OGC City Geography Markup Language (CityGML) 3.0 Conceptual Model
Users Guide

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i. Abstract

CityGML is an open conceptual data model for the storage and exchange of virtual 3D city models. It is defined through a Unified Modeling Language (UML) object model. This UML model extends the ISO Technical Committee 211 (TC211) conceptual model standards for spatial and temporal data. Building on the ISO foundation assures that the man-made features described in the City Models share the same spatial-temporal universe as the surrounding countryside within which they reside.

The aim of the development of CityGML is to reach a common definition of the basic entities, attributes, and relations of a 3D city model. This is especially important with respect to the cost-effective sustainable maintenance of 3D city models, allowing the reuse of the same data in different application fields.

ii. Keywords

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

ogcdoc, OGC document, CityGML, 3D city models

iii. Preface

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Recipients of this document are requested to submit, with their comments, notification of any relevant patent claims or other intellectual property rights of which they may be aware that might be infringed by any implementation of the standard set forth in this document, and to provide supporting documentation.
Chapter 1. Introduction

An increasing number of cities and companies are building virtual 3D city models for different application areas like urban planning, mobile telecommunication, disaster management, 3D cadastre, tourism, vehicle and pedestrian navigation, facility management and environmental simulations. Furthermore, in the implementation of the European Environmental Noise Directive (END, 2002/49/EC) 3D geoinformation and 3D city models play an important role.

In recent years, most virtual 3D city models have been defined as purely graphical or geometrical models, neglecting the semantic and topological aspects. Thus, these models could almost only be used for visualisation purposes but not for thematic queries, analysis tasks, or spatial data mining. Since the limited reusability of models inhibits the broader use of 3D city models, a more general modelling approach had to be taken in order to satisfy the information needs of the various application fields.

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

CityGML is an open conceptual data model for the storage and exchange of virtual 3D city models. It is defined through a Unified Modeling Language (UML) object model. This UML model extends the ISO Technical Committee 211 (TC211) conceptual model standards for spatial and temporal data. Building on the ISO foundation assures that the man-made features described in the City Models share the same spatial-temporal universe as the surrounding countryside within which they reside.

CityGML defines the classes and relations for the most relevant topographic objects in cities and regional models with respect to their geometrical, topological, semantical, and appearance properties. “City” is broadly defined to comprise not just built structures, but also elevation, vegetation, water bodies, “city furniture”, and more. Included are generalisation hierarchies between thematic classes, aggregations, relations between objects, and spatial properties. CityGML is applