sequence>
      <element ref="bldg:ADEOfBuildingInstallation"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfBuildingPart"
substitutionGroup="gml:AbstractObject" type="bldg:ADEOfBuildingPartType">
    <annotation>
      <documentation>ADEOfBuildingPart acts as a hook to define properties within an
ADE that are to be added to a BuildingPart.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfBuildingPartType">
    <sequence/>
  </complexType>
```

```xml
<complexType name="ADEOfBuildingPartPropertyType">
  <sequence>
    <element ref="bldg:ADEOfBuildingPart"/>
  </sequence>
</complexType>
<element abstract="true" name="ADEOfBuildingRoom"
substitutionGroup="gml:AbstractObject" type="bldg:ADEOfBuildingRoomType">
  <annotation>
    <documentation>ADEOfBuildingRoom acts as a hook to define properties within an
ADE that are to be added to a BuildingRoom.</documentation>
  </annotation>
</element>
<complexType abstract="true" name="ADEOfBuildingRoomType">
  <sequence/>
</complexType>
<complexType name="ADEOfBuildingRoomPropertyType">
  <sequence>
    <element ref="bldg:ADEOfBuildingRoom"/>
  </sequence>
</complexType>
<element abstract="true" name="ADEOfBuildingUnit"
substitutionGroup="gml:AbstractObject" type="bldg:ADEOfBuildingUnitType">
  <annotation>
    <documentation>ADEOfBuildingUnit acts as a hook to define properties within an
ADE that are to be added to a BuildingUnit.</documentation>
  </annotation>
</element>
<complexType abstract="true" name="ADEOfBuildingUnitType">
  <sequence/>
</complexType>
<complexType name="ADEOfBuildingUnitPropertyType">
  <sequence>
    <element ref="bldg:ADEOfBuildingUnit"/>
  </sequence>
</complexType>
<element abstract="true" name="ADEOfStorey" substitutionGroup="gml:AbstractObject"
type="bldg:ADEOfStoreyType">
  <annotation>
    <documentation>ADEOfStorey acts as a hook to define properties within an ADE
that are to be added to a Storey.</documentation>
  </annotation>
</element>
<complexType abstract="true" name="ADEOfStoreyType">
  <sequence/>
</complexType>
<complexType name="ADEOfStoreyPropertyType">
  <sequence>
    <element ref="bldg:ADEOfStorey"/>
  </sequence>
</complexType>
<element abstract="true" name="AbstractBuilding"
```

```xml
      substitutionGroup="con:AbstractConstruction" type="bldg:AbstractBuildingType">
    <annotation>
      <documentation>AbstractBuilding is an abstract superclass representing the
common attributes and associations of the classes Building and
BuildingPart.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="AbstractBuildingType">
    <complexContent>
      <extension base="con:AbstractConstructionType">
        <sequence>
          <element minOccurs="0" name="class" type="gml:CodeType">
            <annotation>
              <documentation>Indicates the specific type of the Building or
BuildingPart.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the intended purposes of the Building or
BuildingPart.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the actual uses of the Building or
BuildingPart.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="roofType" type="gml:CodeType">
            <annotation>
              <documentation>Indicates the shape of the roof of the Building or
BuildingPart.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="storeysAboveGround" type="integer">
            <annotation>
              <documentation>Indicates the number of storeys positioned above ground
level.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="storeysBelowGround" type="integer">
            <annotation>
              <documentation>Indicates the number of storeys positioned below ground
level.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="storeyHeightsAboveGround"
type="gml:MeasureOrNilReasonListType">
```

```xml
            <annotation>
              <documentation>Lists the heights of each storey above ground. The first
value in the list denotes the height of the storey closest to the ground level, the
last value denotes the height furthest away.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="storeyHeightsBelowGround"
type="gml:MeasureOrNilReasonListType">
            <annotation>
              <documentation>Lists the height of each storey below ground. The first
value in the list denotes the height of the storey closest to the ground level, the
last value denotes the height furthest away.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0"
name="buildingConstructiveElement">
            <annotation>
              <documentation>Relates the constructive elements to the Building or
BuildingPart.</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
                    <element ref="bldg:BuildingConstructiveElement"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="buildingInstallation">
            <annotation>
              <documentation>Relates the installation objects to the Building or
BuildingPart.</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
                    <element ref="bldg:BuildingInstallation"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="buildingRoom">
            <annotation>
              <documentation>Relates the rooms to the Building or
BuildingPart.</documentation>
```

```xml
              </annotation>
              <complexType>
                <complexContent>
                  <extension base="gml:AbstractFeatureMemberType">
                    <sequence minOccurs="0">
                      <element ref="bldg:BuildingRoom"/>
                    </sequence>
                    <attributeGroup ref="gml:AssociationAttributeGroup"/>
                  </extension>
                </complexContent>
              </complexType>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="buildingFurniture">
              <annotation>
                <documentation>Relates the furniture objects to the Building or
BuildingPart.</documentation>
              </annotation>
              <complexType>
                <complexContent>
                  <extension base="gml:AbstractFeatureMemberType">
                    <sequence minOccurs="0">
                      <element ref="bldg:BuildingFurniture"/>
                    </sequence>
                    <attributeGroup ref="gml:AssociationAttributeGroup"/>
                  </extension>
                </complexContent>
              </complexType>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="buildingSubdivision">
              <annotation>
                <documentation>Relates the logical subdivisions to the Building or
BuildingPart.</documentation>
              </annotation>
              <complexType>
                <complexContent>
                  <extension base="gml:AbstractFeatureMemberType">
                    <sequence minOccurs="0">
                      <element ref="bldg:AbstractBuildingSubdivision"/>
                    </sequence>
                    <attributeGroup ref="gml:AssociationAttributeGroup"/>
                  </extension>
                </complexContent>
              </complexType>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="address"
type="core:AddressPropertyType">
              <annotation>
                <documentation>Relates the addresses to the Building or
BuildingPart.</documentation>
              </annotation>
            </element>
```

```xml
        <element maxOccurs="unbounded" minOccurs="0" name="adeOfAbstractBuilding"
type="bldg:ADEOfAbstractBuildingPropertyType">
          <annotation>
            <documentation>Augments AbstractBuilding with properties defined in an
ADE.</documentation>
          </annotation>
        </element>
      </sequence>
    </extension>
  </complexContent>
</complexType>
<complexType name="AbstractBuildingPropertyType">
  <sequence minOccurs="0">
    <element ref="bldg:AbstractBuilding"/>
  </sequence>
  <attributeGroup ref="gml:AssociationAttributeGroup"/>
  <attributeGroup ref="gml:OwnershipAttributeGroup"/>
</complexType>
<element abstract="true" name="AbstractBuildingSubdivision"
substitutionGroup="core:AbstractLogicalSpace"
type="bldg:AbstractBuildingSubdivisionType">
  <annotation>
    <documentation>AbstractBuildingSubdivision is the abstract superclass for
different kinds of logical building subdivisions.</documentation>
  </annotation>
</element>
<complexType abstract="true" name="AbstractBuildingSubdivisionType">
  <complexContent>
    <extension base="core:AbstractLogicalSpaceType">
      <sequence>
        <element minOccurs="0" name="class" type="gml:CodeType">
          <annotation>
            <documentation>Indicates the specific type of the building
subdivision.</documentation>
          </annotation>
        </element>
        <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
          <annotation>
            <documentation>Specifies the intended purposes of the building
subdivision.</documentation>
          </annotation>
        </element>
        <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
          <annotation>
            <documentation>Specifies the actual uses of the building
subdivision.</documentation>
          </annotation>
        </element>
        <element maxOccurs="unbounded" minOccurs="0" name="elevation"
```

```
type="con:ElevationPropertyType">
            <annotation>
              <documentation>Specifies qualified elevations of the building
subdivision in relation to a well-defined surface which is commonly taken as origin
(e.g. geoid or water level). [cf. INSPIRE]</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="sortKey" type="double">
            <annotation>
              <documentation>Defines an order among the objects that belong to the
building subdivision. An example is the sorting of storeys.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0"
name="buildingConstructiveElement"
type="bldg:BuildingConstructiveElementPropertyType">
            <annotation>
              <documentation>Relates the constructive elements to the building
subdivision.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="buildingFurniture">
            <annotation>
              <documentation>Relates the furniture objects to the building
subdivision.</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
                    <element ref="bldg:BuildingFurniture"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="buildingInstallation">
            <annotation>
              <documentation>Relates the installation objects to the building
subdivision.</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
                    <element ref="bldg:BuildingInstallation"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
```

```xml
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="buildingRoom"
type="bldg:BuildingRoomPropertyType">
            <annotation>
              <documentation>Relates the rooms to the building
subdivision.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0"
name="adeOfAbstractBuildingSubdivision"
type="bldg:ADEOfAbstractBuildingSubdivisionPropertyType">
            <annotation>
              <documentation>Augments AbstractBuildingSubdivision with properties
defined in an ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="AbstractBuildingSubdivisionPropertyType">
    <sequence minOccurs="0">
      <element ref="bldg:AbstractBuildingSubdivision"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="Building" substitutionGroup="bldg:AbstractBuilding"
type="bldg:BuildingType">
    <annotation>
      <documentation>A Building is a free-standing, self-supporting construction that
is roofed, usually walled, and can be entered by humans and is normally designed to
stand permanently in one place. It is intended for human occupancy (e.g. a place of
work or recreation), habitation and/or shelter of humans, animals or
things.</documentation>
    </annotation>
  </element>
  <complexType name="BuildingType">
    <complexContent>
      <extension base="bldg:AbstractBuildingType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="buildingPart">
            <annotation>
              <documentation>Relates the building parts to the
Building.</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
```

```xml
                    <element ref="bldg:BuildingPart"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfBuilding"
type="bldg:ADEOfBuildingPropertyType">
            <annotation>
              <documentation>Augments the Building with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="BuildingPropertyType">
    <sequence minOccurs="0">
      <element ref="bldg:Building"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="BuildingConstructiveElement"
substitutionGroup="con:AbstractConstructiveElement"
type="bldg:BuildingConstructiveElementType">
    <annotation>
      <documentation>A BuildingConstructiveElement is an element of a Building which
is essential from a structural point of view. Examples are walls, slabs, staircases,
beams.</documentation>
    </annotation>
  </element>
  <complexType name="BuildingConstructiveElementType">
    <complexContent>
      <extension base="con:AbstractConstructiveElementType">
        <sequence>
          <element minOccurs="0" name="class" type="gml:CodeType">
            <annotation>
              <documentation>Indicates the specific type of the
BuildingConstructiveElement.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the intended purposes of the
BuildingConstructiveElement.</documentation>
            </annotation>
          </element>
```

```xml
            <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the actual uses of the
BuildingConstructiveElement.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0"
name="adeOfBuildingConstructiveElement"
type="bldg:ADEOfBuildingConstructiveElementPropertyType">
              <annotation>
                <documentation>Augments the BuildingConstructiveElement with properties
defined in an ADE.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
    </complexType>
    <complexType name="BuildingConstructiveElementPropertyType">
      <sequence minOccurs="0">
        <element ref="bldg:BuildingConstructiveElement"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <element name="BuildingFurniture" substitutionGroup="con:AbstractFurniture"
type="bldg:BuildingFurnitureType">
      <annotation>
        <documentation>A BuildingFurniture is an equipment for occupant use, usually not
fixed to the building. [cf. ISO 6707-1]</documentation>
      </annotation>
    </element>
    <complexType name="BuildingFurnitureType">
      <complexContent>
        <extension base="con:AbstractFurnitureType">
          <sequence>
            <element minOccurs="0" name="class" type="gml:CodeType">
              <annotation>
                <documentation>Indicates the specific type of the
BuildingFurniture.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the intended purposes of the
BuildingFurniture.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="usage"
```

```
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the actual uses of the
BuildingFurniture.</documentation>
              </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfBuildingFurniture"
type="bldg:ADEOfBuildingFurniturePropertyType">
              <annotation>
                <documentation>Augments the BuildingFurniture with properties defined in
an ADE.</documentation>
              </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="BuildingFurniturePropertyType">
    <sequence minOccurs="0">
      <element ref="bldg:BuildingFurniture"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="BuildingInstallation" substitutionGroup="con:AbstractInstallation"
type="bldg:BuildingInstallationType">
    <annotation>
      <documentation>A BuildingInstallation is a permanent part of a Building (inside
and/or outside) which has not the significance of a BuildingPart. Examples are stairs,
antennas, balconies or small roofs.</documentation>
    </annotation>
  </element>
  <complexType name="BuildingInstallationType">
    <complexContent>
      <extension base="con:AbstractInstallationType">
        <sequence>
          <element minOccurs="0" name="class" type="gml:CodeType">
            <annotation>
              <documentation>Indicates the specific type of the
BuildingInstallation.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the intended purposes of the
BuildingInstallation.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
```

```xml
            <annotation>
              <documentation>Specifies the actual uses of the
BuildingInstallation.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0"
name="adeOfBuildingInstallation" type="bldg:ADEOfBuildingInstallationPropertyType">
            <annotation>
              <documentation>Augments the BuildingInstallation with properties defined
in an ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="BuildingInstallationPropertyType">
    <sequence minOccurs="0">
      <element ref="bldg:BuildingInstallation"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="BuildingPart" substitutionGroup="bldg:AbstractBuilding"
type="bldg:BuildingPartType">
    <annotation>
      <documentation>A BuildingPart is a physical or functional subdivision of a
Building. It would be considered a Building, if it were not part of a collection of
other BuildingParts.</documentation>
    </annotation>
  </element>
  <complexType name="BuildingPartType">
    <complexContent>
      <extension base="bldg:AbstractBuildingType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfBuildingPart"
type="bldg:ADEOfBuildingPartPropertyType">
            <annotation>
              <documentation>Augments the BuildingPart with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="BuildingPartPropertyType">
    <sequence minOccurs="0">
      <element ref="bldg:BuildingPart"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
```

```xml
        <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="BuildingRoom" substitutionGroup="core:AbstractUnoccupiedSpace"
type="bldg:BuildingRoomType">
    <annotation>
      <documentation>A BuildingRoom is a space within a Building or BuildingPart
intended for human occupancy (e.g. a place of work or recreation) and/or containment
of animals or things. A BuildingRoom is bounded physically and/or virtually (e.g. by
ClosureSurfaces or GenericSurfaces).</documentation>
    </annotation>
  </element>
  <complexType name="BuildingRoomType">
    <complexContent>
      <extension base="core:AbstractUnoccupiedSpaceType">
        <sequence>
          <element minOccurs="0" name="class" type="gml:CodeType">
            <annotation>
              <documentation>Indicates the specific type of the
BuildingRoom.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the intended purposes of the
BuildingRoom.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the actual uses of the
BuildingRoom.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="roomHeight"
type="bldg:RoomHeightPropertyType">
            <annotation>
              <documentation>Specifies qualified heights of the
BuildingRoom.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="buildingFurniture">
            <annotation>
              <documentation>Relates the furniture objects to the
BuildingRoom.</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
```

```xml
                    <element ref="bldg:BuildingFurniture"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="buildingInstallation">
            <annotation>
              <documentation>Relates the installation objects to the
BuildingRoom.</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
                    <element ref="bldg:BuildingInstallation"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfBuildingRoom"
type="bldg:ADEOfBuildingRoomPropertyType">
            <annotation>
              <documentation>Augments the BuildingRoom with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="BuildingRoomPropertyType">
    <sequence minOccurs="0">
      <element ref="bldg:BuildingRoom"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="BuildingUnit" substitutionGroup="bldg:AbstractBuildingSubdivision"
type="bldg:BuildingUnitType">
    <annotation>
      <documentation>A BuildingUnit is a logical subdivision of a Building.
BuildingUnits are formed according to some homogeneous property like function,
ownership, management, or accessibility. They may be separately sold, rented out,
inherited, managed, etc.</documentation>
    </annotation>
  </element>
  <complexType name="BuildingUnitType">
```

```xml
    <complexContent>
      <extension base="bldg:AbstractBuildingSubdivisionType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="storey"
type="bldg:StoreyPropertyType">
            <annotation>
              <documentation>Relates to the storeys on which the BuildingUnit is
located.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="address"
type="core:AddressPropertyType">
            <annotation>
              <documentation>Relates to the addresses that are assigned to the
BuildingUnit.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfBuildingUnit"
type="bldg:ADEOfBuildingUnitPropertyType">
            <annotation>
              <documentation>Augments the BuildingUnit with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="BuildingUnitPropertyType">
    <sequence minOccurs="0">
      <element ref="bldg:BuildingUnit"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="RoomHeight" substitutionGroup="gml:AbstractObject"
type="bldg:RoomHeightType">
    <annotation>
      <documentation>The RoomHeight represents a vertical distance (measured or
estimated) between a low reference and a high reference. [cf. INSPIRE]</documentation>
    </annotation>
  </element>
  <complexType name="RoomHeightType">
    <sequence>
      <element name="highReference" type="gml:CodeType">
        <annotation>
          <documentation>Indicates the high point used to calculate the value of the
room height.</documentation>
        </annotation>
      </element>
      <element name="lowReference" type="gml:CodeType">
```

```xml
          <annotation>
            <documentation>Indicates the low point used to calculate the value of the
room height.</documentation>
          </annotation>
        </element>
        <element name="status" type="con:HeightStatusValueType">
          <annotation>
            <documentation>Indicates the way the room height has been
captured.</documentation>
          </annotation>
        </element>
        <element name="value" type="gml:LengthType">
          <annotation>
            <documentation>Specifies the value of the room height.</documentation>
          </annotation>
        </element>
      </sequence>
  </complexType>
  <complexType name="RoomHeightPropertyType">
    <sequence>
      <element ref="bldg:RoomHeight"/>
    </sequence>
  </complexType>
  <element name="Storey" substitutionGroup="bldg:AbstractBuildingSubdivision"
type="bldg:StoreyType">
    <annotation>
      <documentation>A Storey is typically a horizontal section of a Building. Storeys
are not always defined according to the building structure, but can also be defined
according to logical considerations.</documentation>
    </annotation>
  </element>
  <complexType name="StoreyType">
    <complexContent>
      <extension base="bldg:AbstractBuildingSubdivisionType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="buildingUnit"
type="bldg:BuildingUnitPropertyType">
            <annotation>
              <documentation>Relates to the building units that belong to the
Storey.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfStorey"
type="bldg:ADEOfStoreyPropertyType">
            <annotation>
              <documentation>Augments the Storey with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
```

```
      </complexContent>
    </complexType>
    <complexType name="StoreyPropertyType">
      <sequence minOccurs="0">
        <element ref="bldg:Storey"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
  </schema>
```

C.5. City Furniture module

The CityGML City Furniture module is defined in the XML Schema Definition file *cityFurniture.xsd*
(Listing 12). The target namespace http://www.opengis.net/citygml/cityfurniture/3.0 is associated
with this module.

Listing 12. cityFurniture.xsd

```
<?xml version="1.0" encoding="UTF-8"?><schema xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:core="http://www.opengis.net/citygml/3.0"
xmlns:frn="http://www.opengis.net/citygml/cityfurniture/3.0"
xmlns:gml="http://www.opengis.net/gml/3.2" elementFormDefault="qualified"
targetNamespace="http://www.opengis.net/citygml/cityfurniture/3.0" version="3.0.0">
  <annotation>
    <documentation>The CityFurniture module supports representation of city furniture
objects. City furniture objects are immovable objects like lanterns, traffic signs,
advertising columns, benches, or bus stops that can be found in traffic areas,
residential areas, on squares, or in built-up areas.</documentation>
  </annotation>
  <import namespace="http://www.opengis.net/citygml/3.0" schemaLocation="./core.xsd"/>
  <import namespace="http://www.opengis.net/gml/3.2"
schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd"/>
  <!--XML Schema document created by ShapeChange - http://shapechange.net/-->
  <element abstract="true" name="ADEOfCityFurniture"
substitutionGroup="gml:AbstractObject" type="frn:ADEOfCityFurnitureType">
    <annotation>
      <documentation>ADEOfCityFurniture acts as a hook to define properties within an
ADE that are to be added to a CityFurniture.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfCityFurnitureType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfCityFurniturePropertyType">
    <sequence>
      <element ref="frn:ADEOfCityFurniture"/>
    </sequence>
  </complexType>
  <element name="CityFurniture" substitutionGroup="core:AbstractOccupiedSpace"
```

```
type="frn:CityFurnitureType">
    <annotation>
      <documentation>CityFurniture is an object or piece of equipment installed in the
outdoor environment for various purposes. Examples include street signs, traffic
signals, street lamps, benches, fountains.</documentation>
    </annotation>
  </element>
  <complexType name="CityFurnitureType">
    <complexContent>
      <extension base="core:AbstractOccupiedSpaceType">
        <sequence>
          <element minOccurs="0" name="class" type="gml:CodeType">
            <annotation>
              <documentation>Indicates the specific type of the
CityFurniture.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the intended purposes of the
CityFurniture.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the actual uses of the
CityFurniture.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfCityFurniture"
type="frn:ADEOfCityFurniturePropertyType">
            <annotation>
              <documentation>Augments the CityFurniture with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="CityFurniturePropertyType">
    <sequence minOccurs="0">
      <element ref="frn:CityFurniture"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
</schema>
```

C.6. City Object Group module

The CityGML City Object Group module is defined in the XML Schema Definition file *cityObjectGroup.xsd* (Listing 13). The target namespace http://www.opengis.net/citygml/cityobjectgroup/3.0 is associated with this module.

Listing 13. cityObjectGroup.xsd

```xml
<?xml version="1.0" encoding="UTF-8"?><schema xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:core="http://www.opengis.net/citygml/3.0"
xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:grp="http://www.opengis.net/citygml/cityobjectgroup/3.0"
elementFormDefault="qualified"
targetNamespace="http://www.opengis.net/citygml/cityobjectgroup/3.0" version="3.0.0">
  <annotation>
    <documentation>The CityObjectGroup module supports grouping of city objects.
Arbitrary city objects may be aggregated in groups according to user-defined criteria.
A group may be further classified by application-specific attributes.</documentation>
  </annotation>
  <import namespace="http://www.opengis.net/citygml/3.0" schemaLocation="./core.xsd"/>
  <import namespace="http://www.opengis.net/gml/3.2"
schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd"/>
  <!--XML Schema document created by ShapeChange - http://shapechange.net/-->
  <element abstract="true" name="ADEOfCityObjectGroup"
substitutionGroup="gml:AbstractObject" type="grp:ADEOfCityObjectGroupType">
    <annotation>
      <documentation>ADEOfCityObjectGroup acts as a hook to define properties within
an ADE that are to be added to a CityObjectGroup.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfCityObjectGroupType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfCityObjectGroupPropertyType">
    <sequence>
      <element ref="grp:ADEOfCityObjectGroup"/>
    </sequence>
  </complexType>
  <element name="CityObjectGroup" substitutionGroup="core:AbstractLogicalSpace"
type="grp:CityObjectGroupType">
    <annotation>
      <documentation>A CityObjectGroup represents an application-specific aggregation
of city objects according to some user-defined criteria. Examples for groups are the
buildings in a specific region, the result of a query, or objects put together for
visualization purposes. Each member of a group may be qualified by a role name,
reflecting the role each city object plays in the context of the
group.</documentation>
    </annotation>
  </element>
  <complexType name="CityObjectGroupType">
    <complexContent>
```

```xml
<extension base="core:AbstractLogicalSpaceType">
  <sequence>
    <element minOccurs="0" name="class" type="gml:CodeType">
      <annotation>
        <documentation>Indicates the specific type of the
CityObjectGroup.</documentation>
      </annotation>
    </element>
    <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
      <annotation>
        <documentation>Specifies the intended purposes of the
CityObjectGroup.</documentation>
      </annotation>
    </element>
    <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
      <annotation>
        <documentation>Specifies the actual usages of the
CityObjectGroup.</documentation>
      </annotation>
    </element>
    <element maxOccurs="unbounded" minOccurs="0" name="groupMember">
      <complexType>
        <complexContent>
          <extension base="gml:AbstractMemberType">
            <sequence>
              <element ref="grp:Role"/>
            </sequence>
          </extension>
        </complexContent>
      </complexType>
    </element>
    <element minOccurs="0" name="parent" type="gml:ReferenceType">
      <annotation>
        <documentation>Relates to a city object to which the CityObjectGroup
belongs.</documentation>
        <appinfo>
          <targetElement
xmlns="http://www.opengis.net/gml/3.2">core:AbstractCityObject</targetElement>
        </appinfo>
      </annotation>
    </element>
    <element maxOccurs="unbounded" minOccurs="0" name="adeOfCityObjectGroup"
type="grp:ADEOfCityObjectGroupPropertyType">
      <annotation>
        <documentation>Augments the CityObjectGroup with properties defined in
an ADE.</documentation>
      </annotation>
    </element>
  </sequence>
```

```xml
      </extension>
    </complexContent>
  </complexType>
  <complexType name="CityObjectGroupPropertyType">
    <sequence minOccurs="0">
      <element ref="grp:CityObjectGroup"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="Role" substitutionGroup="gml:AbstractGML" type="grp:RoleType">
    <annotation>
      <documentation>Role qualifies the function of a city object within the
CityObjectGroup.</documentation>
    </annotation>
  </element>
  <complexType name="RoleType">
    <complexContent>
      <extension base="gml:AbstractGMLType">
        <sequence>
          <element minOccurs="0" name="role" type="string"/>
          <element name="groupMember">
            <annotation>
              <appinfo>
                <targetElement
xmlns="http://www.opengis.net/gml/3.2">core:AbstractCityObject</targetElement>
              </appinfo>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence/>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="RolePropertyType">
    <sequence minOccurs="0">
      <element ref="grp:Role"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
</schema>
```

C.7. Construction module

The CityGML Construction module is defined in the XML Schema Definition file *construction.xsd* (Listing 14). The target namespace http://www.opengis.net/citygml/construction/3.0 is associated with this module.

Listing 14. construction.xsd

```xml
<?xml version="1.0" encoding="UTF-8"?><schema xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:con="http://www.opengis.net/citygml/construction/3.0"
xmlns:core="http://www.opengis.net/citygml/3.0"
xmlns:gml="http://www.opengis.net/gml/3.2" elementFormDefault="qualified"
targetNamespace="http://www.opengis.net/citygml/construction/3.0" version="3.0.0">
  <annotation>
    <documentation>The Construction module supports representation of key elements of
different types of constructions. These key elements include construction surfaces
(e.g floor and ceiling), windows and doors, constructive elements (e.g. beams and
slabs), installations, and furniture.</documentation>
  </annotation>
  <import namespace="http://www.opengis.net/citygml/3.0" schemaLocation="./core.xsd"/>
  <import namespace="http://www.opengis.net/gml/3.2"
schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd"/>
  <!--XML Schema document created by ShapeChange - http://shapechange.net/-->
  <element abstract="true" name="ADEOfAbstractConstruction"
substitutionGroup="gml:AbstractObject" type="con:ADEOfAbstractConstructionType">
    <annotation>
      <documentation>ADEOfAbstractConstruction acts as a hook to define properties
within an ADE that are to be added to AbstractConstruction.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAbstractConstructionType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfAbstractConstructionPropertyType">
    <sequence>
      <element ref="con:ADEOfAbstractConstruction"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfAbstractConstructionSurface"
substitutionGroup="gml:AbstractObject"
type="con:ADEOfAbstractConstructionSurfaceType">
    <annotation>
      <documentation>ADEOfAbstractConstructionSurface acts as a hook to define
properties within an ADE that are to be added to
AbstractConstructionSurface.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAbstractConstructionSurfaceType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfAbstractConstructionSurfacePropertyType">
```

```xml
      <sequence>
        <element ref="con:ADEOfAbstractConstructionSurface"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfAbstractConstructiveElement"
substitutionGroup="gml:AbstractObject"
type="con:ADEOfAbstractConstructiveElementType">
      <annotation>
        <documentation>ADEOfAbstractConstructiveElement acts as a hook to define
properties within an ADE that are to be added to
AbstractConstructiveElement.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfAbstractConstructiveElementType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfAbstractConstructiveElementPropertyType">
      <sequence>
        <element ref="con:ADEOfAbstractConstructiveElement"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfAbstractFillingElement"
substitutionGroup="gml:AbstractObject" type="con:ADEOfAbstractFillingElementType">
      <annotation>
        <documentation>ADEOfAbstractFillingElement acts as a hook to define properties
within an ADE that are to be added to AbstractFillingElement.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfAbstractFillingElementType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfAbstractFillingElementPropertyType">
      <sequence>
        <element ref="con:ADEOfAbstractFillingElement"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfAbstractFillingSurface"
substitutionGroup="gml:AbstractObject" type="con:ADEOfAbstractFillingSurfaceType">
      <annotation>
        <documentation>ADEOfAbstractFillingSurface acts as a hook to define properties
within an ADE that are to be added to AbstractFillingSurface.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfAbstractFillingSurfaceType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfAbstractFillingSurfacePropertyType">
      <sequence>
        <element ref="con:ADEOfAbstractFillingSurface"/>
      </sequence>
    </complexType>
```

```xml
  <element abstract="true" name="ADEOfAbstractFurniture"
substitutionGroup="gml:AbstractObject" type="con:ADEOfAbstractFurnitureType">
    <annotation>
      <documentation>ADEOfAbstractFurniture acts as a hook to define properties within
an ADE that are to be added to AbstractFurniture.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAbstractFurnitureType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfAbstractFurniturePropertyType">
    <sequence>
      <element ref="con:ADEOfAbstractFurniture"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfAbstractInstallation"
substitutionGroup="gml:AbstractObject" type="con:ADEOfAbstractInstallationType">
    <annotation>
      <documentation>ADEOfAbstractInstallation acts as a hook to define properties
within an ADE that are to be added to AbstractInstallation.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAbstractInstallationType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfAbstractInstallationPropertyType">
    <sequence>
      <element ref="con:ADEOfAbstractInstallation"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfCeilingSurface"
substitutionGroup="gml:AbstractObject" type="con:ADEOfCeilingSurfaceType">
    <annotation>
      <documentation>ADEOfCeilingSurface acts as a hook to define properties within an
ADE that are to be added to a CeilingSurface.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfCeilingSurfaceType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfCeilingSurfacePropertyType">
    <sequence>
      <element ref="con:ADEOfCeilingSurface"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfDoor" substitutionGroup="gml:AbstractObject"
type="con:ADEOfDoorType">
    <annotation>
      <documentation>ADEOfDoor acts as a hook to define properties within an ADE that
are to be added to a Door.</documentation>
    </annotation>
```

```
    </element>
    <complexType abstract="true" name="ADEOfDoorType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfDoorPropertyType">
      <sequence>
        <element ref="con:ADEOfDoor"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfDoorSurface"
substitutionGroup="gml:AbstractObject" type="con:ADEOfDoorSurfaceType">
      <annotation>
        <documentation>ADEOfDoorSurface acts as a hook to define properties within an
ADE that are to be added to a DoorSurface.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfDoorSurfaceType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfDoorSurfacePropertyType">
      <sequence>
        <element ref="con:ADEOfDoorSurface"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfFloorSurface"
substitutionGroup="gml:AbstractObject" type="con:ADEOfFloorSurfaceType">
      <annotation>
        <documentation>ADEOfFloorSurface acts as a hook to define properties within an
ADE that are to be added to a FloorSurface.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfFloorSurfaceType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfFloorSurfacePropertyType">
      <sequence>
        <element ref="con:ADEOfFloorSurface"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfGroundSurface"
substitutionGroup="gml:AbstractObject" type="con:ADEOfGroundSurfaceType">
      <annotation>
        <documentation>ADEOfGroundSurface acts as a hook to define properties within an
ADE that are to be added to a GroundSurface.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfGroundSurfaceType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfGroundSurfacePropertyType">
      <sequence>
```

```xml
      <element ref="con:ADEOfGroundSurface"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfInteriorWallSurface"
substitutionGroup="gml:AbstractObject" type="con:ADEOfInteriorWallSurfaceType">
    <annotation>
      <documentation>ADEOfInteriorWallSurface acts as a hook to define properties
within an ADE that are to be added to an InteriorWallSurface.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfInteriorWallSurfaceType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfInteriorWallSurfacePropertyType">
    <sequence>
      <element ref="con:ADEOfInteriorWallSurface"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfOtherConstruction"
substitutionGroup="gml:AbstractObject" type="con:ADEOfOtherConstructionType">
    <annotation>
      <documentation>ADEOfOtherConstruction acts as a hook to define properties within
an ADE that are to be added to an OtherConstruction.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfOtherConstructionType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfOtherConstructionPropertyType">
    <sequence>
      <element ref="con:ADEOfOtherConstruction"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfOuterCeilingSurface"
substitutionGroup="gml:AbstractObject" type="con:ADEOfOuterCeilingSurfaceType">
    <annotation>
      <documentation>ADEOfOuterCeilingSurface acts as a hook to define properties
within an ADE that are to be added to an OuterCeilingSurface.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfOuterCeilingSurfaceType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfOuterCeilingSurfacePropertyType">
    <sequence>
      <element ref="con:ADEOfOuterCeilingSurface"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfOuterFloorSurface"
substitutionGroup="gml:AbstractObject" type="con:ADEOfOuterFloorSurfaceType">
    <annotation>
```

```
      <documentation>ADEOfOuterFloorSurface acts as a hook to define properties within
an ADE that are to be added to an OuterFloorSurface.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfOuterFloorSurfaceType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfOuterFloorSurfacePropertyType">
    <sequence>
      <element ref="con:ADEOfOuterFloorSurface"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfRoofSurface"
substitutionGroup="gml:AbstractObject" type="con:ADEOfRoofSurfaceType">
    <annotation>
      <documentation>ADEOfRoofSurface acts as a hook to define properties within an
ADE that are to be added to a RoofSurface.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfRoofSurfaceType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfRoofSurfacePropertyType">
    <sequence>
      <element ref="con:ADEOfRoofSurface"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfWallSurface"
substitutionGroup="gml:AbstractObject" type="con:ADEOfWallSurfaceType">
    <annotation>
      <documentation>ADEOfWallSurface acts as a hook to define properties within an
ADE that are to be added to a WallSurface.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfWallSurfaceType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfWallSurfacePropertyType">
    <sequence>
      <element ref="con:ADEOfWallSurface"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfWindow" substitutionGroup="gml:AbstractObject"
type="con:ADEOfWindowType">
    <annotation>
      <documentation>ADEOfWindow acts as a hook to define properties within an ADE
that are to be added to a Window.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfWindowType">
    <sequence/>
```

```xml
      </complexType>
      <complexType name="ADEOfWindowPropertyType">
        <sequence>
          <element ref="con:ADEOfWindow"/>
        </sequence>
      </complexType>
      <element abstract="true" name="ADEOfWindowSurface"
substitutionGroup="gml:AbstractObject" type="con:ADEOfWindowSurfaceType">
        <annotation>
          <documentation>ADEOfWindowSurface acts as a hook to define properties within an
ADE that are to be added to a WindowSurface.</documentation>
        </annotation>
      </element>
      <complexType abstract="true" name="ADEOfWindowSurfaceType">
        <sequence/>
      </complexType>
      <complexType name="ADEOfWindowSurfacePropertyType">
        <sequence>
          <element ref="con:ADEOfWindowSurface"/>
        </sequence>
      </complexType>
      <element abstract="true" name="AbstractConstruction"
substitutionGroup="core:AbstractOccupiedSpace" type="con:AbstractConstructionType">
        <annotation>
          <documentation>AbstractConstruction is the abstract superclass for objects that
are manufactured by humans from construction materials, are connected to earth, and
are intended to be permanent. A connection with the ground also exists when the
construction rests by its own weight on the ground or is moveable limited on
stationary rails or if the construction  is intended to be used mainly
stationary.</documentation>
        </annotation>
      </element>
      <complexType abstract="true" name="AbstractConstructionType">
        <complexContent>
          <extension base="core:AbstractOccupiedSpaceType">
            <sequence>
              <element minOccurs="0" name="conditionOfConstruction"
type="con:ConditionOfConstructionValueType">
                <annotation>
                  <documentation>Indicates the life-cycle status of the construction. [cf.
INSPIRE]</documentation>
                </annotation>
              </element>
              <element minOccurs="0" name="dateOfConstruction" type="date">
                <annotation>
                  <documentation>Indicates the date at which the construction was
completed.</documentation>
                </annotation>
              </element>
              <element minOccurs="0" name="dateOfDemolition" type="date">
                <annotation>
```

```
                <documentation>Indicates the date at which the construction was
demolished.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="constructionEvent"
type="con:ConstructionEventPropertyType">
            <annotation>
              <documentation>Describes specific events in the life-time of the
construction.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="elevation"
type="con:ElevationPropertyType">
            <annotation>
              <documentation>Specifies qualified elevations of the construction in
relation to a well-defined surface which is commonly taken as origin (e.g. geoid or
water level). [cf. INSPIRE]</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="height"
type="con:HeightPropertyType">
            <annotation>
              <documentation>Specifies qualified heights of the construction above
ground or below ground. [cf. INSPIRE]</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="occupancy"
type="core:OccupancyPropertyType">
            <annotation>
              <documentation>Provides qualified information on the residency of
persons, animals, or other moveable objects in the construction.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0"
name="adeOfAbstractConstruction" type="con:ADEOfAbstractConstructionPropertyType">
            <annotation>
              <documentation>Augments AbstractConstruction with properties defined in
an ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="AbstractConstructionPropertyType">
    <sequence minOccurs="0">
      <element ref="con:AbstractConstruction"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
```

```xml
  <element abstract="true" name="AbstractConstructionSurface"
substitutionGroup="core:AbstractThematicSurface"
type="con:AbstractConstructionSurfaceType">
    <annotation>
      <documentation>AbstractConstructionSurface is the abstract superclass for
different kinds of surfaces that bound a construction.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="AbstractConstructionSurfaceType">
    <complexContent>
      <extension base="core:AbstractThematicSurfaceType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="fillingSurface"
type="con:AbstractFillingSurfacePropertyType">
            <annotation>
              <documentation>Relates to the surfaces that seal the openings of the
construction surface.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0"
name="adeOfAbstractConstructionSurface"
type="con:ADEOfAbstractConstructionSurfacePropertyType">
            <annotation>
              <documentation>Augments AbstractConstructionSurface with properties
defined in an ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="AbstractConstructionSurfacePropertyType">
    <sequence minOccurs="0">
      <element ref="con:AbstractConstructionSurface"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element abstract="true" name="AbstractConstructiveElement"
substitutionGroup="core:AbstractOccupiedSpace"
type="con:AbstractConstructiveElementType">
    <annotation>
      <documentation>AbstractConstructiveElement is the abstract superclass for the
representation of volumetric elements of a construction. Examples are walls, beams,
slabs.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="AbstractConstructiveElementType">
    <complexContent>
      <extension base="core:AbstractOccupiedSpaceType">
        <sequence>
```

```
            <element minOccurs="0" name="isStructuralElement" type="boolean">
              <annotation>
                <documentation>Indicates whether the constructive element is essential
from a structural point of view. A structural element cannot be omitted without
collapsing of the construction. Examples are pylons and anchorages of
bridges.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="filling"
type="con:AbstractFillingElementPropertyType">
              <annotation>
                <documentation>Relates to the elements that fill the opening of the
constructive element.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0"
name="adeOfAbstractConstructiveElement"
type="con:ADEOfAbstractConstructiveElementPropertyType">
              <annotation>
                <documentation>Augments AbstractConstructiveElement with properties
defined in an ADE.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
    </complexType>
    <complexType name="AbstractConstructiveElementPropertyType">
      <sequence minOccurs="0">
        <element ref="con:AbstractConstructiveElement"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <element abstract="true" name="AbstractFillingElement"
substitutionGroup="core:AbstractOccupiedSpace" type="con:AbstractFillingElementType">
      <annotation>
        <documentation>AbstractFillingElement is the abstract superclass for different
kinds of elements that fill the openings of a construction.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="AbstractFillingElementType">
      <complexContent>
        <extension base="core:AbstractOccupiedSpaceType">
          <sequence>
            <element maxOccurs="unbounded" minOccurs="0"
name="adeOfAbstractFillingElement" type="con:ADEOfAbstractFillingElementPropertyType">
              <annotation>
                <documentation>Augments AbstractFillingElement with properties defined
in an ADE.</documentation>
              </annotation>
```

```
        </element>
      </sequence>
    </extension>
  </complexContent>
</complexType>
<complexType name="AbstractFillingElementPropertyType">
  <sequence minOccurs="0">
    <element ref="con:AbstractFillingElement"/>
  </sequence>
  <attributeGroup ref="gml:AssociationAttributeGroup"/>
  <attributeGroup ref="gml:OwnershipAttributeGroup"/>
</complexType>
<element abstract="true" name="AbstractFillingSurface"
substitutionGroup="core:AbstractThematicSurface"
type="con:AbstractFillingSurfaceType">
  <annotation>
    <documentation>AbstractFillingSurface is the abstract superclass for different
kinds of surfaces that seal openings filled by filling elements.</documentation>
  </annotation>
</element>
<complexType abstract="true" name="AbstractFillingSurfaceType">
  <complexContent>
    <extension base="core:AbstractThematicSurfaceType">
      <sequence>
        <element maxOccurs="unbounded" minOccurs="0"
name="adeOfAbstractFillingSurface" type="con:ADEOfAbstractFillingSurfacePropertyType">
          <annotation>
            <documentation>Augments AbstractFillingSurface with properties defined
in an ADE.</documentation>
          </annotation>
        </element>
      </sequence>
    </extension>
  </complexContent>
</complexType>
<complexType name="AbstractFillingSurfacePropertyType">
  <sequence minOccurs="0">
    <element ref="con:AbstractFillingSurface"/>
  </sequence>
  <attributeGroup ref="gml:AssociationAttributeGroup"/>
  <attributeGroup ref="gml:OwnershipAttributeGroup"/>
</complexType>
<element abstract="true" name="AbstractFurniture"
substitutionGroup="core:AbstractOccupiedSpace" type="con:AbstractFurnitureType">
  <annotation>
    <documentation>AbstractFurniture is the abstract superclass for the
representation of furniture objects of a construction.</documentation>
  </annotation>
</element>
<complexType abstract="true" name="AbstractFurnitureType">
  <complexContent>
```

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      <extension base="core:AbstractOccupiedSpaceType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfAbstractFurniture"
type="con:ADEOfAbstractFurniturePropertyType">
            <annotation>
              <documentation>Augments AbstractFurniture with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="AbstractFurniturePropertyType">
    <sequence minOccurs="0">
      <element ref="con:AbstractFurniture"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element abstract="true" name="AbstractInstallation"
substitutionGroup="core:AbstractOccupiedSpace" type="con:AbstractInstallationType">
    <annotation>
      <documentation>AbstractInstallation is the abstract superclass for the
representation of installation objects of a construction.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="AbstractInstallationType">
    <complexContent>
      <extension base="core:AbstractOccupiedSpaceType">
        <sequence>
          <element minOccurs="0" name="relationToConstruction"
type="con:RelationToConstructionType">
            <annotation>
              <documentation>Indicates whether the installation is located inside
and/or outside of the construction.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0"
name="adeOfAbstractInstallation" type="con:ADEOfAbstractInstallationPropertyType">
            <annotation>
              <documentation>Augments AbstractInstallation with properties defined in
an ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="AbstractInstallationPropertyType">
    <sequence minOccurs="0">
```

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      <element ref="con:AbstractInstallation"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="CeilingSurface" substitutionGroup="con:AbstractConstructionSurface"
type="con:CeilingSurfaceType">
    <annotation>
      <documentation>A CeilingSurface is a surface that represents the interior
ceiling of a construction. An example is the ceiling of a room.</documentation>
    </annotation>
  </element>
  <complexType name="CeilingSurfaceType">
    <complexContent>
      <extension base="con:AbstractConstructionSurfaceType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfCeilingSurface"
type="con:ADEOfCeilingSurfacePropertyType">
            <annotation>
              <documentation>Augments the CeilingSurface with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="CeilingSurfacePropertyType">
    <sequence minOccurs="0">
      <element ref="con:CeilingSurface"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <simpleType name="ConditionOfConstructionValueType">
    <annotation>
      <documentation>ConditionOfConstructionValue enumerates different conditions of a
construction. [cf. INSPIRE]</documentation>
    </annotation>
    <restriction base="string">
      <enumeration value="declined">
        <annotation>
          <documentation>Indicates that the construction cannot be used under normal
conditions, though its main elements (walls, roof) are still present. [cf.
INSPIRE]</documentation>
        </annotation>
      </enumeration>
      <enumeration value="demolished">
        <annotation>
          <documentation>Indicates that the construction has been demolished. There
are no more visible remains. [cf. INSPIRE]</documentation>
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        </annotation>
      </enumeration>
      <enumeration value="functional">
        <annotation>
          <documentation>Indicates that the construction is functional. [cf.
INSPIRE]</documentation>
        </annotation>
      </enumeration>
      <enumeration value="projected">
        <annotation>
          <documentation>Indicates that the construction is being designed.
Construction works have not yet started. [cf. INSPIRE]</documentation>
        </annotation>
      </enumeration>
      <enumeration value="ruin">
        <annotation>
          <documentation>Indicates that the construction has been partly demolished
and some main elements (roof, walls) have been destroyed. There are some visible
remains of the construction. [cf. INSPIRE]</documentation>
        </annotation>
      </enumeration>
      <enumeration value="underConstruction">
        <annotation>
          <documentation>Indicates that the construction is under construction and not
yet functional. This applies only to the initial construction works of the
construction and not to maintenance work. [cf. INSPIRE]</documentation>
        </annotation>
      </enumeration>
    </restriction>
  </simpleType>
  <element name="ConstructionEvent" substitutionGroup="gml:AbstractObject"
type="con:ConstructionEventType">
    <annotation>
      <documentation>A ConstructionEvent is a data type used to describe a specific
event that is associated with a construction. Examples are the issuing of a building
permit or the renovation of a building.</documentation>
    </annotation>
  </element>
  <complexType name="ConstructionEventType">
    <sequence>
      <element name="event" type="gml:CodeType">
        <annotation>
          <documentation>Indicates the specific event type.</documentation>
        </annotation>
      </element>
      <element name="dateOfEvent" type="date">
        <annotation>
          <documentation>Specifies the date at which the event took or will take
place.</documentation>
        </annotation>
      </element>
```

```
        <element minOccurs="0" name="description" type="string">
          <annotation>
            <documentation>Provides additional information on the event.</documentation>
          </annotation>
        </element>
      </sequence>
    </complexType>
    <complexType name="ConstructionEventPropertyType">
      <sequence>
        <element ref="con:ConstructionEvent"/>
      </sequence>
    </complexType>
    <element name="Door" substitutionGroup="con:AbstractFillingElement"
type="con:DoorType">
      <annotation>
        <documentation>A Door is a construction for closing an opening intended
primarily for access or egress or both. [cf. ISO 6707-1]</documentation>
      </annotation>
    </element>
    <complexType name="DoorType">
      <complexContent>
        <extension base="con:AbstractFillingElementType">
          <sequence>
            <element minOccurs="0" name="class" type="gml:CodeType">
              <annotation>
                <documentation>Indicates the specific type of the Door.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the intended purposes of the
Door.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the actual uses of the Door.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="address"
type="core:AddressPropertyType">
              <annotation>
                <documentation>Relates to the addresses that are assigned to the
Door.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="adeOfDoor"
type="con:ADEOfDoorPropertyType">
              <annotation>
```

```
                 <documentation>Augments the Door with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="DoorPropertyType">
    <sequence minOccurs="0">
      <element ref="con:Door"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="DoorSurface" substitutionGroup="con:AbstractFillingSurface"
type="con:DoorSurfaceType">
    <annotation>
      <documentation>A DoorSurface is either a boundary surface of a Door feature or a
surface that seals an opening filled by a door.</documentation>
    </annotation>
  </element>
  <complexType name="DoorSurfaceType">
    <complexContent>
      <extension base="con:AbstractFillingSurfaceType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="address"
type="core:AddressPropertyType">
            <annotation>
              <documentation>Relates to the addresses that are assigned to the
DoorSurface.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfDoorSurface"
type="con:ADEOfDoorSurfacePropertyType">
            <annotation>
              <documentation>Augments the DoorSurface with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="DoorSurfacePropertyType">
    <sequence minOccurs="0">
      <element ref="con:DoorSurface"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
```

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  <element name="Elevation" substitutionGroup="gml:AbstractObject"
type="con:ElevationType">
    <annotation>
      <documentation>Elevation is a data type that includes the elevation value itself
and information on how this elevation was measured. [cf. INSPIRE]</documentation>
    </annotation>
  </element>
  <complexType name="ElevationType">
    <sequence>
      <element name="elevationReference" type="gml:CodeType">
        <annotation>
          <documentation>Specifies the level from which the elevation was measured.
[cf. INSPIRE]</documentation>
        </annotation>
      </element>
      <element name="elevationValue" type="gml:DirectPositionType">
        <annotation>
          <documentation>Specifies the value of the elevation. [cf.
INSPIRE]</documentation>
        </annotation>
      </element>
    </sequence>
  </complexType>
  <complexType name="ElevationPropertyType">
    <sequence>
      <element ref="con:Elevation"/>
    </sequence>
  </complexType>
  <element name="FloorSurface" substitutionGroup="con:AbstractConstructionSurface"
type="con:FloorSurfaceType">
    <annotation>
      <documentation>A FloorSurface is surface that represents the interior floor of a
construction. An example is the floor of a room.</documentation>
    </annotation>
  </element>
  <complexType name="FloorSurfaceType">
    <complexContent>
      <extension base="con:AbstractConstructionSurfaceType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfFloorSurface"
type="con:ADEOfFloorSurfacePropertyType">
            <annotation>
              <documentation>Augments the FloorSurface with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="FloorSurfacePropertyType">
```

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      <sequence minOccurs="0">
        <element ref="con:FloorSurface"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <element name="GroundSurface" substitutionGroup="con:AbstractConstructionSurface"
type="con:GroundSurfaceType">
      <annotation>
        <documentation>A GroundSurface is a surface that represents the ground plate of
a construction. The polygon defining the ground plate is congruent with the footprint
of the construction.</documentation>
      </annotation>
    </element>
    <complexType name="GroundSurfaceType">
      <complexContent>
        <extension base="con:AbstractConstructionSurfaceType">
          <sequence>
            <element maxOccurs="unbounded" minOccurs="0" name="adeOfGroundSurface"
type="con:ADEOfGroundSurfacePropertyType">
              <annotation>
                <documentation>Augments the GroundSurface with properties defined in an
ADE.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
    </complexType>
    <complexType name="GroundSurfacePropertyType">
      <sequence minOccurs="0">
        <element ref="con:GroundSurface"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <element name="Height" substitutionGroup="gml:AbstractObject" type="con:HeightType">
      <annotation>
        <documentation>Height represents a vertical distance (measured or estimated)
between a low reference and a high reference. [cf. INSPIRE]</documentation>
      </annotation>
    </element>
    <complexType name="HeightType">
      <sequence>
        <element name="highReference" type="gml:CodeType">
          <annotation>
            <documentation>Indicates the high point used to calculate the value of the
height. [cf. INSPIRE]</documentation>
          </annotation>
        </element>
        <element name="lowReference" type="gml:CodeType">
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          <annotation>
            <documentation>Indicates the low point used to calculate the value of the
height. [cf. INSPIRE]</documentation>
          </annotation>
        </element>
        <element name="status" type="con:HeightStatusValueType">
          <annotation>
            <documentation>Indicates the way the height has been captured. [cf.
INSPIRE]</documentation>
          </annotation>
        </element>
        <element name="value" type="gml:LengthType">
          <annotation>
            <documentation>Specifies the value of the height above or below ground. [cf.
INSPIRE]</documentation>
          </annotation>
        </element>
      </sequence>
    </complexType>
    <complexType name="HeightPropertyType">
      <sequence>
        <element ref="con:Height"/>
      </sequence>
    </complexType>
    <simpleType name="HeightStatusValueType">
      <annotation>
        <documentation>HeightStatusValue enumerates the different methods used to
capture a height. [cf. INSPIRE]</documentation>
      </annotation>
      <restriction base="string">
        <enumeration value="estimated">
          <annotation>
            <documentation>Indicates that the height has been estimated and not
measured. [cf. INSPIRE]</documentation>
          </annotation>
        </enumeration>
        <enumeration value="measured">
          <annotation>
            <documentation>Indicates that the height has been (directly or indirectly)
measured. [cf. INSPIRE]</documentation>
          </annotation>
        </enumeration>
      </restriction>
    </simpleType>
    <element name="InteriorWallSurface"
substitutionGroup="con:AbstractConstructionSurface"
type="con:InteriorWallSurfaceType">
      <annotation>
        <documentation>An InteriorWallSurface is a surface that is visible from inside a
construction. An example is the wall of a room.</documentation>
      </annotation>
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        </element>
      <complexType name="InteriorWallSurfaceType">
        <complexContent>
          <extension base="con:AbstractConstructionSurfaceType">
            <sequence>
              <element maxOccurs="unbounded" minOccurs="0" name="adeOfInteriorWallSurface"
type="con:ADEOfInteriorWallSurfacePropertyType">
                <annotation>
                  <documentation>Augments the InteriorWallSurface with properties defined
in an ADE.</documentation>
                </annotation>
              </element>
            </sequence>
          </extension>
        </complexContent>
      </complexType>
      <complexType name="InteriorWallSurfacePropertyType">
        <sequence minOccurs="0">
          <element ref="con:InteriorWallSurface"/>
        </sequence>
        <attributeGroup ref="gml:AssociationAttributeGroup"/>
        <attributeGroup ref="gml:OwnershipAttributeGroup"/>
      </complexType>
      <element name="OtherConstruction" substitutionGroup="con:AbstractConstruction"
type="con:OtherConstructionType">
        <annotation>
          <documentation>An OtherConstruction is a construction that is not covered by any
of the other subclasses of AbstractConstruction.</documentation>
        </annotation>
      </element>
      <complexType name="OtherConstructionType">
        <complexContent>
          <extension base="con:AbstractConstructionType">
            <sequence>
              <element minOccurs="0" name="class" type="gml:CodeType">
                <annotation>
                  <documentation>Indicates the specific type of the
OtherConstruction.</documentation>
                </annotation>
              </element>
              <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
                <annotation>
                  <documentation>Specifies the intended purposes of the
OtherConstruction.</documentation>
                </annotation>
              </element>
              <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
                <annotation>
                  <documentation>Specifies the actual uses of the
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OtherConstruction.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfOtherConstruction"
type="con:ADEOfOtherConstructionPropertyType">
            <annotation>
              <documentation>Augments the OtherConstruction with properties defined in
an ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="OtherConstructionPropertyType">
    <sequence minOccurs="0">
      <element ref="con:OtherConstruction"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="OuterCeilingSurface"
substitutionGroup="con:AbstractConstructionSurface"
type="con:OuterCeilingSurfaceType">
    <annotation>
      <documentation>An OuterCeilingSurface is a surface that belongs to the outer
building shell with the orientation pointing downwards. An example is the ceiling of a
loggia.</documentation>
    </annotation>
  </element>
  <complexType name="OuterCeilingSurfaceType">
    <complexContent>
      <extension base="con:AbstractConstructionSurfaceType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfOuterCeilingSurface"
type="con:ADEOfOuterCeilingSurfacePropertyType">
            <annotation>
              <documentation>Augments the OuterCeilingSurface with properties defined
in an ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="OuterCeilingSurfacePropertyType">
    <sequence minOccurs="0">
      <element ref="con:OuterCeilingSurface"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
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      </complexType>
  <element name="OuterFloorSurface"
substitutionGroup="con:AbstractConstructionSurface" type="con:OuterFloorSurfaceType">
    <annotation>
      <documentation>An OuterFloorSurface is a surface that belongs to the outer
construction shell with the orientation pointing upwards. An example is the floor of a
loggia.</documentation>
    </annotation>
  </element>
  <complexType name="OuterFloorSurfaceType">
    <complexContent>
      <extension base="con:AbstractConstructionSurfaceType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfOuterFloorSurface"
type="con:ADEOfOuterFloorSurfacePropertyType">
            <annotation>
              <documentation>Augments the OuterFloorSurface with properties defined in
an ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="OuterFloorSurfacePropertyType">
    <sequence minOccurs="0">
      <element ref="con:OuterFloorSurface"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <simpleType name="RelationToConstructionType">
    <annotation>
      <documentation>RelationToConstruction is an enumeration used to describe whether
an installation is positioned inside and/or outside of a construction.</documentation>
    </annotation>
    <restriction base="string">
      <enumeration value="inside">
        <annotation>
          <documentation>Indicates that the installation is positioned inside of the
construction.</documentation>
        </annotation>
      </enumeration>
      <enumeration value="outside">
        <annotation>
          <documentation>Indicates that the installation is positioned outside of the
construction.</documentation>
        </annotation>
      </enumeration>
      <enumeration value="bothInsideAndOutside">
        <annotation>
```

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          <documentation>Indicates that the installation is positioned inside as well
as outside of the construction.</documentation>
        </annotation>
      </enumeration>
    </restriction>
  </simpleType>
  <element name="RoofSurface" substitutionGroup="con:AbstractConstructionSurface"
type="con:RoofSurfaceType">
    <annotation>
      <documentation>A RoofSurface is a surface that delimits major roof parts of a
construction.</documentation>
    </annotation>
  </element>
  <complexType name="RoofSurfaceType">
    <complexContent>
      <extension base="con:AbstractConstructionSurfaceType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfRoofSurface"
type="con:ADEOfRoofSurfacePropertyType">
            <annotation>
              <documentation>Augments the RoofSurface with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="RoofSurfacePropertyType">
    <sequence minOccurs="0">
      <element ref="con:RoofSurface"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="WallSurface" substitutionGroup="con:AbstractConstructionSurface"
type="con:WallSurfaceType">
    <annotation>
      <documentation>A WallSurface is a surface that is part of the building facade
visible from the outside.</documentation>
    </annotation>
  </element>
  <complexType name="WallSurfaceType">
    <complexContent>
      <extension base="con:AbstractConstructionSurfaceType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfWallSurface"
type="con:ADEOfWallSurfacePropertyType">
            <annotation>
              <documentation>Augments the WallSurface with properties defined in an
ADE.</documentation>
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            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="WallSurfacePropertyType">
    <sequence minOccurs="0">
      <element ref="con:WallSurface"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="Window" substitutionGroup="con:AbstractFillingElement"
type="con:WindowType">
    <annotation>
      <documentation>A Window is a construction for closing an opening in a wall  or
roof, primarily intended to admit light and/or provide ventilation. [cf. ISO  6707-
1]</documentation>
    </annotation>
  </element>
  <complexType name="WindowType">
    <complexContent>
      <extension base="con:AbstractFillingElementType">
        <sequence>
          <element minOccurs="0" name="class" type="gml:CodeType">
            <annotation>
              <documentation>Indicates the specific type of the
Window.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the intended purposes of the
Window.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the actual uses of the Window.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfWindow"
type="con:ADEOfWindowPropertyType">
            <annotation>
              <documentation>Augments the Window with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
```

```
          </sequence>
        </extension>
      </complexContent>
    </complexType>
    <complexType name="WindowPropertyType">
      <sequence minOccurs="0">
        <element ref="con:Window"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <element name="WindowSurface" substitutionGroup="con:AbstractFillingSurface"
type="con:WindowSurfaceType">
      <annotation>
        <documentation>A WindowSurface is either a boundary surface of a Window feature
or a surface that seals an opening filled by a window.</documentation>
      </annotation>
    </element>
    <complexType name="WindowSurfaceType">
      <complexContent>
        <extension base="con:AbstractFillingSurfaceType">
          <sequence>
            <element maxOccurs="unbounded" minOccurs="0" name="adeOfWindowSurface"
type="con:ADEOfWindowSurfacePropertyType">
              <annotation>
                <documentation>Augments the WindowSurface with properties defined in an
ADE.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
    </complexType>
    <complexType name="WindowSurfacePropertyType">
      <sequence minOccurs="0">
        <element ref="con:WindowSurface"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
</schema>
```

C.8. Dynamizer module

The CityGML Dynamizer module is defined in the XML Schema Definition file *dynamizer.xsd*
(Listing 15). The target namespace http://www.opengis.net/citygml/dynamizer/3.0 is associated with
this module.

Listing 15. dynamizer.xsd

```xml
<?xml version="1.0" encoding="UTF-8"?><schema xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:core="http://www.opengis.net/citygml/3.0"
xmlns:dyn="http://www.opengis.net/citygml/dynamizer/3.0"
xmlns:gml="http://www.opengis.net/gml/3.2" elementFormDefault="qualified"
targetNamespace="http://www.opengis.net/citygml/dynamizer/3.0" version="3.0.0">
  <annotation>
    <documentation>The Dynamizer module supports the injection of timeseries data for
individual attributes of CityGML features. Timeseries data can either be retrieved
from external Sensor APIs (e.g. OGC SensorThings API, OGC Sensor Observation Services,
MQTT, proprietary platforms), external standardized timeseries files (e.g. OGC
TimeseriesML or OGC Observations &amp; Measurements), external tabulated files (e.g
CSV) or can be represented inline as basic time-value pairs.</documentation>
  </annotation>
  <import namespace="http://www.opengis.net/citygml/3.0" schemaLocation="./core.xsd"/>
  <import namespace="http://www.opengis.net/gml/3.2"
schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd"/>
  <!--XML Schema document created by ShapeChange - http://shapechange.net/-->
  <element abstract="true" name="ADEOfAbstractAtomicTimeseries"
substitutionGroup="gml:AbstractObject" type="dyn:ADEOfAbstractAtomicTimeseriesType">
    <annotation>
      <documentation>ADEOfAbstractAtomicTimeseries acts as a hook to define properties
within an ADE that are to be added to AbstractAtomicTimeseries.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAbstractAtomicTimeseriesType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfAbstractAtomicTimeseriesPropertyType">
    <sequence>
      <element ref="dyn:ADEOfAbstractAtomicTimeseries"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfAbstractTimeseries"
substitutionGroup="gml:AbstractObject" type="dyn:ADEOfAbstractTimeseriesType">
    <annotation>
      <documentation>ADEOfAbstractTimeseries acts as a hook to define properties
within an ADE that are to be added to AbstractTimeseries.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAbstractTimeseriesType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfAbstractTimeseriesPropertyType">
    <sequence>
      <element ref="dyn:ADEOfAbstractTimeseries"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfCompositeTimeseries"
substitutionGroup="gml:AbstractObject" type="dyn:ADEOfCompositeTimeseriesType">
    <annotation>
      <documentation>ADEOfCompositeTimeseries acts as a hook to define properties
```

```
within an ADE that are to be added to a CompositeTimeseries.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfCompositeTimeseriesType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfCompositeTimeseriesPropertyType">
    <sequence>
      <element ref="dyn:ADEOfCompositeTimeseries"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfDynamizer"
substitutionGroup="gml:AbstractObject" type="dyn:ADEOfDynamizerType">
    <annotation>
      <documentation>ADEOfDynamizer acts as a hook to define properties within an ADE
that are to be added to a Dynamizer.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfDynamizerType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfDynamizerPropertyType">
    <sequence>
      <element ref="dyn:ADEOfDynamizer"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfGenericTimeseries"
substitutionGroup="gml:AbstractObject" type="dyn:ADEOfGenericTimeseriesType">
    <annotation>
      <documentation>ADEOfGenericTimeseries acts as a hook to define properties within
an ADE that are to be added to a GenericTimeseries.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfGenericTimeseriesType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfGenericTimeseriesPropertyType">
    <sequence>
      <element ref="dyn:ADEOfGenericTimeseries"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfStandardFileTimeseries"
substitutionGroup="gml:AbstractObject" type="dyn:ADEOfStandardFileTimeseriesType">
    <annotation>
      <documentation>ADEOfStandardFileTimeseries acts as a hook to define properties
within an ADE that are to be added to a StandardFileTimeseries.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfStandardFileTimeseriesType">
    <sequence/>
  </complexType>
```

```xml
  <complexType name="ADEOfStandardFileTimeseriesPropertyType">
    <sequence>
      <element ref="dyn:ADEOfStandardFileTimeseries"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfTabulatedFileTimeseries"
substitutionGroup="gml:AbstractObject" type="dyn:ADEOfTabulatedFileTimeseriesType">
    <annotation>
      <documentation>ADEOfTabulatedFileTimeseries acts as a hook to define properties
within an ADE that are to be added to a TabulatedFileTimeseries.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfTabulatedFileTimeseriesType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfTabulatedFileTimeseriesPropertyType">
    <sequence>
      <element ref="dyn:ADEOfTabulatedFileTimeseries"/>
    </sequence>
  </complexType>
  <element abstract="true" name="AbstractAtomicTimeseries"
substitutionGroup="dyn:AbstractTimeseries" type="dyn:AbstractAtomicTimeseriesType">
    <annotation>
      <documentation>AbstractAtomicTimeseries represents the attributes and
relationships that are common to all kinds of atomic timeseries (GenericTimeseries,
TabulatedFileTimeseries, StandardFileTimeseries). An atomic timeseries represents
time-varying data of a specific data type for a single contiguous time
interval.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="AbstractAtomicTimeseriesType">
    <complexContent>
      <extension base="dyn:AbstractTimeseriesType">
        <sequence>
          <element name="observationProperty" type="string">
            <annotation>
              <documentation>Specifies the phenomenon for which the atomic timeseries
provides observation values.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="uom" type="string">
            <annotation>
              <documentation>Specifies the unit of measurement of the observation
values.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0"
name="adeOfAbstractAtomicTimeseries"
type="dyn:ADEOfAbstractAtomicTimeseriesPropertyType">
            <annotation>
              <documentation>Augments AbstractAtomicTimeseries with properties defined
```

```xml
in an ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="AbstractAtomicTimeseriesPropertyType">
    <sequence minOccurs="0">
      <element ref="dyn:AbstractAtomicTimeseries"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element abstract="true" name="AbstractTimeseries"
substitutionGroup="core:AbstractFeature" type="dyn:AbstractTimeseriesType">
    <annotation>
      <documentation>AbstractTimeseries is the abstract superclass representing any
type of timeseries data.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="AbstractTimeseriesType">
    <complexContent>
      <extension base="core:AbstractFeatureType">
        <sequence>
          <element minOccurs="0" name="firstTimestamp" type="gml:TimePositionType">
            <annotation>
              <documentation>Specifies the beginning of the
timeseries.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="lastTimestamp" type="gml:TimePositionType">
            <annotation>
              <documentation>Specifies the end of the timeseries.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfAbstractTimeseries"
type="dyn:ADEOfAbstractTimeseriesPropertyType">
            <annotation>
              <documentation>Augments AbstractTimeseries with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="AbstractTimeseriesPropertyType">
    <sequence minOccurs="0">
      <element ref="dyn:AbstractTimeseries"/>
    </sequence>
```

```xml
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <element name="CompositeTimeseries" substitutionGroup="dyn:AbstractTimeseries"
type="dyn:CompositeTimeseriesType">
      <annotation>
        <documentation>A CompositeTimeseries is a (possibly recursive) aggregation of
atomic and composite timeseries. The components of a composite timeseries must have
non-overlapping time intervals.</documentation>
      </annotation>
    </element>
    <complexType name="CompositeTimeseriesType">
      <complexContent>
        <extension base="dyn:AbstractTimeseriesType">
          <sequence>
            <element maxOccurs="unbounded" name="component"
type="dyn:TimeseriesComponentPropertyType">
              <annotation>
                <documentation>Relates to the atomic and composite timeseries that are
part of the CompositeTimeseries. The referenced timeseries are sequentially
ordered.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="adeOfCompositeTimeseries"
type="dyn:ADEOfCompositeTimeseriesPropertyType">
              <annotation>
                <documentation>Augments the CompositeTimeseries with properties defined
in an ADE.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
    </complexType>
    <complexType name="CompositeTimeseriesPropertyType">
      <sequence minOccurs="0">
        <element ref="dyn:CompositeTimeseries"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <element name="Dynamizer" substitutionGroup="core:AbstractDynamizer"
type="dyn:DynamizerType">
      <annotation>
        <documentation>A Dynamizer is an object that injects timeseries data for an
individual attribute of the city object in which it is included. The timeseries data
overrides the static value of the referenced city object attribute in order to
represent dynamic (time-dependent) variations of its value.</documentation>
      </annotation>
    </element>
    <complexType name="DynamizerType">
```

```xml
    <complexContent>
      <extension base="core:AbstractDynamizerType">
        <sequence>
          <element name="attributeRef" type="string">
            <annotation>
              <documentation>Specifies the attribute of a CityGML feature whose value
is overridden or replaced by the (dynamic) values specified by the
Dynamizer.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="startTime" type="gml:TimePositionType">
            <annotation>
              <documentation>Specifies the beginning of the time span for which the
Dynamizer provides dynamic values.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="endTime" type="gml:TimePositionType">
            <annotation>
              <documentation>Specifies the end of the time span for which the
Dynamizer provides dynamic values.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="dynamicData">
            <annotation>
              <documentation>Relates to the timeseries data that is given either
inline within a CityGML dataset or by a link to an external file containing timeseries
data.</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
                    <element ref="dyn:AbstractTimeseries"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
          </element>
          <element minOccurs="0" name="sensorConnection"
type="dyn:SensorConnectionPropertyType">
            <annotation>
              <documentation>Relates to the sensor API that delivers timeseries
data.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfDynamizer"
type="dyn:ADEOfDynamizerPropertyType">
            <annotation>
              <documentation>Augments the Dynamizer with properties defined in an
ADE.</documentation>
```

```xml
          </annotation>
        </element>
      </sequence>
    </extension>
  </complexContent>
</complexType>
<complexType name="DynamizerPropertyType">
  <sequence minOccurs="0">
    <element ref="dyn:Dynamizer"/>
  </sequence>
  <attributeGroup ref="gml:AssociationAttributeGroup"/>
  <attributeGroup ref="gml:OwnershipAttributeGroup"/>
</complexType>
<element name="GenericTimeseries" substitutionGroup="dyn:AbstractAtomicTimeseries"
type="dyn:GenericTimeseriesType">
  <annotation>
    <documentation>A GenericTimeseries represents time-varying data in the form of
embedded time-value-pairs of a specific data type for a single contiguous time
interval.</documentation>
  </annotation>
</element>
<complexType name="GenericTimeseriesType">
  <complexContent>
    <extension base="dyn:AbstractAtomicTimeseriesType">
      <sequence>
        <element name="valueType" type="dyn:TimeseriesTypeValueType">
          <annotation>
            <documentation>Indicates the specific type of all time-value-pairs that
are part of the GenericTimeseries.</documentation>
          </annotation>
        </element>
        <element maxOccurs="unbounded" name="timeValuePair"
type="dyn:TimeValuePairPropertyType">
          <annotation>
            <documentation>Relates to the time-value-pairs that are part of the
GenericTimeseries.</documentation>
          </annotation>
        </element>
        <element maxOccurs="unbounded" minOccurs="0" name="adeOfGenericTimeseries"
type="dyn:ADEOfGenericTimeseriesPropertyType">
          <annotation>
            <documentation>Augments the GenericTimeseries with properties defined in
an ADE.</documentation>
          </annotation>
        </element>
      </sequence>
    </extension>
  </complexContent>
</complexType>
<complexType name="GenericTimeseriesPropertyType">
  <sequence minOccurs="0">
```

```xml
        <element ref="dyn:GenericTimeseries"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <element name="SensorConnection" substitutionGroup="gml:AbstractObject"
type="dyn:SensorConnectionType">
      <annotation>
        <documentation>A SensorConnection provides all details that are required to
retrieve a specific datastream from an external sensor web service. This data type
comprises the service type (e.g. OGC SensorThings API, OGC Sensor Observation
Services, MQTT, proprietary platforms), the URL of the sensor service, the identifier
for the sensor or thing, and its observed property as well as information about the
required authentication method.</documentation>
      </annotation>
    </element>
    <complexType name="SensorConnectionType">
      <sequence>
        <element name="connectionType" type="gml:CodeType">
          <annotation>
            <documentation>Indicates the type of Sensor API to which the
SensorConnection refers.</documentation>
          </annotation>
        </element>
        <element name="observationProperty" type="string">
          <annotation>
            <documentation>Specifies the phenomenon for which the SensorConnection
provides observations.</documentation>
          </annotation>
        </element>
        <element minOccurs="0" name="uom" type="string">
          <annotation>
            <documentation>Specifies the unit of measurement of the
observations.</documentation>
          </annotation>
        </element>
        <element minOccurs="0" name="sensorID" type="string">
          <annotation>
            <documentation>Specifies the unique identifier of the sensor from which the
SensorConnection retrieves observations.</documentation>
          </annotation>
        </element>
        <element minOccurs="0" name="sensorName" type="string">
          <annotation>
            <documentation>Specifies the name of the sensor from which the
SensorConnection retrieves observations.</documentation>
          </annotation>
        </element>
        <element minOccurs="0" name="observationID" type="string">
          <annotation>
            <documentation>Specifies the unique identifier of the observation that is
```

```
retrieved by the SensorConnection.</documentation>
        </annotation>
      </element>
      <element minOccurs="0" name="datastreamID" type="string">
        <annotation>
          <documentation>Specifies the datastream that is retrieved by the
SensorConnection.</documentation>
        </annotation>
      </element>
      <element minOccurs="0" name="baseURL" type="anyURI">
        <annotation>
          <documentation>Specifies the base URL of the Sensor API
request.</documentation>
        </annotation>
      </element>
      <element minOccurs="0" name="authType" type="gml:CodeType">
        <annotation>
          <documentation>Specifies the type of authentication required to be able to
access the Sensor API.</documentation>
        </annotation>
      </element>
      <element minOccurs="0" name="mqttServer" type="string">
        <annotation>
          <documentation>Specifies the name of the MQTT Server. This attribute is
relevant when the MQTT Protocol is used to connect to a Sensor API.</documentation>
        </annotation>
      </element>
      <element minOccurs="0" name="mqttTopic" type="string">
        <annotation>
          <documentation>Names the specific datastream that is retrieved by the
SensorConnection. This attribute is relevant when the MQTT Protocol is used to connect
to a Sensor API.</documentation>
        </annotation>
      </element>
      <element minOccurs="0" name="linkToObservation" type="string">
        <annotation>
          <documentation>Specifies the complete URL to the observation
request.</documentation>
        </annotation>
      </element>
      <element minOccurs="0" name="linkToSensorDescription" type="string">
        <annotation>
          <documentation>Specifies the complete URL to the sensor description
request.</documentation>
        </annotation>
      </element>
      <element minOccurs="0" name="sensorLocation" type="gml:ReferenceType">
        <annotation>
          <documentation>Relates the sensor to the city object where it is
located.</documentation>
          <appinfo>
```

```
                <targetElement
xmlns="http://www.opengis.net/gml/3.2">core:AbstractCityObject</targetElement>
            </appinfo>
          </annotation>
        </element>
      </sequence>
    </complexType>
    <complexType name="SensorConnectionPropertyType">
      <sequence>
        <element ref="dyn:SensorConnection"/>
      </sequence>
    </complexType>
    <element name="StandardFileTimeseries"
substitutionGroup="dyn:AbstractAtomicTimeseries"
type="dyn:StandardFileTimeseriesType">
      <annotation>
        <documentation>A StandardFileTimeseries represents time-varying data for a
single contiguous time interval. The data is provided in an external file referenced
in the StandardFileTimeseries. The data within the external file is encoded according
to a dedicated format for the representation of timeseries data such as using the OGC
TimeseriesML or OGC Observations &amp; Measurements Standard. The data type of the
data has to be specified within the external file.</documentation>
      </annotation>
    </element>
    <complexType name="StandardFileTimeseriesType">
      <complexContent>
        <extension base="dyn:AbstractAtomicTimeseriesType">
          <sequence>
            <element name="fileLocation" type="anyURI">
              <annotation>
                <documentation>Specifies the URI that points to the external timeseries
file.</documentation>
              </annotation>
            </element>
            <element name="fileType" type="gml:CodeType">
              <annotation>
                <documentation>Specifies the format used to represent the timeseries
data.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="mimeType" type="gml:CodeType">
              <annotation>
                <documentation>Specifies the MIME type of the external timeseries
file.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0"
name="adeOfStandardFileTimeseries" type="dyn:ADEOfStandardFileTimeseriesPropertyType">
              <annotation>
                <documentation>Augments the StandardFileTimeseries with properties
defined in an ADE.</documentation>
```

```
          </annotation>
        </element>
      </sequence>
    </extension>
  </complexContent>
</complexType>
<complexType name="StandardFileTimeseriesPropertyType">
  <sequence minOccurs="0">
    <element ref="dyn:StandardFileTimeseries"/>
  </sequence>
  <attributeGroup ref="gml:AssociationAttributeGroup"/>
  <attributeGroup ref="gml:OwnershipAttributeGroup"/>
</complexType>
<element name="TabulatedFileTimeseries"
substitutionGroup="dyn:AbstractAtomicTimeseries"
type="dyn:TabulatedFileTimeseriesType">
  <annotation>
    <documentation>A TabulatedFileTimeseries represents time-varying data of a
specific data type for a single contiguous time interval. The data is provided in an
external file referenced in the TabulatedFileTimeseries. The file contains table
structured data using an appropriate file format such as comma-separated values (CSV),
Microsoft Excel (XLSX) or Google Spreadsheet. The timestamps and the values are given
in specific columns of the table. Each row represents a single time-value-pair. A
subset of rows can be selected using the idColumn and idValue
attributes.</documentation>
  </annotation>
</element>
<complexType name="TabulatedFileTimeseriesType">
  <complexContent>
    <extension base="dyn:AbstractAtomicTimeseriesType">
      <sequence>
        <element name="fileLocation" type="anyURI">
          <annotation>
            <documentation>Specifies the URI that points to the external timeseries
file.</documentation>
          </annotation>
        </element>
        <element name="fileType" type="gml:CodeType">
          <annotation>
            <documentation>Specifies the format used to represent the timeseries
data.</documentation>
          </annotation>
        </element>
        <element minOccurs="0" name="mimeType" type="gml:CodeType">
          <annotation>
            <documentation>Specifies the MIME type of the external timeseries
file.</documentation>
          </annotation>
        </element>
        <element name="valueType" type="dyn:TimeseriesTypeValueType">
          <annotation>
```

```
            <documentation>Indicates the specific type of the timeseries
data.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="numberOfHeaderLines" type="integer">
            <annotation>
            <documentation>Indicates the number of lines at the beginning of the
tabulated file that represent headers.</documentation>
            </annotation>
          </element>
          <element name="fieldSeparator" type="string">
            <annotation>
            <documentation>Indicates which symbol is used to separate the individual
values in the tabulated file.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="decimalSymbol" type="string">
            <annotation>
            <documentation>Indicates which symbol is used to separate the integer
part from the fractional part of a decimal number.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="idColumnNo" type="integer">
            <annotation>
            <documentation>Specifies the number of the column that stores the
identifier of the time-value-pair.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="idColumnName" type="string">
            <annotation>
            <documentation>Specifies the name of the column that stores the
identifier of the time-value-pair.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="idValue" type="string">
            <annotation>
            <documentation>Specifies the value of the identifier for which the time-
value-pairs are to be selected.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="timeColumnNo" type="integer">
            <annotation>
            <documentation>Specifies the number of the column that stores the
timestamp of the time-value-pair.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="timeColumnName" type="string">
            <annotation>
            <documentation>Specifies the name of the column that stores the
timestamp of the time-value-pair.</documentation>
            </annotation>
```

```
            </element>
            <element minOccurs="0" name="valueColumnNo" type="integer">
              <annotation>
                <documentation>Specifies the number of the column that stores the value
of the time-value-pair.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="valueColumnName" type="string">
              <annotation>
                <documentation>Specifies the name of the column that stores the value of
the time-value-pair.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0"
name="adeOfTabulatedFileTimeseries"
type="dyn:ADEOfTabulatedFileTimeseriesPropertyType">
              <annotation>
                <documentation>Augments the TabulatedFileTimeseries with properties
defined in an ADE.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
  </complexType>
  <complexType name="TabulatedFileTimeseriesPropertyType">
    <sequence minOccurs="0">
      <element ref="dyn:TabulatedFileTimeseries"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="TimeValuePair" substitutionGroup="gml:AbstractObject"
type="dyn:TimeValuePairType">
    <annotation>
      <documentation>A TimeValuePair represents a value that is valid for a given
timepoint. For each TimeValuePair, only one of the value properties can be used
mutually exclusive. Which value property has to be provided depends on the selected
value type in the GenericTimeSeries feature, in which the TimeValuePair is
included.</documentation>
    </annotation>
  </element>
  <complexType name="TimeValuePairType">
    <sequence>
      <element name="timestamp" type="gml:TimePositionType">
        <annotation>
          <documentation>Specifies the timepoint at which the value of the
TimeValuePair is valid.</documentation>
        </annotation>
      </element>
      <element minOccurs="0" name="intValue" type="integer">
```

```
        <annotation>
          <documentation>Specifies the "Integer" value of the
TimeValuePair.</documentation>
        </annotation>
      </element>
      <element minOccurs="0" name="doubleValue" type="double">
        <annotation>
          <documentation>Specifies the "Double" value of the
TimeValuePair.</documentation>
        </annotation>
      </element>
      <element minOccurs="0" name="stringValue" type="string">
        <annotation>
          <documentation>Specifies the "String" value of the
TimeValuePair.</documentation>
        </annotation>
      </element>
      <element minOccurs="0" name="geometryValue" type="gml:GeometryPropertyType">
        <annotation>
          <documentation>Specifies the geometry value of the
TimeValuePair.</documentation>
        </annotation>
      </element>
      <element minOccurs="0" name="uriValue" type="anyURI">
        <annotation>
          <documentation>Specifies the "URI" value of the
TimeValuePair.</documentation>
        </annotation>
      </element>
      <element minOccurs="0" name="boolValue" type="boolean">
        <annotation>
          <documentation>Specifies the "Boolean" value of the
TimeValuePair.</documentation>
        </annotation>
      </element>
      <element minOccurs="0" name="implicitGeometryValue">
        <annotation>
          <documentation>Specifies the "ImplicitGeometry" value of the
TimeValuePair.</documentation>
        </annotation>
        <complexType>
          <complexContent>
            <extension base="gml:AbstractMemberType">
              <sequence minOccurs="0">
                <element ref="core:ImplicitGeometry"/>
              </sequence>
              <attributeGroup ref="gml:AssociationAttributeGroup"/>
            </extension>
          </complexContent>
        </complexType>
      </element>
```

```xml
        <element minOccurs="0" name="appearanceValue">
          <annotation>
            <documentation>Specifies the "Appearance" value of the
TimeValuePair.</documentation>
          </annotation>
          <complexType>
            <complexContent>
              <extension base="gml:AbstractFeatureMemberType">
                <sequence minOccurs="0">
                  <element ref="core:AbstractAppearance"/>
                </sequence>
                <attributeGroup ref="gml:AssociationAttributeGroup"/>
              </extension>
            </complexContent>
          </complexType>
        </element>
      </sequence>
    </complexType>
    <complexType name="TimeValuePairPropertyType">
      <sequence>
        <element ref="dyn:TimeValuePair"/>
      </sequence>
    </complexType>
    <element name="TimeseriesComponent" substitutionGroup="gml:AbstractObject"
type="dyn:TimeseriesComponentType">
      <annotation>
        <documentation>TimeseriesComponent represents an element of a
CompositeTimeseries.</documentation>
      </annotation>
    </element>
    <complexType name="TimeseriesComponentType">
      <sequence>
        <element name="repetitions" type="integer">
          <annotation>
            <documentation>Specifies how often the timeseries that is referenced by the
TimeseriesComponent should be iterated.</documentation>
          </annotation>
        </element>
        <element minOccurs="0" name="additionalGap" type="duration">
          <annotation>
            <documentation>Specifies how much extra time is added after all repetitions
as an additional gap.</documentation>
          </annotation>
        </element>
        <element name="timeseries" type="dyn:AbstractTimeseriesPropertyType">
          <annotation>
            <documentation>Relates a timeseries to the
TimeseriesComponent.</documentation>
          </annotation>
        </element>
      </sequence>
```

```
  </complexType>
  <complexType name="TimeseriesComponentPropertyType">
    <sequence>
      <element ref="dyn:TimeseriesComponent"/>
    </sequence>
  </complexType>
  <simpleType name="TimeseriesTypeValueType">
    <annotation>
      <documentation>TimeseriesTypeValue enumerates the possible value types for
GenericTimeseries and TimeValuePair.</documentation>
    </annotation>
    <restriction base="string">
      <enumeration value="int">
        <annotation>
          <documentation>Indicates that the values of the GenericTimeseries are of
type "Integer".</documentation>
        </annotation>
      </enumeration>
      <enumeration value="double">
        <annotation>
          <documentation>Indicates that the values of the GenericTimeseries  are of
type "Double".</documentation>
        </annotation>
      </enumeration>
      <enumeration value="string">
        <annotation>
          <documentation>Indicates that the values of the GenericTimeseries are of
type "String".</documentation>
        </annotation>
      </enumeration>
      <enumeration value="geometry">
        <annotation>
          <documentation>Indicates that the values of the GenericTimeseries are
geometries.</documentation>
        </annotation>
      </enumeration>
      <enumeration value="uri">
        <annotation>
          <documentation>Indicates that the values of the GenericTimeseries are of
type "URI".</documentation>
        </annotation>
      </enumeration>
      <enumeration value="bool">
        <annotation>
          <documentation>Indicates that the values of the GenericTimeseries are of
type "Boolean".</documentation>
        </annotation>
      </enumeration>
      <enumeration value="implicitGeometry">
        <annotation>
          <documentation>Indicates that the values of the GenericTimeseries are of
```

```
type "ImplicitGeometry".</documentation>
        </annotation>
      </enumeration>
      <enumeration value="appearance">
        <annotation>
          <documentation>Indicates that the values of the GenericTimeseries are of
type "Appearance".</documentation>
        </annotation>
      </enumeration>
    </restriction>
  </simpleType>
</schema>
```

C.9. Generics module

The CityGML Generics module is defined in the XML Schema Definition file *generics.xsd* (Listing 16).
The target namespace http://www.opengis.net/citygml/generics/3.0 is associated with this module.

Listing 16. generics.xsd

```
<?xml version="1.0" encoding="UTF-8"?><schema xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:core="http://www.opengis.net/citygml/3.0"
xmlns:gen="http://www.opengis.net/citygml/generics/3.0"
xmlns:gml="http://www.opengis.net/gml/3.2" elementFormDefault="qualified"
targetNamespace="http://www.opengis.net/citygml/generics/3.0" version="3.0.0">
  <annotation>
    <documentation>The Generics module supports application-specific extensions to the
CityGML conceptual model. These extensions may be used to model and exchange
additional attributes and features not covered by the predefined thematic classes of
CityGML. Generic extensions shall only be used if appropriate thematic classes or
attributes are not provided by any other CityGML module.</documentation>
  </annotation>
  <import namespace="http://www.opengis.net/citygml/3.0" schemaLocation="./core.xsd"/>
  <import namespace="http://www.opengis.net/gml/3.2"
schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd"/>
  <!--XML Schema document created by ShapeChange - http://shapechange.net/-->
  <element abstract="true" name="ADEOfGenericLogicalSpace"
substitutionGroup="gml:AbstractObject" type="gen:ADEOfGenericLogicalSpaceType">
    <annotation>
      <documentation>ADEOfGenericLogicalSpace acts as a hook to define properties
within an ADE that are to be added to a GenericLogicalSpace.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfGenericLogicalSpaceType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfGenericLogicalSpacePropertyType">
    <sequence>
      <element ref="gen:ADEOfGenericLogicalSpace"/>
    </sequence>
```

```xml
    </complexType>
  <element abstract="true" name="ADEOfGenericOccupiedSpace"
substitutionGroup="gml:AbstractObject" type="gen:ADEOfGenericOccupiedSpaceType">
    <annotation>
      <documentation>ADEOfGenericOccupiedSpace acts as a hook to define properties
within an ADE that are to be added to a GenericOccupiedSpace.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfGenericOccupiedSpaceType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfGenericOccupiedSpacePropertyType">
    <sequence>
      <element ref="gen:ADEOfGenericOccupiedSpace"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfGenericThematicSurface"
substitutionGroup="gml:AbstractObject" type="gen:ADEOfGenericThematicSurfaceType">
    <annotation>
      <documentation>ADEOfGenericThematicSurface acts as a hook to define properties
within an ADE that are to be added to a GenericThematicSurface.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfGenericThematicSurfaceType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfGenericThematicSurfacePropertyType">
    <sequence>
      <element ref="gen:ADEOfGenericThematicSurface"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfGenericUnoccupiedSpace"
substitutionGroup="gml:AbstractObject" type="gen:ADEOfGenericUnoccupiedSpaceType">
    <annotation>
      <documentation>ADEOfGenericUnoccupiedSpace acts as a hook to define properties
within an ADE that are to be added to a GenericUnoccupiedSpace.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfGenericUnoccupiedSpaceType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfGenericUnoccupiedSpacePropertyType">
    <sequence>
      <element ref="gen:ADEOfGenericUnoccupiedSpace"/>
    </sequence>
  </complexType>
  <element name="CodeAttribute" substitutionGroup="core:AbstractGenericAttribute"
type="gen:CodeAttributeType">
    <annotation>
      <documentation>CodeAttribute is a data type used to define generic attributes of
type "Code".</documentation>
```

```xml
          </annotation>
        </element>
        <complexType name="CodeAttributeType">
          <complexContent>
            <extension base="core:AbstractGenericAttributeType">
              <sequence>
                <element name="name" type="string">
                  <annotation>
                    <documentation>Specifies the name of the CodeAttribute.</documentation>
                  </annotation>
                </element>
                <element name="value" type="gml:CodeType">
                  <annotation>
                    <documentation>Specifies the "Code" value.</documentation>
                  </annotation>
                </element>
              </sequence>
            </extension>
          </complexContent>
        </complexType>
        <complexType name="CodeAttributePropertyType">
          <sequence>
            <element ref="gen:CodeAttribute"/>
          </sequence>
        </complexType>
        <element name="DateAttribute" substitutionGroup="core:AbstractGenericAttribute"
    type="gen:DateAttributeType">
          <annotation>
            <documentation>DateAttribute is a data type used to define generic attributes of
    type "Date".</documentation>
          </annotation>
        </element>
        <complexType name="DateAttributeType">
          <complexContent>
            <extension base="core:AbstractGenericAttributeType">
              <sequence>
                <element name="name" type="string">
                  <annotation>
                    <documentation>Specifies the name of the DateAttribute.</documentation>
                  </annotation>
                </element>
                <element name="value" type="date">
                  <annotation>
                    <documentation>Specifies the "Date" value.</documentation>
                  </annotation>
                </element>
              </sequence>
            </extension>
          </complexContent>
        </complexType>
        <complexType name="DateAttributePropertyType">
```

```xml
      <sequence>
        <element ref="gen:DateAttribute"/>
      </sequence>
    </complexType>
    <element name="DoubleAttribute" substitutionGroup="core:AbstractGenericAttribute"
type="gen:DoubleAttributeType">
      <annotation>
        <documentation>DoubleAttribute is a data type used to define generic attributes
of type "Double".</documentation>
      </annotation>
    </element>
    <complexType name="DoubleAttributeType">
      <complexContent>
        <extension base="core:AbstractGenericAttributeType">
          <sequence>
            <element name="name" type="string">
              <annotation>
                <documentation>Specifies the name of the
DoubleAttribute.</documentation>
              </annotation>
            </element>
            <element name="value" type="double">
              <annotation>
                <documentation>Specifies the "Double" value.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
    </complexType>
    <complexType name="DoubleAttributePropertyType">
      <sequence>
        <element ref="gen:DoubleAttribute"/>
      </sequence>
    </complexType>
    <element name="GenericAttributeSet"
substitutionGroup="core:AbstractGenericAttribute" type="gen:GenericAttributeSetType">
      <annotation>
        <documentation>A GenericAttributeSet is a named collection of generic
attributes.</documentation>
      </annotation>
    </element>
    <complexType name="GenericAttributeSetType">
      <complexContent>
        <extension base="core:AbstractGenericAttributeType">
          <sequence>
            <element name="name" type="string">
              <annotation>
                <documentation>Specifies the name of the
GenericAttributeSet.</documentation>
              </annotation>
```

```
            </element>
            <element minOccurs="0" name="codeSpace" type="anyURI">
              <annotation>
                <documentation>Associates the GenericAttributeSet with an authority that
maintains the collection of generic attributes.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" name="genericAttribute"
type="core:AbstractGenericAttributePropertyType">
              <annotation>
                <documentation>Relates to the generic attributes that are part of the
GenericAttributeSet.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
    </complexType>
    <complexType name="GenericAttributeSetPropertyType">
      <sequence>
        <element ref="gen:GenericAttributeSet"/>
      </sequence>
    </complexType>
    <element name="GenericLogicalSpace" substitutionGroup="core:AbstractLogicalSpace"
type="gen:GenericLogicalSpaceType">
      <annotation>
        <documentation>A GenericLogicalSpace is a space that is not represented by any
explicitly modelled AbstractLogicalSpace subclass within CityGML.</documentation>
      </annotation>
    </element>
    <complexType name="GenericLogicalSpaceType">
      <complexContent>
        <extension base="core:AbstractLogicalSpaceType">
          <sequence>
            <element minOccurs="0" name="class" type="gml:CodeType">
              <annotation>
                <documentation>Indicates the specific type of the
GenericLogicalSpace.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the intended purposes of the
GenericLogicalSpace.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the actual uses of the
```

```
GenericLogicalSpace.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="adeOfGenericLogicalSpace"
type="gen:ADEOfGenericLogicalSpacePropertyType">
              <annotation>
                <documentation>Augments the GenericLogicalSpace with properties defined
in an ADE.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
  </complexType>
  <complexType name="GenericLogicalSpacePropertyType">
    <sequence minOccurs="0">
      <element ref="gen:GenericLogicalSpace"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="GenericOccupiedSpace" substitutionGroup="core:AbstractOccupiedSpace"
type="gen:GenericOccupiedSpaceType">
    <annotation>
      <documentation>A GenericOccupiedSpace is a space that is not represented by any
explicitly modelled AbstractOccupiedSpace subclass within CityGML.</documentation>
    </annotation>
  </element>
  <complexType name="GenericOccupiedSpaceType">
    <complexContent>
      <extension base="core:AbstractOccupiedSpaceType">
        <sequence>
          <element minOccurs="0" name="class" type="gml:CodeType">
            <annotation>
              <documentation>Indicates the specific type of the
GenericOccupiedSpace.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the intended purposes of the
GenericOccupiedSpace.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the actual uses of the
GenericOccupiedSpace.</documentation>
            </annotation>
```

```
            </element>
            <element maxOccurs="unbounded" minOccurs="0"
name="adeOfGenericOccupiedSpace" type="gen:ADEOfGenericOccupiedSpacePropertyType">
              <annotation>
                <documentation>Augments the GenericOccupiedSpace with properties defined
in an ADE.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
    </complexType>
    <complexType name="GenericOccupiedSpacePropertyType">
      <sequence minOccurs="0">
        <element ref="gen:GenericOccupiedSpace"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <element name="GenericThematicSurface"
substitutionGroup="core:AbstractThematicSurface"
type="gen:GenericThematicSurfaceType">
      <annotation>
        <documentation>A GenericThematicSurface is a surface that is not represented by
any explicitly modelled AbstractThematicSurface subclass within
CityGML.</documentation>
      </annotation>
    </element>
    <complexType name="GenericThematicSurfaceType">
      <complexContent>
        <extension base="core:AbstractThematicSurfaceType">
          <sequence>
            <element minOccurs="0" name="class" type="gml:CodeType">
              <annotation>
                <documentation>Indicates the specific type of the
GenericThematicSurface.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the intended purposes of the
GenericThematicSurface.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the actual uses of the
GenericThematicSurface.</documentation>
              </annotation>
```

```xml
            </element>
            <element maxOccurs="unbounded" minOccurs="0"
name="adeOfGenericThematicSurface" type="gen:ADEOfGenericThematicSurfacePropertyType">
                <annotation>
                    <documentation>Augments the GenericThematicSurface with properties
defined in an ADE.</documentation>
                </annotation>
            </element>
        </sequence>
    </extension>
</complexContent>
</complexType>
<complexType name="GenericThematicSurfacePropertyType">
    <sequence minOccurs="0">
        <element ref="gen:GenericThematicSurface"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
</complexType>
<element name="GenericUnoccupiedSpace"
substitutionGroup="core:AbstractUnoccupiedSpace"
type="gen:GenericUnoccupiedSpaceType">
    <annotation>
        <documentation>A GenericUnoccupiedSpace is a space that is not represented by
any explicitly modelled AbstractUnoccupiedSpace subclass within
CityGML.</documentation>
    </annotation>
</element>
<complexType name="GenericUnoccupiedSpaceType">
    <complexContent>
        <extension base="core:AbstractUnoccupiedSpaceType">
            <sequence>
                <element minOccurs="0" name="class" type="gml:CodeType">
                    <annotation>
                        <documentation>Indicates the specific type of the
GenericUnoccupiedSpace.</documentation>
                    </annotation>
                </element>
                <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
                    <annotation>
                        <documentation>Specifies the intended purposes of the
GenericUnoccupiedSpace.</documentation>
                    </annotation>
                </element>
                <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
                    <annotation>
                        <documentation>Specifies the actual uses of the
GenericUnoccupiedSpace.</documentation>
                    </annotation>
```

```xml
          </element>
          <element maxOccurs="unbounded" minOccurs="0"
name="adeOfGenericUnoccupiedSpace" type="gen:ADEOfGenericUnoccupiedSpacePropertyType">
            <annotation>
              <documentation>Augments the GenericUnoccupiedSpace with properties
defined in an ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="GenericUnoccupiedSpacePropertyType">
    <sequence minOccurs="0">
      <element ref="gen:GenericUnoccupiedSpace"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="IntAttribute" substitutionGroup="core:AbstractGenericAttribute"
type="gen:IntAttributeType">
    <annotation>
      <documentation>IntAttribute is a data type used to define generic attributes of
type "Integer".</documentation>
    </annotation>
  </element>
  <complexType name="IntAttributeType">
    <complexContent>
      <extension base="core:AbstractGenericAttributeType">
        <sequence>
          <element name="name" type="string">
            <annotation>
              <documentation>Specifies the name of the IntAttribute.</documentation>
            </annotation>
          </element>
          <element name="value" type="integer">
            <annotation>
              <documentation>Specifies the "Integer" value.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="IntAttributePropertyType">
    <sequence>
      <element ref="gen:IntAttribute"/>
    </sequence>
  </complexType>
  <element name="MeasureAttribute" substitutionGroup="core:AbstractGenericAttribute"
type="gen:MeasureAttributeType">
```

```xml
      <annotation>
        <documentation>MeasureAttribute is a data type used to define generic attributes
of type "Measure".</documentation>
      </annotation>
    </element>
  <complexType name="MeasureAttributeType">
    <complexContent>
      <extension base="core:AbstractGenericAttributeType">
        <sequence>
          <element name="name" type="string">
            <annotation>
              <documentation>Specifies the name of the
MeasureAttribute.</documentation>
            </annotation>
          </element>
          <element name="value" type="gml:MeasureType">
            <annotation>
              <documentation>Specifies the value of the MeasureAttribute. The value is
of type "Measure", which can additionally provide the units of measure. [cf. ISO
19103]</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="MeasureAttributePropertyType">
    <sequence>
      <element ref="gen:MeasureAttribute"/>
    </sequence>
  </complexType>
  <element name="StringAttribute" substitutionGroup="core:AbstractGenericAttribute"
type="gen:StringAttributeType">
    <annotation>
      <documentation>StringAttribute is a data type used to define generic attributes
of type "String".</documentation>
    </annotation>
  </element>
  <complexType name="StringAttributeType">
    <complexContent>
      <extension base="core:AbstractGenericAttributeType">
        <sequence>
          <element name="name" type="string">
            <annotation>
              <documentation>Specifies the name of the
StringAttribute.</documentation>
            </annotation>
          </element>
          <element name="value" type="string">
            <annotation>
              <documentation>Specifies the "String" value.</documentation>
```

```
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="StringAttributePropertyType">
    <sequence>
      <element ref="gen:StringAttribute"/>
    </sequence>
  </complexType>
  <element name="UriAttribute" substitutionGroup="core:AbstractGenericAttribute"
type="gen:UriAttributeType">
    <annotation>
      <documentation>UriAttribute is a data type used to define generic attributes of
type "URI".</documentation>
    </annotation>
  </element>
  <complexType name="UriAttributeType">
    <complexContent>
      <extension base="core:AbstractGenericAttributeType">
        <sequence>
          <element name="name" type="string">
            <annotation>
              <documentation>Specifies the name of the UriAttribute.</documentation>
            </annotation>
          </element>
          <element name="value" type="anyURI">
            <annotation>
              <documentation>Specifies the "URI" value.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="UriAttributePropertyType">
    <sequence>
      <element ref="gen:UriAttribute"/>
    </sequence>
  </complexType>
</schema>
```

C.10. Land Use module

The CityGML Land Use module is defined in the XML Schema Definition file *landUse.xsd* (Listing 17). The target namespace http://www.opengis.net/citygml/landuse/3.0 is associated with this module.

Listing 17. landUse.xsd

```xml
<?xml version="1.0" encoding="UTF-8"?><schema xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:core="http://www.opengis.net/citygml/3.0"
xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:luse="http://www.opengis.net/citygml/landuse/3.0" elementFormDefault="qualified"
targetNamespace="http://www.opengis.net/citygml/landuse/3.0" version="3.0.0">
  <annotation>
    <documentation>The LandUse module supports representation of areas of the earth□s
surface dedicated to a specific land use.</documentation>
  </annotation>
  <import namespace="http://www.opengis.net/citygml/3.0" schemaLocation="./core.xsd"/>
  <import namespace="http://www.opengis.net/gml/3.2"
schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd"/>
  <!--XML Schema document created by ShapeChange - http://shapechange.net/-->
  <element abstract="true" name="ADEOfLandUse" substitutionGroup="gml:AbstractObject"
type="luse:ADEOfLandUseType">
    <annotation>
      <documentation>ADEOfLandUse acts as a hook to define properties within an ADE
that are to be added to a LandUse.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfLandUseType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfLandUsePropertyType">
    <sequence>
      <element ref="luse:ADEOfLandUse"/>
    </sequence>
  </complexType>
  <element name="LandUse" substitutionGroup="core:AbstractThematicSurface"
type="luse:LandUseType">
    <annotation>
      <documentation>A LandUse object is an area of the earth's surface dedicated to a
specific land use or having a specific land cover with or without vegetation, such as
sand, rock, mud flats, forest, grasslands, or wetlands.</documentation>
    </annotation>
  </element>
  <complexType name="LandUseType">
    <complexContent>
      <extension base="core:AbstractThematicSurfaceType">
        <sequence>
          <element minOccurs="0" name="class" type="gml:CodeType">
            <annotation>
              <documentation>Indicates the specific type of the
LandUse.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the intended purposes of the
```

```
LandUse.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the actual uses of the LandUse.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfLandUse"
type="luse:ADEOfLandUsePropertyType">
            <annotation>
              <documentation>Augments the LandUse with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="LandUsePropertyType">
    <sequence minOccurs="0">
      <element ref="luse:LandUse"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
</schema>
```

C.11. Point Cloud module

The CityGML Point Cloud module is defined in the XML Schema Definition file *pointCloud.xsd*
(Listing 18). The target namespace http://www.opengis.net/citygml/pointcloud/3.0 is associated with
this module.

Listing 18. pointCloud.xsd

```
<?xml version="1.0" encoding="UTF-8"?><schema xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:core="http://www.opengis.net/citygml/3.0"
xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:pcl="http://www.opengis.net/citygml/pointcloud/3.0"
elementFormDefault="qualified"
targetNamespace="http://www.opengis.net/citygml/pointcloud/3.0" version="3.0.0">
  <annotation>
    <documentation>The PointCloud module supports representation of CityGML features
by a collection of points.</documentation>
  </annotation>
  <import namespace="http://www.opengis.net/citygml/3.0" schemaLocation="./core.xsd"/>
  <import namespace="http://www.opengis.net/gml/3.2"
schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd"/>
```

```xml
<!--XML Schema document created by ShapeChange - http://shapechange.net/-->
<element abstract="true" name="ADEOfPointCloud"
substitutionGroup="gml:AbstractObject" type="pcl:ADEOfPointCloudType">
  <annotation>
    <documentation>ADEOfPointCloud acts as a hook to define properties within an ADE
that are to be added to a PointCloud.</documentation>
  </annotation>
</element>
<complexType abstract="true" name="ADEOfPointCloudType">
  <sequence/>
</complexType>
<complexType name="ADEOfPointCloudPropertyType">
  <sequence>
    <element ref="pcl:ADEOfPointCloud"/>
  </sequence>
</complexType>
<element name="PointCloud" substitutionGroup="core:AbstractPointCloud"
type="pcl:PointCloudType">
  <annotation>
    <documentation>A PointCloud is an unordered collection of points that is a
sampling of the geometry of a space or space boundary.</documentation>
  </annotation>
</element>
<complexType name="PointCloudType">
  <complexContent>
    <extension base="core:AbstractPointCloudType">
      <sequence>
        <element minOccurs="0" name="mimeType" type="gml:CodeType">
          <annotation>
            <documentation>Specifies the MIME type of the external point cloud
file.</documentation>
          </annotation>
        </element>
        <element minOccurs="0" name="pointFile" type="anyURI">
          <annotation>
            <documentation>Specifies the URI that points to the external point cloud
file.</documentation>
          </annotation>
        </element>
        <element minOccurs="0" name="pointFileSrsName" type="string">
          <annotation>
            <documentation>Indicates the coordinate reference system used by the
external point cloud file.</documentation>
          </annotation>
        </element>
        <element minOccurs="0" name="points" type="gml:MultiPointPropertyType">
          <annotation>
            <documentation>Relates to the 3D MultiPoint geometry of the PointCloud
stored inline with the city model.</documentation>
          </annotation>
        </element>
```

```
            <element maxOccurs="unbounded" minOccurs="0" name="adeOfPointCloud"
type="pcl:ADEOfPointCloudPropertyType">
              <annotation>
                <documentation>Augments the PointCloud with properties defined in an
ADE.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
    </complexType>
    <complexType name="PointCloudPropertyType">
      <sequence minOccurs="0">
        <element ref="pcl:PointCloud"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
</schema>
```

C.12. Relief module

The CityGML Relief module is defined in the XML Schema Definition file *relief.xsd* (Listing 19). The target namespace http://www.opengis.net/citygml/relief/3.0 is associated with this module.

Listing 19. relief.xsd

```
<?xml version="1.0" encoding="UTF-8"?><schema xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:core="http://www.opengis.net/citygml/3.0"
xmlns:dem="http://www.opengis.net/citygml/relief/3.0"
xmlns:gml="http://www.opengis.net/gml/3.2" elementFormDefault="qualified"
targetNamespace="http://www.opengis.net/citygml/relief/3.0" version="3.0.0">
  <annotation>
    <documentation>The Relief module supports representation of the terrain. CityGML
supports terrain representations at different levels of detail, reflecting different
accuracies or resolutions. Terrain may be specified as a regular raster or grid, as a
TIN, by break lines, and/or by mass points.</documentation>
  </annotation>
  <import namespace="http://www.opengis.net/citygml/3.0" schemaLocation="./core.xsd"/>
  <import namespace="http://www.opengis.net/gml/3.2"
schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd"/>
  <!--XML Schema document created by ShapeChange - http://shapechange.net/-->
  <element abstract="true" name="ADEOfAbstractReliefComponent"
substitutionGroup="gml:AbstractObject" type="dem:ADEOfAbstractReliefComponentType">
    <annotation>
      <documentation>ADEOfAbstractReliefComponent acts as a hook to define properties
within an ADE that are to be added to AbstractReliefComponent.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAbstractReliefComponentType">
```

```xml
      <sequence/>
    </complexType>
    <complexType name="ADEOfAbstractReliefComponentPropertyType">
      <sequence>
        <element ref="dem:ADEOfAbstractReliefComponent"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfBreaklineRelief"
substitutionGroup="gml:AbstractObject" type="dem:ADEOfBreaklineReliefType">
      <annotation>
        <documentation>ADEOfBreaklineRelief acts as a hook to define properties within
an ADE that are to be added to a BreaklineRelief.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfBreaklineReliefType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfBreaklineReliefPropertyType">
      <sequence>
        <element ref="dem:ADEOfBreaklineRelief"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfMassPointRelief"
substitutionGroup="gml:AbstractObject" type="dem:ADEOfMassPointReliefType">
      <annotation>
        <documentation>ADEOfMassPointRelief acts as a hook to define properties within
an ADE that are to be added to a MassPointRelief.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfMassPointReliefType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfMassPointReliefPropertyType">
      <sequence>
        <element ref="dem:ADEOfMassPointRelief"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfRasterRelief"
substitutionGroup="gml:AbstractObject" type="dem:ADEOfRasterReliefType">
      <annotation>
        <documentation>ADEOfRasterRelief acts as a hook to define properties within an
ADE that are to be added to a RasterRelief.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfRasterReliefType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfRasterReliefPropertyType">
      <sequence>
        <element ref="dem:ADEOfRasterRelief"/>
      </sequence>
```

```xml
      </complexType>
  <element abstract="true" name="ADEOfReliefFeature"
substitutionGroup="gml:AbstractObject" type="dem:ADEOfReliefFeatureType">
    <annotation>
      <documentation>ADEOfReliefFeature acts as a hook to define properties within an
ADE that are to be added to a ReliefFeature.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfReliefFeatureType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfReliefFeaturePropertyType">
    <sequence>
      <element ref="dem:ADEOfReliefFeature"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfTINRelief"
substitutionGroup="gml:AbstractObject" type="dem:ADEOfTINReliefType">
    <annotation>
      <documentation>ADEOfTINRelief acts as a hook to define properties within an ADE
that are to be added to a TINRelief.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfTINReliefType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfTINReliefPropertyType">
    <sequence>
      <element ref="dem:ADEOfTINRelief"/>
    </sequence>
  </complexType>
  <element abstract="true" name="AbstractReliefComponent"
substitutionGroup="core:AbstractSpaceBoundary" type="dem:AbstractReliefComponentType">
    <annotation>
      <documentation>An AbstractReliefComponent represents an element of the terrain
surface - either a TIN, a raster or grid, mass points or break lines.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="AbstractReliefComponentType">
    <complexContent>
      <extension base="core:AbstractSpaceBoundaryType">
        <sequence>
          <element name="lod" type="core:IntegerBetween0and3Type">
            <annotation>
              <documentation>Indicates the Level of Detail of the terrain
component.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="extent" type="gml:SurfacePropertyType">
            <annotation>
              <documentation>Indicates the geometrical extent of the terrain
```

```xml
component. The geometrical extent is provided as a 2D Surface
geometry.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0"
name="adeOfAbstractReliefComponent"
type="dem:ADEOfAbstractReliefComponentPropertyType">
            <annotation>
              <documentation>Augments AbstractReliefComponent with properties defined
in an ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="AbstractReliefComponentPropertyType">
    <sequence minOccurs="0">
      <element ref="dem:AbstractReliefComponent"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="BreaklineRelief" substitutionGroup="dem:AbstractReliefComponent"
type="dem:BreaklineReliefType">
    <annotation>
      <documentation>A BreaklineRelief represents a terrain component with 3D lines.
These lines denote break lines or ridge/valley lines.</documentation>
    </annotation>
  </element>
  <complexType name="BreaklineReliefType">
    <complexContent>
      <extension base="dem:AbstractReliefComponentType">
        <sequence>
          <element minOccurs="0" name="ridgeOrValleyLines"
type="gml:MultiCurvePropertyType">
            <annotation>
              <documentation>Relates to the 3D MultiCurve geometry of the
MassPointRelief. This association role is used to represent ridge or valley
lines.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="breaklines" type="gml:MultiCurvePropertyType">
            <annotation>
              <documentation>Relates to the 3D MultiCurve geometry of the
MassPointRelief. This association role is used to represent break
lines.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfBreaklineRelief"
type="dem:ADEOfBreaklineReliefPropertyType">
```

```
            <annotation>
              <documentation>Augments the BreaklineRelief with properties defined in
an ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="BreaklineReliefPropertyType">
    <sequence minOccurs="0">
      <element ref="dem:BreaklineRelief"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="MassPointRelief" substitutionGroup="dem:AbstractReliefComponent"
type="dem:MassPointReliefType">
    <annotation>
      <documentation>A MassPointRelief represents a terrain component as a collection
of 3D points.</documentation>
    </annotation>
  </element>
  <complexType name="MassPointReliefType">
    <complexContent>
      <extension base="dem:AbstractReliefComponentType">
        <sequence>
          <element minOccurs="0" name="reliefPoints"
type="gml:MultiPointPropertyType">
            <annotation>
              <documentation>Relates to the 3D MultiPoint geometry of the
MassPointRelief.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="pointCloud"
type="core:AbstractPointCloudPropertyType">
            <annotation>
              <documentation>Relates to the 3D PointCloud of the
MassPointRelief.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfMassPointRelief"
type="dem:ADEOfMassPointReliefPropertyType">
            <annotation>
              <documentation>Augments the MassPointRelief with properties defined in
an ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
```

```xml
      </complexType>
      <complexType name="MassPointReliefPropertyType">
        <sequence minOccurs="0">
          <element ref="dem:MassPointRelief"/>
        </sequence>
        <attributeGroup ref="gml:AssociationAttributeGroup"/>
        <attributeGroup ref="gml:OwnershipAttributeGroup"/>
      </complexType>
      <element name="RasterRelief" substitutionGroup="dem:AbstractReliefComponent"
  type="dem:RasterReliefType">
        <annotation>
          <documentation>A RasterRelief represents a terrain component as a regular raster
  or grid.</documentation>
        </annotation>
      </element>
      <complexType name="RasterReliefType">
        <complexContent>
          <extension base="dem:AbstractReliefComponentType">
            <sequence>
              <element name="grid">
                <annotation>
                  <documentation>Relates to the DiscreteGridPointCoverage of the
  RasterRelief.</documentation>
                </annotation>
                <complexType>
                  <sequence minOccurs="0">
                    <element ref="gml:RectifiedGridCoverage"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                  <attributeGroup ref="gml:OwnershipAttributeGroup"/>
                </complexType>
              </element>
              <element maxOccurs="unbounded" minOccurs="0" name="adeOfRasterRelief"
  type="dem:ADEOfRasterReliefPropertyType">
                <annotation>
                  <documentation>Augments the RasterRelief with properties defined in an
  ADE.</documentation>
                </annotation>
              </element>
            </sequence>
          </extension>
        </complexContent>
      </complexType>
      <complexType name="RasterReliefPropertyType">
        <sequence minOccurs="0">
          <element ref="dem:RasterRelief"/>
        </sequence>
        <attributeGroup ref="gml:AssociationAttributeGroup"/>
        <attributeGroup ref="gml:OwnershipAttributeGroup"/>
      </complexType>
      <element name="ReliefFeature" substitutionGroup="core:AbstractSpaceBoundary"
```

```
type="dem:ReliefFeatureType">
    <annotation>
      <documentation>A ReliefFeature is a collection of terrain components
representing the Earth's surface, also known as the Digital Terrain
Model.</documentation>
    </annotation>
  </element>
  <complexType name="ReliefFeatureType">
    <complexContent>
      <extension base="core:AbstractSpaceBoundaryType">
        <sequence>
          <element name="lod" type="core:IntegerBetween0and3Type">
            <annotation>
              <documentation>Indicates the Level of Detail of the
ReliefFeature.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" name="reliefComponent">
            <annotation>
              <documentation>Relates to the terrain components that are part of the
ReliefFeature.</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
                    <element ref="dem:AbstractReliefComponent"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfReliefFeature"
type="dem:ADEOfReliefFeaturePropertyType">
            <annotation>
              <documentation>Augments the ReliefFeature with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="ReliefFeaturePropertyType">
    <sequence minOccurs="0">
      <element ref="dem:ReliefFeature"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
```

```
  <element name="TINRelief" substitutionGroup="dem:AbstractReliefComponent"
type="dem:TINReliefType">
    <annotation>
      <documentation>A TINRelief represents a terrain component as a triangulated
irregular network.</documentation>
    </annotation>
  </element>
  <complexType name="TINReliefType">
    <complexContent>
      <extension base="dem:AbstractReliefComponentType">
        <sequence>
          <element name="tin">
            <annotation>
              <documentation>Relates to the triangulated surface of the
TINRelief.</documentation>
            </annotation>
            <complexType>
              <sequence minOccurs="0">
                <element ref="gml:TriangulatedSurface"/>
              </sequence>
              <attributeGroup ref="gml:AssociationAttributeGroup"/>
              <attributeGroup ref="gml:OwnershipAttributeGroup"/>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfTINRelief"
type="dem:ADEOfTINReliefPropertyType">
            <annotation>
              <documentation>Augments the TINRelief with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="TINReliefPropertyType">
    <sequence minOccurs="0">
      <element ref="dem:TINRelief"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
</schema>
```

C.13. Transportation module

The CityGML Transportation module is defined in the XML Schema Definition file *transportation.xsd* (Listing 20). The target namespace http://www.opengis.net/citygml/transportation/3.0 is associated with this module.

Listing 20. transportation.xsd

```xml
<?xml version="1.0" encoding="UTF-8"?><schema xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:core="http://www.opengis.net/citygml/3.0"
xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:tran="http://www.opengis.net/citygml/transportation/3.0"
elementFormDefault="qualified"
targetNamespace="http://www.opengis.net/citygml/transportation/3.0" version="3.0.0">
  <annotation>
    <documentation>The Transportation module supports representation of the
transportation infrastructure. Transportation features include roads, tracks,
waterways, railways, and squares. Transportation features may be represented as a
network and/or as a collection of spaces or surface elements embedded in a three-
dimensional space.</documentation>
  </annotation>
  <import namespace="http://www.opengis.net/citygml/3.0" schemaLocation="./core.xsd"/>
  <import namespace="http://www.opengis.net/gml/3.2"
schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd"/>
  <!--XML Schema document created by ShapeChange - http://shapechange.net/-->
  <element abstract="true" name="ADEOfAbstractTransportationSpace"
substitutionGroup="gml:AbstractObject"
type="tran:ADEOfAbstractTransportationSpaceType">
    <annotation>
      <documentation>ADEOfAbstractTransportationSpace acts as a hook to define
properties within an ADE that are to be added to
AbstractTransportationSpace.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAbstractTransportationSpaceType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfAbstractTransportationSpacePropertyType">
    <sequence>
      <element ref="tran:ADEOfAbstractTransportationSpace"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfAuxiliaryTrafficArea"
substitutionGroup="gml:AbstractObject" type="tran:ADEOfAuxiliaryTrafficAreaType">
    <annotation>
      <documentation>ADEOfAuxiliaryTrafficArea acts as a hook to define properties
within an ADE that are to be added to an AuxiliaryTrafficArea.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAuxiliaryTrafficAreaType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfAuxiliaryTrafficAreaPropertyType">
    <sequence>
      <element ref="tran:ADEOfAuxiliaryTrafficArea"/>
    </sequence>
  </complexType>
```

```xml
  <element abstract="true" name="ADEOfAuxiliaryTrafficSpace"
substitutionGroup="gml:AbstractObject" type="tran:ADEOfAuxiliaryTrafficSpaceType">
    <annotation>
      <documentation>ADEOfAuxiliaryTrafficSpace acts as a hook to define properties
within an ADE that are to be added to an AuxiliaryTrafficSpace.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAuxiliaryTrafficSpaceType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfAuxiliaryTrafficSpacePropertyType">
    <sequence>
      <element ref="tran:ADEOfAuxiliaryTrafficSpace"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfClearanceSpace"
substitutionGroup="gml:AbstractObject" type="tran:ADEOfClearanceSpaceType">
    <annotation>
      <documentation>ADEOfClearanceSpace acts as a hook to define properties within an
ADE that are to be added to a ClearanceSpace.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfClearanceSpaceType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfClearanceSpacePropertyType">
    <sequence>
      <element ref="tran:ADEOfClearanceSpace"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfHole" substitutionGroup="gml:AbstractObject"
type="tran:ADEOfHoleType">
    <annotation>
      <documentation>ADEOfHole acts as a hook to define properties within an ADE that
are to be added to a Hole.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfHoleType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfHolePropertyType">
    <sequence>
      <element ref="tran:ADEOfHole"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfHoleSurface"
substitutionGroup="gml:AbstractObject" type="tran:ADEOfHoleSurfaceType">
    <annotation>
      <documentation>ADEOfHoleSurface acts as a hook to define properties within an
ADE that are to be added to a HoleSurface.</documentation>
    </annotation>
```

```
    </element>
    <complexType abstract="true" name="ADEOfHoleSurfaceType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfHoleSurfacePropertyType">
      <sequence>
        <element ref="tran:ADEOfHoleSurface"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfIntersection"
substitutionGroup="gml:AbstractObject" type="tran:ADEOfIntersectionType">
      <annotation>
        <documentation>ADEOfIntersection acts as a hook to define properties within an
ADE that are to be added to an Intersection.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfIntersectionType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfIntersectionPropertyType">
      <sequence>
        <element ref="tran:ADEOfIntersection"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfMarking" substitutionGroup="gml:AbstractObject"
type="tran:ADEOfMarkingType">
      <annotation>
        <documentation>ADEOfMarking acts as a hook to define properties within an ADE
that are to be added to a Marking.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfMarkingType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfMarkingPropertyType">
      <sequence>
        <element ref="tran:ADEOfMarking"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfRailway" substitutionGroup="gml:AbstractObject"
type="tran:ADEOfRailwayType">
      <annotation>
        <documentation>ADEOfRailway acts as a hook to define properties within an ADE
that are to be added to a Railway.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfRailwayType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfRailwayPropertyType">
      <sequence>
```

```xml
      <element ref="tran:ADEOfRailway"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfRoad" substitutionGroup="gml:AbstractObject"
type="tran:ADEOfRoadType">
    <annotation>
      <documentation>ADEOfRoad acts as a hook to define properties within an ADE that
are to be added to a Road.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfRoadType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfRoadPropertyType">
    <sequence>
      <element ref="tran:ADEOfRoad"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfSection" substitutionGroup="gml:AbstractObject"
type="tran:ADEOfSectionType">
    <annotation>
      <documentation>ADEOfSection acts as a hook to define properties within an ADE
that are to be added to a Section.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfSectionType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfSectionPropertyType">
    <sequence>
      <element ref="tran:ADEOfSection"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfSquare" substitutionGroup="gml:AbstractObject"
type="tran:ADEOfSquareType">
    <annotation>
      <documentation>ADEOfSquare acts as a hook to define properties within an ADE
that are to be added to a Square.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfSquareType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfSquarePropertyType">
    <sequence>
      <element ref="tran:ADEOfSquare"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfTrack" substitutionGroup="gml:AbstractObject"
type="tran:ADEOfTrackType">
    <annotation>
```

```
          <documentation>ADEOfTrack acts as a hook to define properties within an ADE that
are to be added to a Track.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfTrackType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfTrackPropertyType">
    <sequence>
      <element ref="tran:ADEOfTrack"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfTrafficArea"
substitutionGroup="gml:AbstractObject" type="tran:ADEOfTrafficAreaType">
    <annotation>
      <documentation>ADEOfTrafficArea acts as a hook to define properties within an
ADE that are to be added to a TrafficArea.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfTrafficAreaType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfTrafficAreaPropertyType">
    <sequence>
      <element ref="tran:ADEOfTrafficArea"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfTrafficSpace"
substitutionGroup="gml:AbstractObject" type="tran:ADEOfTrafficSpaceType">
    <annotation>
      <documentation>ADEOfTrafficSpace acts as a hook to define properties within an
ADE that are to be added to a TrafficSpace.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfTrafficSpaceType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfTrafficSpacePropertyType">
    <sequence>
      <element ref="tran:ADEOfTrafficSpace"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfWaterway" substitutionGroup="gml:AbstractObject"
type="tran:ADEOfWaterwayType">
    <annotation>
      <documentation>ADEOfWaterway acts as a hook to define properties within an ADE
that are to be added to a Waterway.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfWaterwayType">
    <sequence/>
```

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    </complexType>
    <complexType name="ADEOfWaterwayPropertyType">
      <sequence>
        <element ref="tran:ADEOfWaterway"/>
      </sequence>
    </complexType>
    <element abstract="true" name="AbstractTransportationSpace"
substitutionGroup="core:AbstractUnoccupiedSpace"
type="tran:AbstractTransportationSpaceType">
      <annotation>
        <documentation>AbstractTransportationSpace is the abstract superclass of
transportation objects such as Roads, Tracks, Railways, Waterways or
Squares.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="AbstractTransportationSpaceType">
      <complexContent>
        <extension base="core:AbstractUnoccupiedSpaceType">
          <sequence>
            <element minOccurs="0" name="trafficDirection"
type="tran:TrafficDirectionValueType">
              <annotation>
                <documentation>Indicates the direction of traffic flow relative to the
corresponding linear geometry representation.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="occupancy"
type="core:OccupancyPropertyType">
              <annotation>
                <documentation>Provides information on the residency of persons,
vehicles, or other moving features in the transportation space.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="trafficSpace">
              <annotation>
                <documentation>Relates to the traffic spaces that are part of the
transportation space.</documentation>
              </annotation>
              <complexType>
                <complexContent>
                  <extension base="gml:AbstractFeatureMemberType">
                    <sequence minOccurs="0">
                      <element ref="tran:TrafficSpace"/>
                    </sequence>
                    <attributeGroup ref="gml:AssociationAttributeGroup"/>
                  </extension>
                </complexContent>
              </complexType>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="auxiliaryTrafficSpace">
              <annotation>
```

```xml
            <documentation>Relates to the auxiliary traffic spaces that are part of
the transportation space.</documentation>
          </annotation>
          <complexType>
            <complexContent>
              <extension base="gml:AbstractFeatureMemberType">
                <sequence minOccurs="0">
                  <element ref="tran:AuxiliaryTrafficSpace"/>
                </sequence>
                <attributeGroup ref="gml:AssociationAttributeGroup"/>
              </extension>
            </complexContent>
          </complexType>
        </element>
        <element maxOccurs="unbounded" minOccurs="0" name="hole">
          <annotation>
            <documentation>Relates to the holes that are part of the transportation
space.</documentation>
          </annotation>
          <complexType>
            <complexContent>
              <extension base="gml:AbstractFeatureMemberType">
                <sequence minOccurs="0">
                  <element ref="tran:Hole"/>
                </sequence>
                <attributeGroup ref="gml:AssociationAttributeGroup"/>
              </extension>
            </complexContent>
          </complexType>
        </element>
        <element maxOccurs="unbounded" minOccurs="0" name="marking">
          <annotation>
            <documentation>Relates to the markings that are part of the
transportation space.</documentation>
          </annotation>
          <complexType>
            <complexContent>
              <extension base="gml:AbstractFeatureMemberType">
                <sequence minOccurs="0">
                  <element ref="tran:Marking"/>
                </sequence>
                <attributeGroup ref="gml:AssociationAttributeGroup"/>
              </extension>
            </complexContent>
          </complexType>
        </element>
        <element maxOccurs="unbounded" minOccurs="0"
name="adeOfAbstractTransportationSpace"
type="tran:ADEOfAbstractTransportationSpacePropertyType">
          <annotation>
            <documentation>Augments AbstractTransportationSpace with properties
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defined in an ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="AbstractTransportationSpacePropertyType">
    <sequence minOccurs="0">
      <element ref="tran:AbstractTransportationSpace"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="AuxiliaryTrafficArea"
substitutionGroup="core:AbstractThematicSurface" type="tran:AuxiliaryTrafficAreaType">
    <annotation>
      <documentation>An AuxiliaryTrafficArea is the ground surface of an
AuxiliaryTrafficSpace.</documentation>
    </annotation>
  </element>
  <complexType name="AuxiliaryTrafficAreaType">
    <complexContent>
      <extension base="core:AbstractThematicSurfaceType">
        <sequence>
          <element minOccurs="0" name="class" type="gml:CodeType">
            <annotation>
              <documentation>Indicates the specific type of the
AuxiliaryTrafficArea.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the intended purposes of the
AuxiliaryTrafficArea.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the actual uses of the
AuxiliaryTrafficArea.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="surfaceMaterial" type="gml:CodeType">
            <annotation>
              <documentation>Specifies the type of pavement of the
AuxiliaryTrafficArea.</documentation>
            </annotation>
          </element>
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            <element maxOccurs="unbounded" minOccurs="0"
name="adeOfAuxiliaryTrafficArea" type="tran:ADEOfAuxiliaryTrafficAreaPropertyType">
              <annotation>
                <documentation>Augments the AuxiliaryTrafficArea with properties defined
in an ADE.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
    </complexType>
    <complexType name="AuxiliaryTrafficAreaPropertyType">
      <sequence minOccurs="0">
        <element ref="tran:AuxiliaryTrafficArea"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <element name="AuxiliaryTrafficSpace"
substitutionGroup="core:AbstractUnoccupiedSpace"
type="tran:AuxiliaryTrafficSpaceType">
      <annotation>
        <documentation>An AuxiliaryTrafficSpace is a space within the transportation
space not intended for traffic purposes.</documentation>
      </annotation>
    </element>
    <complexType name="AuxiliaryTrafficSpaceType">
      <complexContent>
        <extension base="core:AbstractUnoccupiedSpaceType">
          <sequence>
            <element minOccurs="0" name="class" type="gml:CodeType">
              <annotation>
                <documentation>Indicates the specific type of the
AuxiliaryTrafficSpace.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the intended purposes of the
AuxiliaryTrafficSpace.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the actual uses of the
AuxiliaryTrafficSpace.</documentation>
              </annotation>
            </element>
            <element name="granularity" type="tran:GranularityValueType">
```

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            <annotation>
              <documentation>Defines whether auxiliary traffic spaces are represented
by individual ways or by individual lanes, depending on the desired level of spatial
and semantic decomposition.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0"
name="adeOfAuxiliaryTrafficSpace" type="tran:ADEOfAuxiliaryTrafficSpacePropertyType">
            <annotation>
              <documentation>Augments the AuxiliaryTrafficSpace with properties
defined in an ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="AuxiliaryTrafficSpacePropertyType">
    <sequence minOccurs="0">
      <element ref="tran:AuxiliaryTrafficSpace"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="ClearanceSpace" substitutionGroup="core:AbstractUnoccupiedSpace"
type="tran:ClearanceSpaceType">
    <annotation>
      <documentation>A ClearanceSpace represents the actual free space above a
TrafficArea within which a mobile object can move without contacting an
obstruction.</documentation>
    </annotation>
  </element>
  <complexType name="ClearanceSpaceType">
    <complexContent>
      <extension base="core:AbstractUnoccupiedSpaceType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="class"
type="gml:CodeType">
            <annotation>
              <documentation>Indicates the specific type of the
ClearanceSpace.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfClearanceSpace"
type="tran:ADEOfClearanceSpacePropertyType">
            <annotation>
              <documentation>Augments the ClearanceSpace with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
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          </extension>
      </complexContent>
    </complexType>
    <complexType name="ClearanceSpacePropertyType">
      <sequence minOccurs="0">
        <element ref="tran:ClearanceSpace"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <simpleType name="GranularityValueType">
      <annotation>
        <documentation>GranularityValue enumerates the different levels of granularity
in which transportation objects are represented.</documentation>
      </annotation>
      <restriction base="string">
        <enumeration value="lane">
          <annotation>
            <documentation>Indicates that the individual lanes of the transportation
object are represented.</documentation>
          </annotation>
        </enumeration>
        <enumeration value="way">
          <annotation>
            <documentation>Indicates that the individual (carriage)ways of the
transportation object are represented.</documentation>
          </annotation>
        </enumeration>
      </restriction>
    </simpleType>
    <element name="Hole" substitutionGroup="core:AbstractUnoccupiedSpace"
type="tran:HoleType">
      <annotation>
        <documentation>A Hole is an opening in the surface of a Road, Track or Square
such as road damages, manholes or drains. Holes can span multiple transportation
objects.</documentation>
      </annotation>
    </element>
    <complexType name="HoleType">
      <complexContent>
        <extension base="core:AbstractUnoccupiedSpaceType">
          <sequence>
            <element minOccurs="0" name="class" type="gml:CodeType">
              <annotation>
                <documentation>Indicates the specific type of the Hole.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="adeOfHole"
type="tran:ADEOfHolePropertyType">
              <annotation>
                <documentation>Augments the Hole with properties defined in an
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ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="HolePropertyType">
    <sequence minOccurs="0">
      <element ref="tran:Hole"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="HoleSurface" substitutionGroup="core:AbstractThematicSurface"
type="tran:HoleSurfaceType">
    <annotation>
      <documentation>A HoleSurface is a representation of the ground surface of a
hole.</documentation>
    </annotation>
  </element>
  <complexType name="HoleSurfaceType">
    <complexContent>
      <extension base="core:AbstractThematicSurfaceType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfHoleSurface"
type="tran:ADEOfHoleSurfacePropertyType">
            <annotation>
              <documentation>Augments the HoleSurface with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="HoleSurfacePropertyType">
    <sequence minOccurs="0">
      <element ref="tran:HoleSurface"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="Intersection" substitutionGroup="tran:AbstractTransportationSpace"
type="tran:IntersectionType">
    <annotation>
      <documentation>An Intersection is a transportation space that is a shared
segment of multiple Road, Track, Railway, or Waterway objects (e.g. a crossing of two
roads or a level crossing of a road and a railway).</documentation>
    </annotation>
  </element>
```

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  <complexType name="IntersectionType">
    <complexContent>
      <extension base="tran:AbstractTransportationSpaceType">
        <sequence>
          <element minOccurs="0" name="class" type="gml:CodeType">
            <annotation>
              <documentation>Indicates the specific type of the
Intersection.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfIntersection"
type="tran:ADEOfIntersectionPropertyType">
            <annotation>
              <documentation>Augments the Intersection with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="IntersectionPropertyType">
    <sequence minOccurs="0">
      <element ref="tran:Intersection"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="Marking" substitutionGroup="core:AbstractThematicSurface"
type="tran:MarkingType">
    <annotation>
      <documentation>A Marking is a visible pattern on a transportation area relevant
to the structuring or restriction of traffic. Examples are road markings and markings
related to railway or waterway traffic.</documentation>
    </annotation>
  </element>
  <complexType name="MarkingType">
    <complexContent>
      <extension base="core:AbstractThematicSurfaceType">
        <sequence>
          <element minOccurs="0" name="class" type="gml:CodeType">
            <annotation>
              <documentation>Indicates the specific type of the
Marking.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfMarking"
type="tran:ADEOfMarkingPropertyType">
            <annotation>
              <documentation>Augments the Marking with properties defined in an
ADE.</documentation>
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            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="MarkingPropertyType">
    <sequence minOccurs="0">
      <element ref="tran:Marking"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="Railway" substitutionGroup="tran:AbstractTransportationSpace"
type="tran:RailwayType">
    <annotation>
      <documentation>A Railway is a transportation space used by wheeled vehicles on
rails.</documentation>
    </annotation>
  </element>
  <complexType name="RailwayType">
    <complexContent>
      <extension base="tran:AbstractTransportationSpaceType">
        <sequence>
          <element minOccurs="0" name="class" type="gml:CodeType">
            <annotation>
              <documentation>Indicates the specific type of the
Railway.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the intended purposes of the
Railway.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the actual uses of the Railway.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="section">
            <annotation>
              <documentation>Relates to the sections that are part of the
Railway.</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
```

```xml
                    <sequence minOccurs="0">
                      <element ref="tran:Section"/>
                    </sequence>
                    <attributeGroup ref="gml:AssociationAttributeGroup"/>
                  </extension>
                </complexContent>
              </complexType>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="intersection">
              <annotation>
                <documentation>Relates to the intersections that are part of the
Railway.</documentation>
              </annotation>
              <complexType>
                <complexContent>
                  <extension base="gml:AbstractFeatureMemberType">
                    <sequence minOccurs="0">
                      <element ref="tran:Intersection"/>
                    </sequence>
                    <attributeGroup ref="gml:AssociationAttributeGroup"/>
                  </extension>
                </complexContent>
              </complexType>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="adeOfRailway"
type="tran:ADEOfRailwayPropertyType">
              <annotation>
                <documentation>Augments the Railway with properties defined in an
ADE.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
    </complexType>
    <complexType name="RailwayPropertyType">
      <sequence minOccurs="0">
        <element ref="tran:Railway"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <element name="Road" substitutionGroup="tran:AbstractTransportationSpace"
type="tran:RoadType">
      <annotation>
        <documentation>A Road is a transportation space used by vehicles, bicycles
and/or pedestrians.</documentation>
      </annotation>
    </element>
    <complexType name="RoadType">
      <complexContent>
```

```xml
      <extension base="tran:AbstractTransportationSpaceType">
        <sequence>
          <element minOccurs="0" name="class" type="gml:CodeType">
            <annotation>
              <documentation>Indicates the specific type of the Road.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the intended purposes of the
Road.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the actual uses of the Road.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="section">
            <annotation>
              <documentation>Relates to the sections that are part of the
Road.</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
                    <element ref="tran:Section"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="intersection">
            <annotation>
              <documentation>Relates to the intersections that are part of the
Road.</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
                    <element ref="tran:Intersection"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
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          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfRoad"
type="tran:ADEOfRoadPropertyType">
            <annotation>
              <documentation>Augments the Road with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="RoadPropertyType">
    <sequence minOccurs="0">
      <element ref="tran:Road"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="Section" substitutionGroup="tran:AbstractTransportationSpace"
type="tran:SectionType">
    <annotation>
      <documentation>A Section is a transportation space that is a segment of a Road,
Railway, Track, or Waterway.</documentation>
    </annotation>
  </element>
  <complexType name="SectionType">
    <complexContent>
      <extension base="tran:AbstractTransportationSpaceType">
        <sequence>
          <element minOccurs="0" name="class" type="gml:CodeType">
            <annotation>
              <documentation>Indicates the specific type of the
Section.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfSection"
type="tran:ADEOfSectionPropertyType">
            <annotation>
              <documentation>Augments the Section with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="SectionPropertyType">
    <sequence minOccurs="0">
      <element ref="tran:Section"/>
    </sequence>
```

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      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="Square" substitutionGroup="tran:AbstractTransportationSpace"
type="tran:SquareType">
    <annotation>
      <documentation>A Square is a transportation space for unrestricted movement for
vehicles, bicycles and/or pedestrians. This includes plazas as well as large sealed
surfaces such as parking lots.</documentation>
    </annotation>
  </element>
  <complexType name="SquareType">
    <complexContent>
      <extension base="tran:AbstractTransportationSpaceType">
        <sequence>
          <element minOccurs="0" name="class" type="gml:CodeType">
            <annotation>
              <documentation>Indicates the specific type of the
Square.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the intended purposes of the
Square.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the actual uses of the Square.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfSquare"
type="tran:ADEOfSquarePropertyType">
            <annotation>
              <documentation>Augments the Square with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="SquarePropertyType">
    <sequence minOccurs="0">
      <element ref="tran:Square"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
```

```
    </complexType>
    <element name="Track" substitutionGroup="tran:AbstractTransportationSpace"
type="tran:TrackType">
      <annotation>
        <documentation>A Track is a small path mainly used by pedestrians. Tracks can be
segmented into Sections and Intersections.</documentation>
      </annotation>
    </element>
    <complexType name="TrackType">
      <complexContent>
        <extension base="tran:AbstractTransportationSpaceType">
          <sequence>
            <element minOccurs="0" name="class" type="gml:CodeType">
              <annotation>
                <documentation>Indicates the specific type of the Track.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the intended purposes of the
Track.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the actual uses of the Track.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="section">
              <annotation>
                <documentation>Relates to the sections that are part of the
Track.</documentation>
              </annotation>
              <complexType>
                <complexContent>
                  <extension base="gml:AbstractFeatureMemberType">
                    <sequence minOccurs="0">
                      <element ref="tran:Section"/>
                    </sequence>
                    <attributeGroup ref="gml:AssociationAttributeGroup"/>
                  </extension>
                </complexContent>
              </complexType>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="intersection">
              <annotation>
                <documentation>Relates to the intersections that are part of the
Track.</documentation>
              </annotation>
```

```xml
              <complexType>
                <complexContent>
                  <extension base="gml:AbstractFeatureMemberType">
                    <sequence minOccurs="0">
                      <element ref="tran:Intersection"/>
                    </sequence>
                    <attributeGroup ref="gml:AssociationAttributeGroup"/>
                  </extension>
                </complexContent>
              </complexType>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="adeOfTrack"
type="tran:ADEOfTrackPropertyType">
              <annotation>
                <documentation>Augments the Track with properties defined in an
ADE.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
    </complexType>
    <complexType name="TrackPropertyType">
      <sequence minOccurs="0">
        <element ref="tran:Track"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <element name="TrafficArea" substitutionGroup="core:AbstractThematicSurface"
type="tran:TrafficAreaType">
      <annotation>
        <documentation>A TrafficArea is the ground surface of a TrafficSpace. Traffic
areas are the surfaces upon which traffic actually takes place.</documentation>
      </annotation>
    </element>
    <complexType name="TrafficAreaType">
      <complexContent>
        <extension base="core:AbstractThematicSurfaceType">
          <sequence>
            <element minOccurs="0" name="class" type="gml:CodeType">
              <annotation>
                <documentation>Indicates the specific type of the
TrafficArea.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the intended purposes of the
TrafficArea.</documentation>
```

```
                </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
                <annotation>
                    <documentation>Specifies the actual uses of the
TrafficArea.</documentation>
                </annotation>
            </element>
            <element minOccurs="0" name="surfaceMaterial" type="gml:CodeType">
                <annotation>
                    <documentation>Specifies the type of pavement of the
TrafficArea.</documentation>
                </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="adeOfTrafficArea"
type="tran:ADEOfTrafficAreaPropertyType">
                <annotation>
                    <documentation>Augments the TrafficArea with properties defined in an
ADE.</documentation>
                </annotation>
            </element>
        </sequence>
    </extension>
  </complexContent>
</complexType>
<complexType name="TrafficAreaPropertyType">
    <sequence minOccurs="0">
        <element ref="tran:TrafficArea"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
</complexType>
<simpleType name="TrafficDirectionValueType">
    <annotation>
        <documentation>TrafficDirectionValue enumerates the allowed directions of travel
of a mobile object.</documentation>
    </annotation>
    <restriction base="string">
        <enumeration value="forwards">
            <annotation>
                <documentation>Indicates that traffic flows in the direction of the
corresponding linear geometry.</documentation>
            </annotation>
        </enumeration>
        <enumeration value="backwards">
            <annotation>
                <documentation>Indicates that traffic flows in the opposite direction of the
corresponding linear geometry.</documentation>
            </annotation>
        </enumeration>
```

```
      <enumeration value="both">
        <annotation>
          <documentation>Indicates that traffic flows in both
directions.</documentation>
        </annotation>
      </enumeration>
    </restriction>
  </simpleType>
  <element name="TrafficSpace" substitutionGroup="core:AbstractUnoccupiedSpace"
type="tran:TrafficSpaceType">
    <annotation>
      <documentation>A TrafficSpace is a space in which traffic takes place. Traffic
includes the movement of entities such as trains, vehicles, pedestrians, ships, or
other transportation types.</documentation>
    </annotation>
  </element>
  <complexType name="TrafficSpaceType">
    <complexContent>
      <extension base="core:AbstractUnoccupiedSpaceType">
        <sequence>
          <element minOccurs="0" name="class" type="gml:CodeType">
            <annotation>
              <documentation>Indicates the specific type of the
TrafficSpace.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the intended purposes of the
TrafficSpace.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the actual uses of the
TrafficSpace.</documentation>
            </annotation>
          </element>
          <element name="granularity" type="tran:GranularityValueType">
            <annotation>
              <documentation>Defines whether traffic spaces are represented by
individual ways or by individual lanes, depending on the desired level of spatial and
semantic decomposition.</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="trafficDirection"
type="tran:TrafficDirectionValueType">
            <annotation>
              <documentation>Indicates the direction of traffic flow relative to the
```

```
corresponding linear geometry representation.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="occupancy"
type="core:OccupancyPropertyType">
            <annotation>
              <documentation>Provides information on the residency of persons,
vehicles, or other moving features in the TrafficSpace.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="predecessor"
type="gml:ReferenceType">
            <annotation>
              <documentation>Indicates the predecessor(s) of the
TrafficSpace.</documentation>
              <appinfo>
                <targetElement
xmlns="http://www.opengis.net/gml/3.2">tran:TrafficSpace</targetElement>
              </appinfo>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="successor"
type="gml:ReferenceType">
            <annotation>
              <documentation>Indicates the successor(s) of the
TrafficSpace.</documentation>
              <appinfo>
                <targetElement
xmlns="http://www.opengis.net/gml/3.2">tran:TrafficSpace</targetElement>
              </appinfo>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="clearanceSpace">
            <annotation>
              <documentation>Relates to the clearance spaces that are part of the
TrafficSpace.</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
                    <element ref="tran:ClearanceSpace"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfTrafficSpace"
type="tran:ADEOfTrafficSpacePropertyType">
            <annotation>
```

```
                <documentation>Augments the TrafficSpace with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="TrafficSpacePropertyType">
    <sequence minOccurs="0">
      <element ref="tran:TrafficSpace"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="Waterway" substitutionGroup="tran:AbstractTransportationSpace"
type="tran:WaterwayType">
    <annotation>
      <documentation>A Waterway is a transportation space used for the movement of
vessels upon or within a water body.</documentation>
    </annotation>
  </element>
  <complexType name="WaterwayType">
    <complexContent>
      <extension base="tran:AbstractTransportationSpaceType">
        <sequence>
          <element minOccurs="0" name="class" type="gml:CodeType">
            <annotation>
              <documentation>Indicates the specific type of the
Waterway.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the intended purposes of the
Waterway.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the actual uses of the
Waterway.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="section">
            <annotation>
              <documentation>Relates to the sections that are part of the
Waterway.</documentation>
            </annotation>
```

```
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
                    <element ref="tran:Section"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="intersection">
            <annotation>
              <documentation>Relates to the intersections that are part of the
Waterway.</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
                    <element ref="tran:Intersection"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfWaterway"
type="tran:ADEOfWaterwayPropertyType">
            <annotation>
              <documentation>Augments the Waterway with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="WaterwayPropertyType">
    <sequence minOccurs="0">
      <element ref="tran:Waterway"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
</schema>
```

C.14. Tunnel module

The CityGML Tunnel module is defined in the XML Schema Definition file *tunnel.xsd* (Listing 21).

The target namespace http://www.opengis.net/citygml/tunnel/3.0 is associated with this module.

Listing 21. tunnel.xsd

```xml
<?xml version="1.0" encoding="UTF-8"?><schema xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:con="http://www.opengis.net/citygml/construction/3.0"
xmlns:core="http://www.opengis.net/citygml/3.0"
xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:tun="http://www.opengis.net/citygml/tunnel/3.0" elementFormDefault="qualified"
targetNamespace="http://www.opengis.net/citygml/tunnel/3.0" version="3.0.0">
  <annotation>
    <documentation>The Tunnel module supports representation of thematic and spatial
aspects of tunnels, tunnel parts, tunnel installations, and interior tunnel
structures.</documentation>
  </annotation>
  <import namespace="http://www.opengis.net/citygml/3.0" schemaLocation="./core.xsd"/>
  <import namespace="http://www.opengis.net/citygml/construction/3.0"
schemaLocation="./construction.xsd"/>
  <import namespace="http://www.opengis.net/gml/3.2"
schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd"/>
  <!--XML Schema document created by ShapeChange - http://shapechange.net/-->
  <element abstract="true" name="ADEOfAbstractTunnel"
substitutionGroup="gml:AbstractObject" type="tun:ADEOfAbstractTunnelType">
    <annotation>
      <documentation>ADEOfAbstractTunnel acts as a hook to define properties within an
ADE that are to be added to AbstractTunnel.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAbstractTunnelType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfAbstractTunnelPropertyType">
    <sequence>
      <element ref="tun:ADEOfAbstractTunnel"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfHollowSpace"
substitutionGroup="gml:AbstractObject" type="tun:ADEOfHollowSpaceType">
    <annotation>
      <documentation>ADEOfHollowSpace acts as a hook to define properties within an
ADE that are to be added to a HollowSpace.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfHollowSpaceType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfHollowSpacePropertyType">
    <sequence>
      <element ref="tun:ADEOfHollowSpace"/>
    </sequence>
  </complexType>
```

```xml
  <element abstract="true" name="ADEOfTunnel" substitutionGroup="gml:AbstractObject"
type="tun:ADEOfTunnelType">
    <annotation>
      <documentation>ADEOfTunnel acts as a hook to define properties within an ADE
that are to be added to a Tunnel.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfTunnelType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfTunnelPropertyType">
    <sequence>
      <element ref="tun:ADEOfTunnel"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfTunnelConstructiveElement"
substitutionGroup="gml:AbstractObject" type="tun:ADEOfTunnelConstructiveElementType">
    <annotation>
      <documentation>ADEOfTunnelConstructiveElement acts as a hook to define
properties within an ADE that are to be added to a
TunnelConstructiveElement.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfTunnelConstructiveElementType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfTunnelConstructiveElementPropertyType">
    <sequence>
      <element ref="tun:ADEOfTunnelConstructiveElement"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfTunnelFurniture"
substitutionGroup="gml:AbstractObject" type="tun:ADEOfTunnelFurnitureType">
    <annotation>
      <documentation>ADEOfTunnelFurniture acts as a hook to define properties within
an ADE that are to be added to a TunnelFurniture.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfTunnelFurnitureType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfTunnelFurniturePropertyType">
    <sequence>
      <element ref="tun:ADEOfTunnelFurniture"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfTunnelInstallation"
substitutionGroup="gml:AbstractObject" type="tun:ADEOfTunnelInstallationType">
    <annotation>
      <documentation>ADEOfTunnelInstallation acts as a hook to define properties
within an ADE that are to be added to a TunnelInstallation.</documentation>
```

```xml
          </annotation>
        </element>
      <complexType abstract="true" name="ADEOfTunnelInstallationType">
        <sequence/>
      </complexType>
      <complexType name="ADEOfTunnelInstallationPropertyType">
        <sequence>
          <element ref="tun:ADEOfTunnelInstallation"/>
        </sequence>
      </complexType>
      <element abstract="true" name="ADEOfTunnelPart"
substitutionGroup="gml:AbstractObject" type="tun:ADEOfTunnelPartType">
        <annotation>
          <documentation>ADEOfTunnelPart acts as a hook to define properties within an ADE
that are to be added to a TunnelPart.</documentation>
        </annotation>
      </element>
      <complexType abstract="true" name="ADEOfTunnelPartType">
        <sequence/>
      </complexType>
      <complexType name="ADEOfTunnelPartPropertyType">
        <sequence>
          <element ref="tun:ADEOfTunnelPart"/>
        </sequence>
      </complexType>
      <element abstract="true" name="AbstractTunnel"
substitutionGroup="con:AbstractConstruction" type="tun:AbstractTunnelType">
        <annotation>
          <documentation>AbstractTunnel is an abstract superclass representing the common
attributes and associations of the classes Tunnel and TunnelPart.</documentation>
        </annotation>
      </element>
      <complexType abstract="true" name="AbstractTunnelType">
        <complexContent>
          <extension base="con:AbstractConstructionType">
            <sequence>
              <element minOccurs="0" name="class" type="gml:CodeType">
                <annotation>
                  <documentation>Indicates the specific type of the Tunnel or
TunnelPart.</documentation>
                </annotation>
              </element>
              <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
                <annotation>
                  <documentation>Specifies the intended purposes of the Tunnel or
TunnelPart.</documentation>
                </annotation>
              </element>
              <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
```

```
            <annotation>
              <documentation>Specifies the actual uses of the Tunnel or
TunnelPart.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0"
name="tunnelConstructiveElement">
            <annotation>
              <documentation>Relates the constructive elements to the Tunnel or
TunnelPart.</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
                    <element ref="tun:TunnelConstructiveElement"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="tunnelInstallation">
            <annotation>
              <documentation>Relates the installation objects to the Tunnel or
TunnelPart.</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
                    <element ref="tun:TunnelInstallation"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="hollowSpace">
            <annotation>
              <documentation>Relates the hollow spaces to the Tunnel or
TunnelPart.</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
                    <element ref="tun:HollowSpace"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
```

```
              </complexContent>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="tunnelFurniture">
            <annotation>
              <documentation>Relates the furniture objects to the Tunnel or
TunnelPart.</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
                    <element ref="tun:TunnelFurniture"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfAbstractTunnel"
type="tun:ADEOfAbstractTunnelPropertyType">
            <annotation>
              <documentation>Augments AbstractTunnel with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="AbstractTunnelPropertyType">
    <sequence minOccurs="0">
      <element ref="tun:AbstractTunnel"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="HollowSpace" substitutionGroup="core:AbstractUnoccupiedSpace"
type="tun:HollowSpaceType">
    <annotation>
      <documentation>A HollowSpace is a space within a Tunnel or TunnelPart intended
for certain functions (e.g. transport or passage ways, service rooms, emergency
shelters). A HollowSpace is bounded physically and/or virtually (e.g. by
ClosureSurfaces or GenericSurfaces).</documentation>
    </annotation>
  </element>
  <complexType name="HollowSpaceType">
    <complexContent>
      <extension base="core:AbstractUnoccupiedSpaceType">
        <sequence>
          <element minOccurs="0" name="class" type="gml:CodeType">
```

```xml
          <annotation>
            <documentation>Indicates the specific type of the
HollowSpace.</documentation>
          </annotation>
        </element>
        <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
          <annotation>
            <documentation>Specifies the intended purposes of the
HollowSpace.</documentation>
          </annotation>
        </element>
        <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
          <annotation>
            <documentation>Specifies the actual uses of the
HollowSpace.</documentation>
          </annotation>
        </element>
        <element maxOccurs="unbounded" minOccurs="0" name="tunnelFurniture">
          <annotation>
            <documentation>Relates the furniture objects to the
HollowSpace.</documentation>
          </annotation>
          <complexType>
            <complexContent>
              <extension base="gml:AbstractFeatureMemberType">
                <sequence minOccurs="0">
                  <element ref="tun:TunnelFurniture"/>
                </sequence>
                <attributeGroup ref="gml:AssociationAttributeGroup"/>
              </extension>
            </complexContent>
          </complexType>
        </element>
        <element maxOccurs="unbounded" minOccurs="0" name="tunnelInstallation">
          <annotation>
            <documentation>Relates the installation objects to the
HollowSpace.</documentation>
          </annotation>
          <complexType>
            <complexContent>
              <extension base="gml:AbstractFeatureMemberType">
                <sequence minOccurs="0">
                  <element ref="tun:TunnelInstallation"/>
                </sequence>
                <attributeGroup ref="gml:AssociationAttributeGroup"/>
              </extension>
            </complexContent>
          </complexType>
        </element>
```

```xml
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfHollowSpace"
type="tun:ADEOfHollowSpacePropertyType">
            <annotation>
              <documentation>Augments the HollowSpace with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="HollowSpacePropertyType">
    <sequence minOccurs="0">
      <element ref="tun:HollowSpace"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="Tunnel" substitutionGroup="tun:AbstractTunnel" type="tun:TunnelType">
    <annotation>
      <documentation>A Tunnel represents a horizontal or sloping enclosed passage way
of a certain length, mainly underground or underwater. [cf. ISO 6707-
1]</documentation>
    </annotation>
  </element>
  <complexType name="TunnelType">
    <complexContent>
      <extension base="tun:AbstractTunnelType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="tunnelPart">
            <annotation>
              <documentation>Relates the tunnel parts to the Tunnel.</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence minOccurs="0">
                    <element ref="tun:TunnelPart"/>
                  </sequence>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfTunnel"
type="tun:ADEOfTunnelPropertyType">
            <annotation>
              <documentation>Augments the Tunnel with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
```

```
          </sequence>
        </extension>
      </complexContent>
    </complexType>
    <complexType name="TunnelPropertyType">
      <sequence minOccurs="0">
        <element ref="tun:Tunnel"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <element name="TunnelConstructiveElement"
substitutionGroup="con:AbstractConstructiveElement"
type="tun:TunnelConstructiveElementType">
      <annotation>
        <documentation>A TunnelConstructiveElement is an element of a Tunnel which is
essential from a structural point of view. Examples are walls, slabs,
beams.</documentation>
      </annotation>
    </element>
    <complexType name="TunnelConstructiveElementType">
      <complexContent>
        <extension base="con:AbstractConstructiveElementType">
          <sequence>
            <element minOccurs="0" name="class" type="gml:CodeType">
              <annotation>
                <documentation>Indicates the specific type of the
TunnelConstructiveElement.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the intended purposes of the
TunnelConstructiveElement.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the actual uses of the
TunnelConstructiveElement.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0"
name="adeOfTunnelConstructiveElement"
type="tun:ADEOfTunnelConstructiveElementPropertyType">
              <annotation>
                <documentation>Augments the TunnelConstructiveElement with properties
defined in an ADE.</documentation>
              </annotation>
```

```
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="TunnelConstructiveElementPropertyType">
    <sequence minOccurs="0">
      <element ref="tun:TunnelConstructiveElement"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="TunnelFurniture" substitutionGroup="con:AbstractFurniture"
type="tun:TunnelFurnitureType">
    <annotation>
      <documentation>A TunnelFurniture is an equipment for occupant use, usually not
fixed to the tunnel. [cf. ISO 6707-1]</documentation>
    </annotation>
  </element>
  <complexType name="TunnelFurnitureType">
    <complexContent>
      <extension base="con:AbstractFurnitureType">
        <sequence>
          <element minOccurs="0" name="class" type="gml:CodeType">
            <annotation>
              <documentation>Indicates the specific type of the
TunnelFurniture.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the intended purposes of the
TunnelFurniture.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
            <annotation>
              <documentation>Specifies the actual uses of the
TunnelFurniture.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfTunnelFurniture"
type="tun:ADEOfTunnelFurniturePropertyType">
            <annotation>
              <documentation>Augments the TunnelFurniture with properties defined in
an ADE.</documentation>
            </annotation>
          </element>
        </sequence>
```

```xml
          </extension>
        </complexContent>
      </complexType>
      <complexType name="TunnelFurniturePropertyType">
        <sequence minOccurs="0">
          <element ref="tun:TunnelFurniture"/>
        </sequence>
        <attributeGroup ref="gml:AssociationAttributeGroup"/>
        <attributeGroup ref="gml:OwnershipAttributeGroup"/>
      </complexType>
      <element name="TunnelInstallation" substitutionGroup="con:AbstractInstallation"
  type="tun:TunnelInstallationType">
        <annotation>
          <documentation>A TunnelInstallation is a permanent part of a Tunnel (inside
  and/or outside) which does not have the significance of a TunnelPart. In contrast to
  TunnelConstructiveElement, a TunnelInstallation is not essential from a structural
  point of view. Examples are stairs, antennas or railings.</documentation>
        </annotation>
      </element>
      <complexType name="TunnelInstallationType">
        <complexContent>
          <extension base="con:AbstractInstallationType">
            <sequence>
              <element minOccurs="0" name="class" type="gml:CodeType">
                <annotation>
                  <documentation>Indicates the specific type of the
  TunnelInstallation.</documentation>
                </annotation>
              </element>
              <element maxOccurs="unbounded" minOccurs="0" name="function"
  type="gml:CodeType">
                <annotation>
                  <documentation>Specifies the intended purposes of the
  TunnelInstallation.</documentation>
                </annotation>
              </element>
              <element maxOccurs="unbounded" minOccurs="0" name="usage"
  type="gml:CodeType">
                <annotation>
                  <documentation>Specifies the actual uses of the
  TunnelInstallation.</documentation>
                </annotation>
              </element>
              <element maxOccurs="unbounded" minOccurs="0" name="adeOfTunnelInstallation"
  type="tun:ADEOfTunnelInstallationPropertyType">
                <annotation>
                  <documentation>Augments the TunnelInstallation with properties defined
  in an ADE.</documentation>
                </annotation>
              </element>
            </sequence>
```

```xml
          </extension>
        </complexContent>
      </complexType>
      <complexType name="TunnelInstallationPropertyType">
        <sequence minOccurs="0">
          <element ref="tun:TunnelInstallation"/>
        </sequence>
        <attributeGroup ref="gml:AssociationAttributeGroup"/>
        <attributeGroup ref="gml:OwnershipAttributeGroup"/>
      </complexType>
      <element name="TunnelPart" substitutionGroup="tun:AbstractTunnel"
type="tun:TunnelPartType">
        <annotation>
          <documentation>A TunnelPart is a physical or functional subdivision of a Tunnel.
It would be considered a Tunnel, if it were not part of a collection of other
TunnelParts.</documentation>
        </annotation>
      </element>
      <complexType name="TunnelPartType">
        <complexContent>
          <extension base="tun:AbstractTunnelType">
            <sequence>
              <element maxOccurs="unbounded" minOccurs="0" name="adeOfTunnelPart"
type="tun:ADEOfTunnelPartPropertyType">
                <annotation>
                  <documentation>Augments the TunnelPart with properties defined in an
ADE.</documentation>
                </annotation>
              </element>
            </sequence>
          </extension>
        </complexContent>
      </complexType>
      <complexType name="TunnelPartPropertyType">
        <sequence minOccurs="0">
          <element ref="tun:TunnelPart"/>
        </sequence>
        <attributeGroup ref="gml:AssociationAttributeGroup"/>
        <attributeGroup ref="gml:OwnershipAttributeGroup"/>
      </complexType>
</schema>
```

C.15. Vegetation module

The CityGML Vegetation module is defined in the XML Schema Definition file *vegetation.xsd* ([Listing 22](#)). The target namespace http://www.opengis.net/citygml/vegetation/3.0 is associated with this module.

Listing 22. vegetation.xsd

```xml
<?xml version="1.0" encoding="UTF-8"?><schema xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:core="http://www.opengis.net/citygml/3.0"
xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:veg="http://www.opengis.net/citygml/vegetation/3.0"
elementFormDefault="qualified"
targetNamespace="http://www.opengis.net/citygml/vegetation/3.0" version="3.0.0">
  <annotation>
    <documentation>The Vegetation module supports representation of vegetation objects
with vegetation-specific thematic classes. CityGML□s vegetation model distinguishes
between solitary vegetation objects like trees, and vegetation areas which represent
biotopes like forests or other plant communities.</documentation>
  </annotation>
  <import namespace="http://www.opengis.net/citygml/3.0" schemaLocation="./core.xsd"/>
  <import namespace="http://www.opengis.net/gml/3.2"
schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd"/>
  <!--XML Schema document created by ShapeChange - http://shapechange.net/-->
  <element abstract="true" name="ADEOfAbstractVegetationObject"
substitutionGroup="gml:AbstractObject" type="veg:ADEOfAbstractVegetationObjectType">
    <annotation>
      <documentation>ADEOfAbstractVegetationObject acts as a hook to define properties
within an ADE that are to be added to AbstractVegetationObject.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAbstractVegetationObjectType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfAbstractVegetationObjectPropertyType">
    <sequence>
      <element ref="veg:ADEOfAbstractVegetationObject"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfPlantCover"
substitutionGroup="gml:AbstractObject" type="veg:ADEOfPlantCoverType">
    <annotation>
      <documentation>ADEOfPlantCover acts as a hook to define properties within an ADE
that are to be added to a PlantCover.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfPlantCoverType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfPlantCoverPropertyType">
    <sequence>
      <element ref="veg:ADEOfPlantCover"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfSolitaryVegetationObject"
substitutionGroup="gml:AbstractObject" type="veg:ADEOfSolitaryVegetationObjectType">
    <annotation>
      <documentation>ADEOfSolitaryVegetationObject acts as a hook to define properties
within an ADE that are to be added to a SolitaryVegetationObject.</documentation>
```

```xml
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfSolitaryVegetationObjectType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfSolitaryVegetationObjectPropertyType">
      <sequence>
        <element ref="veg:ADEOfSolitaryVegetationObject"/>
      </sequence>
    </complexType>
    <element abstract="true" name="AbstractVegetationObject"
substitutionGroup="core:AbstractOccupiedSpace"
type="veg:AbstractVegetationObjectType">
      <annotation>
        <documentation>AbstractVegetationObject is the abstract superclass for all kinds
of vegetation objects.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="AbstractVegetationObjectType">
      <complexContent>
        <extension base="core:AbstractOccupiedSpaceType">
          <sequence>
            <element maxOccurs="unbounded" minOccurs="0"
name="adeOfAbstractVegetationObject"
type="veg:ADEOfAbstractVegetationObjectPropertyType">
              <annotation>
                <documentation>Augments AbstractVegetationObject with properties defined
in an ADE.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
    </complexType>
    <complexType name="AbstractVegetationObjectPropertyType">
      <sequence minOccurs="0">
        <element ref="veg:AbstractVegetationObject"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <element name="PlantCover" substitutionGroup="veg:AbstractVegetationObject"
type="veg:PlantCoverType">
      <annotation>
        <documentation>A PlantCover represents a space covered by
vegetation.</documentation>
      </annotation>
    </element>
    <complexType name="PlantCoverType">
      <complexContent>
        <extension base="veg:AbstractVegetationObjectType">
```

```
            <sequence>
              <element minOccurs="0" name="class" type="gml:CodeType">
                <annotation>
                  <documentation>Indicates the specific type of the
PlantCover.</documentation>
                </annotation>
              </element>
              <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
                <annotation>
                  <documentation>Specifies the intended purposes of the
PlantCover.</documentation>
                </annotation>
              </element>
              <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
                <annotation>
                  <documentation>Specifies the actual uses of the
PlantCover.</documentation>
                </annotation>
              </element>
              <element minOccurs="0" name="averageHeight" type="gml:LengthType">
                <annotation>
                  <documentation>Specifies the average height of the
PlantCover.</documentation>
                </annotation>
              </element>
              <element minOccurs="0" name="minHeight" type="gml:LengthType">
                <annotation>
                  <documentation>Specifies the minimum height of the
PlantCover.</documentation>
                </annotation>
              </element>
              <element minOccurs="0" name="maxHeight" type="gml:LengthType">
                <annotation>
                  <documentation>Specifies the maximum height of the
PlantCover.</documentation>
                </annotation>
              </element>
              <element maxOccurs="unbounded" minOccurs="0" name="adeOfPlantCover"
type="veg:ADEOfPlantCoverPropertyType">
                <annotation>
                  <documentation>Augments the PlantCover with properties defined in an
ADE.</documentation>
                </annotation>
              </element>
            </sequence>
          </extension>
        </complexContent>
      </complexType>
      <complexType name="PlantCoverPropertyType">
```

```xml
      <sequence minOccurs="0">
        <element ref="veg:PlantCover"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <element name="SolitaryVegetationObject"
substitutionGroup="veg:AbstractVegetationObject"
type="veg:SolitaryVegetationObjectType">
      <annotation>
        <documentation>A SolitaryVegetationObject represents individual vegetation
objects, e.g. trees or bushes.</documentation>
      </annotation>
    </element>
    <complexType name="SolitaryVegetationObjectType">
      <complexContent>
        <extension base="veg:AbstractVegetationObjectType">
          <sequence>
            <element minOccurs="0" name="class" type="gml:CodeType">
              <annotation>
                <documentation>Indicates the specific type of the
SolitaryVegetationObject.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the intended purposes of the
SolitaryVegetationObject.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the actual uses of the
SolitaryVegetationObject.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="species" type="gml:CodeType">
              <annotation>
                <documentation>Indicates the botanical name of the
SolitaryVegetationObject.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="height" type="gml:LengthType">
              <annotation>
                <documentation>Distance between the highest point of the vegetation
object and the lowest point of the terrain at the bottom of the
object.</documentation>
              </annotation>
            </element>
```

```
            <element minOccurs="0" name="trunkDiameter" type="gml:LengthType">
              <annotation>
                <documentation>Specifies the diameter of the SolitaryCityObject's
trunk.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="crownDiameter" type="gml:LengthType">
              <annotation>
                <documentation>Specifies the diameter of the SolitaryCityObject's
crown.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="rootBallDiameter" type="gml:LengthType">
              <annotation>
                <documentation>Specifies the diameter of the SolitaryCityObject's root
ball.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="maxRootBallDepth" type="gml:LengthType">
              <annotation>
                <documentation>Specifies the vertical distance between the lowest point
of the SolitaryVegetationObject's root ball and the terrain surface.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0"
name="adeOfSolitaryVegetationObject"
type="veg:ADEOfSolitaryVegetationObjectPropertyType">
              <annotation>
                <documentation>Augments the SolitaryVegetationObject with properties
defined in an ADE.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
  </complexType>
  <complexType name="SolitaryVegetationObjectPropertyType">
    <sequence minOccurs="0">
      <element ref="veg:SolitaryVegetationObject"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
</schema>
```

C.16. Versioning module

The CityGML Versioning module is defined in the XML Schema Definition file *versioning.xsd* (Listing
23). The target namespace http://www.opengis.net/citygml/versioning/3.0 is associated with this
module.

Listing 23. versioning.xsd

```xml
<?xml version="1.0" encoding="UTF-8"?><schema xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:core="http://www.opengis.net/citygml/3.0"
xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:vers="http://www.opengis.net/citygml/versioning/3.0"
elementFormDefault="qualified"
targetNamespace="http://www.opengis.net/citygml/versioning/3.0" version="3.0.0">
  <annotation>
    <documentation>The Versioning module supports representation of multiple versions
of CityGML features within a single CityGML model. In addition, also the version
transitions and transactions that lead to the different versions can be
represented.</documentation>
  </annotation>
  <import namespace="http://www.opengis.net/citygml/3.0" schemaLocation="./core.xsd"/>
  <import namespace="http://www.opengis.net/gml/3.2"
schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd"/>
  <!--XML Schema document created by ShapeChange - http://shapechange.net/-->
  <element abstract="true" name="ADEOfVersion" substitutionGroup="gml:AbstractObject"
type="vers:ADEOfVersionType">
    <annotation>
      <documentation>ADEOfVersion acts as a hook to define properties within an ADE
that are to be added to a Version.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfVersionType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfVersionPropertyType">
    <sequence>
      <element ref="vers:ADEOfVersion"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfVersionTransition"
substitutionGroup="gml:AbstractObject" type="vers:ADEOfVersionTransitionType">
    <annotation>
      <documentation>ADEOfVersionTransition acts as a hook to define properties within
an ADE that are to be added to a VersionTransition.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfVersionTransitionType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfVersionTransitionPropertyType">
    <sequence>
      <element ref="vers:ADEOfVersionTransition"/>
    </sequence>
  </complexType>
  <element name="Transaction" substitutionGroup="gml:AbstractObject"
type="vers:TransactionType">
    <annotation>
```

```
      <documentation>Transaction represents a modification of the city model by the
creation, termination, or replacement of a specific city object. While the creation of
a city object also marks its first object version, the termination marks the end of
existence of a real world object and, hence, also terminates the final version of a
city object. The replacement of a city object means that a specific version of it is
replaced by a new version.</documentation>
    </annotation>
  </element>
  <complexType name="TransactionType">
    <sequence>
      <element name="type" type="vers:TransactionTypeValueType">
        <annotation>
          <documentation>Indicates the specific type of the
Transaction.</documentation>
        </annotation>
      </element>
      <element minOccurs="0" name="oldFeature" type="gml:ReferenceType">
        <annotation>
          <documentation>Relates to the version of the city object prior to the
Transaction.</documentation>
          <appinfo>
            <targetElement
xmlns="http://www.opengis.net/gml/3.2">core:AbstractFeatureWithLifespan</targetElement
>
          </appinfo>
        </annotation>
      </element>
      <element minOccurs="0" name="newFeature" type="gml:ReferenceType">
        <annotation>
          <documentation>Relates to the version of the city object subsequent to the
Transaction.</documentation>
          <appinfo>
            <targetElement
xmlns="http://www.opengis.net/gml/3.2">core:AbstractFeatureWithLifespan</targetElement
>
          </appinfo>
        </annotation>
      </element>
    </sequence>
  </complexType>
  <complexType name="TransactionPropertyType">
    <sequence>
      <element ref="vers:Transaction"/>
    </sequence>
  </complexType>
  <simpleType name="TransactionTypeValueType">
    <annotation>
      <documentation>TransactionTypeValue enumerates the three possible types of
transactions: insert, delete, or replace.</documentation>
    </annotation>
    <restriction base="string">
```

```xml
      <enumeration value="insert">
        <annotation>
          <documentation>Indicates that the feature referenced from the Transaction
via the "newFeature" association has been newly created; the association "oldFeature"
is empty in this case.</documentation>
        </annotation>
      </enumeration>
      <enumeration value="delete">
        <annotation>
          <documentation>Indicates that the feature referenced from the Transaction
via the "oldFeature" association ceases to exist; the association "newFeature" is
empty in this case.</documentation>
        </annotation>
      </enumeration>
      <enumeration value="replace">
        <annotation>
          <documentation>Indicates that the feature referenced from the Transaction
via the "oldFeature" association has been replaced by the feature referenced via the
"newFeature" association.</documentation>
        </annotation>
      </enumeration>
    </restriction>
  </simpleType>
  <simpleType name="TransitionTypeValueType">
    <annotation>
      <documentation>TransitionTypeValue enumerates the different kinds of version
transitions. planned and fork should be used in cases when from one city model
version multiple successor versions are being created. realized and merge should be
used when different city model versions are converging into a common successor
version.</documentation>
    </annotation>
    <restriction base="string">
      <enumeration value="planned">
        <annotation>
          <documentation>Indicates that the successor version of the city model
represents a planning state for a possible future of the city.</documentation>
        </annotation>
      </enumeration>
      <enumeration value="realized">
        <annotation>
          <documentation>Indicates that the predecessor version is the chosen one from
a number of possible planning versions.</documentation>
        </annotation>
      </enumeration>
      <enumeration value="historicalSuccession">
        <annotation>
          <documentation>Indicates that the successor version reflects updates on the
city model over time (historical timeline). It shall only be used for at most one
version transition outgoing from a city model version.</documentation>
        </annotation>
      </enumeration>
```

```xml
      <enumeration value="fork">
        <annotation>
          <documentation>Indicates other reasons to create alternative city model
versions, for example, when different parties are updating parts of the city model or
to reflect the results of different simulation runs.</documentation>
        </annotation>
      </enumeration>
      <enumeration value="merge">
        <annotation>
          <documentation>Indicates other reasons to converge multiple versions back
into a common city model version.</documentation>
        </annotation>
      </enumeration>
    </restriction>
  </simpleType>
  <element name="Version" substitutionGroup="core:AbstractVersion"
type="vers:VersionType">
    <annotation>
      <documentation>Version represents a defined state of a city model consisting of
the dedicated versions of all city object instances that belong to the respective city
model version. Versions can have names, a description and can be labeled with an
arbitrary number of user defined tags.</documentation>
    </annotation>
  </element>
  <complexType name="VersionType">
    <complexContent>
      <extension base="core:AbstractVersionType">
        <sequence>
          <element maxOccurs="unbounded" minOccurs="0" name="tag" type="string">
            <annotation>
              <documentation>Allows for adding keywords to the city model
version.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="versionMember">
            <annotation>
              <documentation>Relates to all city objects that are part of the city
model version.</documentation>
              <appinfo>
                <targetElement
xmlns="http://www.opengis.net/gml/3.2">core:AbstractFeatureWithLifespan</targetElement
>
              </appinfo>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractFeatureMemberType">
                  <sequence/>
                  <attributeGroup ref="gml:AssociationAttributeGroup"/>
                </extension>
              </complexContent>
```

```
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfVersion"
type="vers:ADEOfVersionPropertyType">
            <annotation>
              <documentation>Augments the Version with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="VersionPropertyType">
    <sequence minOccurs="0">
      <element ref="vers:Version"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
  <element name="VersionTransition" substitutionGroup="core:AbstractVersionTransition"
type="vers:VersionTransitionType">
    <annotation>
      <documentation>VersionTransition describes the change of the state of a city
model from one version to another. Version transitions can have names, a description
and can be further qualified by a type and a reason.</documentation>
    </annotation>
  </element>
  <complexType name="VersionTransitionType">
    <complexContent>
      <extension base="core:AbstractVersionTransitionType">
        <sequence>
          <element minOccurs="0" name="reason" type="string">
            <annotation>
              <documentation>Specifies why the VersionTransition has been carried
out.</documentation>
            </annotation>
          </element>
          <element name="clonePredecessor" type="boolean">
            <annotation>
              <documentation>Indicates whether the set of city object instances
belonging to the successor version of the city model is either explicitly enumerated
within the successor version object (attribute clonePredecessor=false),  or has to be
derived from the modifications of the city model provided as a list of transactions on
the city object versions contained in the predecessor version (attribute
clonePredecessor=true).</documentation>
            </annotation>
          </element>
          <element minOccurs="0" name="type" type="vers:TransitionTypeValueType">
            <annotation>
              <documentation>Indicates the specific type of the
```

```
VersionTransition.</documentation>
              </annotation>
            </element>
            <element minOccurs="0" name="from" type="gml:ReferenceType">
              <annotation>
                <documentation>Relates to the predecessor version of the
VersionTransition.</documentation>
                <appinfo>
                  <targetElement
xmlns="http://www.opengis.net/gml/3.2">vers:Version</targetElement>
                </appinfo>
              </annotation>
            </element>
            <element minOccurs="0" name="to" type="gml:ReferenceType">
              <annotation>
                <documentation>Relates to the successor version of the
VersionTransition.</documentation>
                <appinfo>
                  <targetElement
xmlns="http://www.opengis.net/gml/3.2">vers:Version</targetElement>
                </appinfo>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="transaction"
type="vers:TransactionPropertyType">
              <annotation>
                <documentation>Relates to all transactions that have been applied as
part of the VersionTransition.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="adeOfVersionTransition"
type="vers:ADEOfVersionTransitionPropertyType">
              <annotation>
                <documentation>Augments the VersionTransition with properties defined in
an ADE.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
    </complexType>
    <complexType name="VersionTransitionPropertyType">
      <sequence minOccurs="0">
        <element ref="vers:VersionTransition"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
</schema>
```

C.17. Water Body module

The CityGML Water Body module is defined in the XML Schema Definition file *waterBody.xsd* (Listing 24). The target namespace http://www.opengis.net/citygml/waterbody/3.0 is associated with this module.

Listing 24. waterBody.xsd

```xml
<?xml version="1.0" encoding="UTF-8"?><schema xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:core="http://www.opengis.net/citygml/3.0"
xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:wtr="http://www.opengis.net/citygml/waterbody/3.0"
elementFormDefault="qualified"
targetNamespace="http://www.opengis.net/citygml/waterbody/3.0" version="3.0.0">
  <annotation>
    <documentation>The WaterBody module supports representation of the thematic
aspects and 3D geometry of rivers, canals, lakes, and basins. It does, however, not
inherit any hydrological or other dynamic aspects of fluid flow.</documentation>
  </annotation>
  <import namespace="http://www.opengis.net/citygml/3.0" schemaLocation="./core.xsd"/>
  <import namespace="http://www.opengis.net/gml/3.2"
schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd"/>
  <!--XML Schema document created by ShapeChange - http://shapechange.net/-->
  <element abstract="true" name="ADEOfAbstractWaterBoundarySurface"
substitutionGroup="gml:AbstractObject"
type="wtr:ADEOfAbstractWaterBoundarySurfaceType">
    <annotation>
      <documentation>ADEOfAbstractWaterBoundarySurface acts as a hook to define
properties within an ADE that are to be added to
AbstractWaterBoundarySurface.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfAbstractWaterBoundarySurfaceType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfAbstractWaterBoundarySurfacePropertyType">
    <sequence>
      <element ref="wtr:ADEOfAbstractWaterBoundarySurface"/>
    </sequence>
  </complexType>
  <element abstract="true" name="ADEOfWaterBody"
substitutionGroup="gml:AbstractObject" type="wtr:ADEOfWaterBodyType">
    <annotation>
      <documentation>ADEOfWaterBody acts as a hook to define properties within an ADE
that are to be added to a WaterBody.</documentation>
    </annotation>
  </element>
  <complexType abstract="true" name="ADEOfWaterBodyType">
    <sequence/>
  </complexType>
  <complexType name="ADEOfWaterBodyPropertyType">
```

```xml
      <sequence>
        <element ref="wtr:ADEOfWaterBody"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfWaterGroundSurface"
substitutionGroup="gml:AbstractObject" type="wtr:ADEOfWaterGroundSurfaceType">
      <annotation>
        <documentation>ADEOfWaterGroundSurface acts as a hook to define properties
within an ADE that are to be added to a WaterGroundSurface.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfWaterGroundSurfaceType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfWaterGroundSurfacePropertyType">
      <sequence>
        <element ref="wtr:ADEOfWaterGroundSurface"/>
      </sequence>
    </complexType>
    <element abstract="true" name="ADEOfWaterSurface"
substitutionGroup="gml:AbstractObject" type="wtr:ADEOfWaterSurfaceType">
      <annotation>
        <documentation>ADEOfWaterSurface acts as a hook to define properties within an
ADE that are to be added to a WaterSurface.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="ADEOfWaterSurfaceType">
      <sequence/>
    </complexType>
    <complexType name="ADEOfWaterSurfacePropertyType">
      <sequence>
        <element ref="wtr:ADEOfWaterSurface"/>
      </sequence>
    </complexType>
    <element abstract="true" name="AbstractWaterBoundarySurface"
substitutionGroup="core:AbstractThematicSurface"
type="wtr:AbstractWaterBoundarySurfaceType">
      <annotation>
        <documentation>AbstractWaterBoundarySurface is the abstract superclass for all
kinds of thematic surfaces bounding a water body.</documentation>
      </annotation>
    </element>
    <complexType abstract="true" name="AbstractWaterBoundarySurfaceType">
      <complexContent>
        <extension base="core:AbstractThematicSurfaceType">
          <sequence>
            <element maxOccurs="unbounded" minOccurs="0"
name="adeOfAbstractWaterBoundarySurface"
type="wtr:ADEOfAbstractWaterBoundarySurfacePropertyType">
              <annotation>
                <documentation>Augments AbstractWaterBoundarySurface with properties
```

```
defined in an ADE.</documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
    </complexType>
    <complexType name="AbstractWaterBoundarySurfacePropertyType">
      <sequence minOccurs="0">
        <element ref="wtr:AbstractWaterBoundarySurface"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
    </complexType>
    <element name="WaterBody" substitutionGroup="core:AbstractOccupiedSpace"
type="wtr:WaterBodyType">
      <annotation>
        <documentation>A WaterBody represents significant and permanent or semi-
permanent accumulations of surface water, usually covering a part of the
Earth.</documentation>
      </annotation>
    </element>
    <complexType name="WaterBodyType">
      <complexContent>
        <extension base="core:AbstractOccupiedSpaceType">
          <sequence>
            <element minOccurs="0" name="class" type="gml:CodeType">
              <annotation>
                <documentation>Indicates the specific type of the
WaterBody.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="function"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the intended purposes of the
WaterBody.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="usage"
type="gml:CodeType">
              <annotation>
                <documentation>Specifies the actual uses of the
WaterBody.</documentation>
              </annotation>
            </element>
            <element maxOccurs="unbounded" minOccurs="0" name="adeOfWaterBody"
type="wtr:ADEOfWaterBodyPropertyType">
              <annotation>
                <documentation>Augments the WaterBody with properties defined in an
ADE.</documentation>
```

```xml
          </annotation>
        </element>
      </sequence>
    </extension>
  </complexContent>
</complexType>
<complexType name="WaterBodyPropertyType">
  <sequence minOccurs="0">
    <element ref="wtr:WaterBody"/>
  </sequence>
  <attributeGroup ref="gml:AssociationAttributeGroup"/>
  <attributeGroup ref="gml:OwnershipAttributeGroup"/>
</complexType>
<element name="WaterGroundSurface"
substitutionGroup="wtr:AbstractWaterBoundarySurface"
type="wtr:WaterGroundSurfaceType">
  <annotation>
    <documentation>A WaterGroundSurface represents the exterior boundary surface of
the submerged bottom of a water body.</documentation>
  </annotation>
</element>
<complexType name="WaterGroundSurfaceType">
  <complexContent>
    <extension base="wtr:AbstractWaterBoundarySurfaceType">
      <sequence>
        <element maxOccurs="unbounded" minOccurs="0" name="adeOfWaterGroundSurface"
type="wtr:ADEOfWaterGroundSurfacePropertyType">
          <annotation>
            <documentation>Augments the WaterGroundSurface with properties defined
in an ADE.</documentation>
          </annotation>
        </element>
      </sequence>
    </extension>
  </complexContent>
</complexType>
<complexType name="WaterGroundSurfacePropertyType">
  <sequence minOccurs="0">
    <element ref="wtr:WaterGroundSurface"/>
  </sequence>
  <attributeGroup ref="gml:AssociationAttributeGroup"/>
  <attributeGroup ref="gml:OwnershipAttributeGroup"/>
</complexType>
<element name="WaterSurface" substitutionGroup="wtr:AbstractWaterBoundarySurface"
type="wtr:WaterSurfaceType">
  <annotation>
    <documentation>A WaterSurface represents the upper exterior interface between a
water body and the atmosphere.</documentation>
  </annotation>
</element>
<complexType name="WaterSurfaceType">
```

```xml
    <complexContent>
      <extension base="wtr:AbstractWaterBoundarySurfaceType">
        <sequence>
          <element minOccurs="0" name="waterLevel" type="gml:CodeType">
            <annotation>
              <documentation>Specifies the level of the WaterSurface.</documentation>
            </annotation>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="adeOfWaterSurface"
type="wtr:ADEOfWaterSurfacePropertyType">
            <annotation>
              <documentation>Augments the WaterSurface with properties defined in an
ADE.</documentation>
            </annotation>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="WaterSurfacePropertyType">
    <sequence minOccurs="0">
      <element ref="wtr:WaterSurface"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
    <attributeGroup ref="gml:OwnershipAttributeGroup"/>
  </complexType>
</schema>
```

Annex D: Conceptual Model Conformance (Normative)

NOTE This is where conformance with CityGML 3.0 Conceptual Model is documented.

Annex E: Codelists (Informative)

Codelists are tables of attribute values and corresponding discription or definition. Values in a specific table may be used for designated properties with the codelist stereotype in the UML Conceptual Model(CM). The CityGML 3.0 CM defines 140 such attributes.

The values for each of these 140 codelist attributes are interpreted in a specific application context. In particular, they may be required, recommended, or suggested by an authority within an organization or community. As a consequence, the lists and contained values are outside the scope of standardization of the CityGML CM or any of its encodings. Since only the values themselves, not the lists or tables, appear in CiotyGML GML-encoded documents, the structure of codelists also lies outside the scope of CityGML CM and Encoding standards. Nevertheless, it is helpful to have some example codelists available for inspection by developers working with a specific encoding. This Annex contains example structures for GML, comma-separated-value (CS), and JSON codelists. SUpplementing these structures, OGC maintains a CityGML 3.0 codelist repository with samples of each of the 140 CityGML 3.0 codelist attributes in GML, CSV, and JSON form at https://data.ogc.org/citygml-swg/3.0/*codelist_name.extension* , where *codelist_name* is the name of the attribute in the CityGML 3.0 CM UML diagram and *extension* is "xml", "csv", or "json" to indicate the encoding.

E.1. Logical Model

There is no standardized model for CityGML codelists but the following is an example that meets rqeuirements for documenting the source, currency, language, and other characteristics of the list of values. This is the model followed by the CityGML 3.0 codelist examples hosted by OGC.
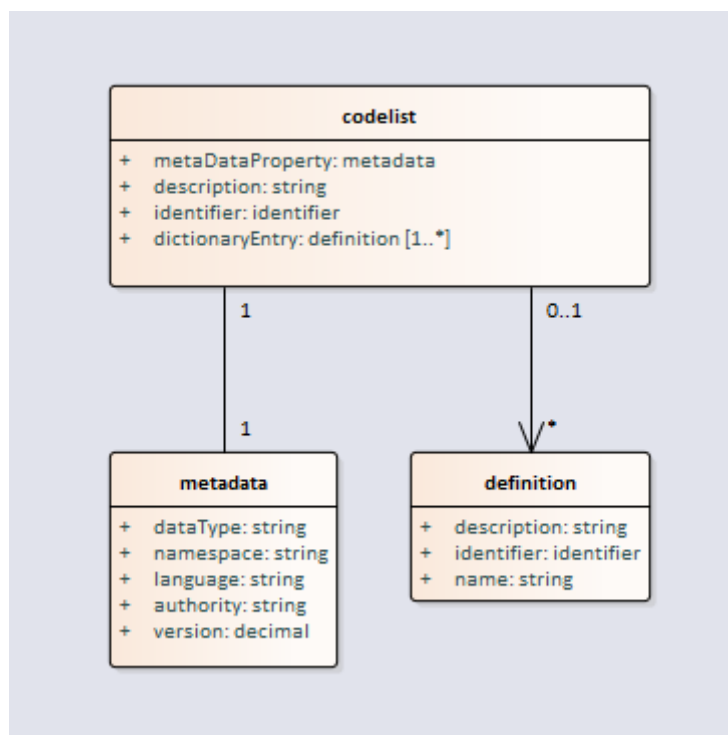

Figure 23. Codelist UML Class Diagram

E.2. Examples

E.2.1. GML

This GML encoding of the example logical model for codelists, dictionary entry, and entry metadata have XML schema definitions as follows:

- codelist

```xml
<?xml version="1.0" encoding="utf-8"?>
<xs:schema xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:cmd="http://www"
attributeFormDefault="unqualified" elementFormDefault="qualified"
xmlns:xs="http://www.w3.org/2001/XMLSchema">
  <xs:import schemaLocation="schema1.xsd" namespace="http://www.opengis.net/gml/3.2"
/>
  <xs:element name="codelist">
    <xs:complexType>
      <xs:sequence>
        <xs:element ref="gml:Dictionary" />
      </xs:sequence>
    </xs:complexType>
  </xs:element>
</xs:schema>
```

- dictionary entry

```xml
<?xml version="1.0" encoding="utf-8"?>
<xs:schema xmlns:tns="http://www.opengis.net/gml/3.2"
attributeFormDefault="unqualified" elementFormDefault="qualified"
targetNamespace="http://www.opengis.net/gml/3.2"
xmlns:xs="http://www.w3.org/2001/XMLSchema">
  <xs:import schemaLocation="schema2.xsd" namespace="http://www" />
  <xs:element name="Dictionary">
    <xs:complexType>
      <xs:sequence>
        <xs:element name="metaDataProperty">
          <xs:complexType>
            <xs:sequence>
              <xs:element xmlns:q1="http://www" ref="q1:CodeListMetaData" />
            </xs:sequence>
          </xs:complexType>
        </xs:element>
        <xs:element name="description" type="xs:string" />
        <xs:element name="identifier">
          <xs:complexType>
            <xs:simpleContent>
              <xs:extension base="xs:string">
                <xs:attribute name="codeSpace" type="xs:string" use="required" />
              </xs:extension>
```

```
          </xs:simpleContent>
        </xs:complexType>
      </xs:element>
      <xs:element maxOccurs="unbounded" name="dictionaryEntry">
        <xs:complexType>
          <xs:sequence>
            <xs:element name="Definition">
              <xs:complexType>
                <xs:sequence>
                  <xs:element name="description" type="xs:string" />
                  <xs:element name="identifier">
                    <xs:complexType>
                      <xs:simpleContent>
                        <xs:extension base="xs:unsignedShort">
                          <xs:attribute name="codeSpace" type="xs:string"
use="required" />
                        </xs:extension>
                      </xs:simpleContent>
                    </xs:complexType>
                  </xs:element>
                  <xs:element name="name" type="xs:string" />
                </xs:sequence>
                <xs:attribute ref="tns:id" use="required" />
              </xs:complexType>
            </xs:element>
          </xs:sequence>
        </xs:complexType>
      </xs:element>
    </xs:sequence>
    <xs:attribute ref="tns:id" use="required" />
  </xs:complexType>
</xs:element>
<xs:attribute name="id" type="xs:string" />
</xs:schema>
```

- metadata

```
<?xml version="1.0" encoding="utf-8"?>
<xs:schema xmlns:tns="http://www" attributeFormDefault="unqualified"
elementFormDefault="qualified" targetNamespace="http://www"
xmlns:xs="http://www.w3.org/2001/XMLSchema">
  <xs:element name="CodeListMetaData">
    <xs:complexType>
      <xs:sequence>
        <xs:element name="dataType" type="xs:string" />
        <xs:element name="namespace" type="xs:string" />
        <xs:element name="language" type="xs:string" />
        <xs:element name="authority" type="xs:string" />
        <xs:element name="version" type="xs:decimal" />
      </xs:sequence>
    </xs:complexType>
  </xs:element>
</xs:schema>
```

The following is an example:

```
<?xml version="1.0" encoding="utf-8"?>
<codelist xmlns:gml="http://www.opengis.net/gml/3.2"
          xmlns:cmd="http://www">
    <gml:Dictionary gml:id="roofTypes">
        <gml:metaDataProperty>
            <cmd:CodeListMetaData>
                <cmd:dataType>RoofTypeValue</cmd:dataType>

<cmd:namespace>http://www.opengis.net/citygml/building/3.0</cmd:namespace>
                <cmd:language>en</cmd:language>
                <cmd:authority>xyz</cmd:authority>
                <cmd:version>1.0</cmd:version>
            </cmd:CodeListMetaData>
        </gml:metaDataProperty>
        <gml:description>Roof type values</gml:description>
        <gml:identifier
codeSpace="https://ogc.org/citygml/3.0/codelists/gml/rooftypes">RoofTypeValue</gml:ide
ntifier>
        <gml:dictionaryEntry>
            <gml:Definition gml:id="id1">
                <gml:description>roof primarily a single plane, not necessarily
level</gml:description>
                <gml:identifier
codeSpace="https://ogc.org/citygml/3.0/codelists/gml/rooftypes">1000</gml:identifier>
                <gml:name>flat roof</gml:name>
            </gml:Definition>
        </gml:dictionaryEntry>
        <gml:dictionaryEntry>
            <gml:Definition gml:id="id2">
                <gml:description>a roof that has a ridge and two
gables</gml:description>
                <gml:identifier
codeSpace="https://ogc.org/citygml/3.0/codelists/gml/rooftypes">3100</gml:identifier>
                <gml:name>saddle roof</gml:name>
            </gml:Definition>
        </gml:dictionaryEntry>
    </gml:Dictionary>
</codelist>
```

E.2.2. Comma Separated Values(CSV) Structure

This CSV encoding of the example logical model is illustrated with the following example:

```
csv example goes here
```

E.2.3. JSON

This JSON encoding of the example logical model for codelists has a JSON-Schema 2019-09

definition as follows:

```
json-schema file content goes here
```

The following is an example:

```
json example goes here
```

Annex F: Revision History

Date	Release	Editor	Primary clauses modified	Description
2016-04-28	0.1	G. Editor	all	initial version

Annex G: Glossary

conformance test class

set of conformance test modules that must be applied to receive a single certificate of conformance
[OGC 08-131r3, definition 4.4]

feature

abstraction of real world phenomena
[ISO 19101-1:2014, definition 4.1.11]

feature attribute

characteristic of a feature
[ISO 19101-1:2014, definition 4.1.12]

feature type

class of features having common characteristics
[ISO 19156:2011, definition 4.7]

measurement

set of operations having the object of determining the value of a quantity
[ISO 19101-2:2018, definition 3.21] / [VIM:1993, 2.1]

model

abstraction of some aspects of reality
[ISO 19109:2015, definition 4.15]

observation

act of measuring or otherwise determining the value of a property
[ISO 19156:2011, definition 4.11]

observation procedure

method, algorithm or instrument, or system of these, which may be used in making an observation
[ISO 19156:2011, 4.12]

observation result

estimate of the value of a property determined through a known observation procedure
[ISO 19156:2011, 4.14]

property

facet or attribute of an object referenced by a name.
[ISO 19143:2010, definition 4.21]

requirements class

aggregate of all requirement modules that must all be satisfied to satisfy a conformance test class
[OGC 08-131r3, definition 4.19]

schema

formal description of a model
[ISO 19101-1:2014, definition 4.1.34]

sensor
type of observation procedure that provides the estimated value of an observed property at its output
[OGC 08-094r1, definition 4.5]

Standardization Target
TBD

timeseries
sequence of data values which are ordered in time
[OGC 15-043r3]

universe of discourse
view of the real or hypothetical world that includes everything of interest
[ISO 19101-1:2014, definition 4.1.38]

version
Particular variation of a spatial object
[INSPIRE Glossary]

G.1. ISO Concepts

The following concepts from the ISO TC211 Harmonized UML model are referenced by the CityGML Conceptual UML model but do not play a major role in its' definition. They are provided here to support a more complete understanding of the model.

Area
The measure of the physical extent of any topologically 2-D geometric object. Usually measured in "square" units of length.
[ISO 19103:2015]

Boolean
boolean is the mathematical datatype associated with two-valued logic
[ISO 19103:2015]

CC_CoordinateOperation
mathematical operation on coordinates that transforms or converts coordinates to another coordinate reference system.
[ISO 19111:2019]

Character
symbol from a standard character-set.
[ISO 19103:2015]

CharacterString
Characterstring is a family of datatypes which represent strings of symbols from standard character-sets.
[ISO 19103:2015]

CRS

Coordinate reference system which is usually single but may be compound.
[ISO 19111:2019]

CV_DiscreteCoverage
A subclass of CV_Coverage that returns a single record of values for any direct position within a single geometric object in its spatiotemporal domain.
[ISO 19123:2005]

CV_DomainObject
[ISO 19123:2005]

CV_GridPointValuePair
[ISO 19123:2005]

CV_GridValuesMatrix
The geometry represented by the various offset vectors is in the image plane of the grid.
[ISO 19123:2005]

CV_ReferenceableGrid
[ISO 19123:2005]

Date
Date gives values for year, month and day. Representation of Date is specified in ISO 8601. Principles for date and time are further discussed in ISO 19108.
[ISO 19103:2015]

DateTime
A DateTime is a combination of a date and a time types. Representation of DateTime is specified in ISO 8601. Principles for date and time are further discussed in ISO 19108.
[ISO 19103:2015]

Distance
Used as a type for returning distances and possibly lengths.
[ISO 19103:2015]

Engineering CRS
A contextually local coordinate reference system which can be divided into two broad categories:

1. earth-fixed systems applied to engineering activities on or near the surface of the earth;

2. CRSs on moving platforms such as road vehicles, vessels, aircraft or spacecraft.
   [ISO 19111:2019]

Generic Name
Generic Name is the abstract class for all names in a NameSpace. Each instance of a GenericName is either a LocalName or a ScopedName.
[ISO 19103:2015]

Geometry
[ISO 19107:2003]

GM_CompositePoint
[ISO 19107:2003]

GM_CompositeSolid
set of geometric solids adjoining one another along common boundary geometric surfaces
[ISO 19107:2003]

GM_GenericSurface
GM_Surface and GM_SurfacePatch both represent sections of surface geometry, and therefore share a number of operation signatures. These are defined in the interface class GM_GenericSurface.
[ISO 19107:2003]

GM_LineString
consists of sequence of line segments, each having a parameterization like the one for GM_LineSegment
[ISO 19107:2003]

GM_MultiPrimitive
[ISO 19107:2003]

GM_OrientableSurface
a surface and an orientation inherited from GM_OrientablePrimitive. If the orientation is "+", then the GM_OrientableSurface is a GM_Surface. If the orientation is "-", then the GM_OrientableSurface is a reference to a GM_Surface with an upNormal that reverses the direction for this GM_OrientableSurface, the sense of "the top of the surface".
[ISO 19107:2003]

GM_PolyhedralSurface
a GM_Surface composed of polygon surfaces (GM_Polygon) connected along their common boundary curves.
[ISO 19107:2003]

GM_Position
a union type consisting of either a DirectPosition or of a reference to a GM_Point from which a DirectPosition shall be obtained.
[ISO 19107:2003]

GM_Primitive
The abstract root class of the geometric primitives. Its main purpose is to define the basic "boundary" operation that ties the primitives in each dimension together.
[ISO 19107:2003]

Integer
An exact integer value, with no fractional part.
[ISO 19103:2015]

Internet of Things
The network of physical objects--"things"--that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet.

IO_IdentifiedObjectBase
[ISO 19103:2015]

Length
The measure of distance as an integral, i.e. the limit of an infinite sum of distances between points on a curve.
[ISO 19103:2015]

Measure
The result from performing the act or process of ascertaining the extent, dimensions, or quantity of some entity.
[ISO 19103:2015]

Number
The base type for all number data, giving the basic algebraic operations.
[ISO 19103:2015]

Point
GM_Point is the basic data type for a geometric object consisting of one and only one point.
[ISO 19107:2003]

Real
The common binary Real finite implementation using base 2.
[ISO 19103:2015]

RS_ReferenceSystem
Description of a spatial and temporal reference system used by a dataset.
[ISO 19111:2019]

Scoped Name
ScopedName is a composite of a LocalName for locating another NameSpace and a GenericName valid in that NameSpace. ScopedName contains a LocalName as head and a GenericName, which might be a LocalName or a ScopedName, as tail.
[ISO 19103:2015]

Solid
GM_Solid, a subclass of GM_Primitive, is the basis for 3-dimensional geometry. The extent of a solid is defined by the boundary surfaces.
[ISO 19107:2003]

Time
Time is the designation of an instant on a selected time scale, astronomical or atomic. It is used in the sense of time of day.
[ISO 19103:2015]

TM_Duration
[ISO 19108:2006]

TM_TemporalPosition
The position of a TM_Instant relative to a TM_ReferenceSystem.
[ISO 19108:2006]

Unit of Measure
Any of the systems devised to measure some physical quantity such distance or area or a system devised to measure such things as the passage of time.
[ISO 19103:2015]

URI
Uniform Resource Identifier (URI), is a compact string of characters used to identify or name a resource
[ISO 19103:2015]

Volume
Volume is the measure of the physical space of any 3-D geometric object.
[ISO 19103:2015]

G.2. Abbreviated Terms

- 2D   Two Dimensional

- 3D   Three Dimensional

- AEC   Architecture, Engineering, Construction

- ALKIS   German National Standard for Cadastral Information

- ATKIS   German National Standard for Topographic and Cartographic Information

- BIM   Building Information Modeling

- B-Rep   Boundary Representation

- bSI   buildingSMART International

- CAD   Computer Aided Design

- COLLADA   Collaborative Design Activity

- CSG   Constructive Solid Geometry

- DTM   Digital Terrain Model

- DXF   Drawing Exchange Format

- EuroSDR   European Spatial Data Research Organisation

- ESRI   Environmental Systems Research Institute

- FM   Facility Management

- GDF   Geographic Data Files

- GDI-DE   Spatial Data Infrastructure Germany (Geodateninfrastruktur Deutschland)

- GDI   NRW Geodata Infrastructure North-Rhine Westphalia

- GML   Geography Markup Language

- IAI   International Alliance for Interoperability (now buildingSMART International (bSI))

- IETF   Internet Engineering Task Force

- IFC   Industry Foundation Classes

- IoT   Internet of Things

- ISO   International Organization for Standardisation

- ISO/TC211   ISO Technical Committee 211

- LOD   Levels of Detail

- MQTT

- NBIMS   National Building Information Model Standard

- OASIS   Organisation for the Advancement of Structured Information Standards

- OGC   Open Geospatial Consortium

- OSCRE   Open Standards Consortium for Real Estate

- SIG 3D   Special Interest Group 3D of the GDI-DE

- TIC   Terrain Intersection Curve

- TIN   Triangulated Irregular Network

- UML   Unified Modeling Language

- URI   Uniform Resource Identifier

- VRML   Virtual Reality Modeling Language

- W3C   World Wide Web Consortium

- W3DS   OGC Web 3D Service

- WFS   OGC Web Feature Service

- X3D   Open Standards XML-enabled 3D file format of the Web 3D Consortium

- XML   Extensible Markup Language

- xAL   OASIS extensible Address Language

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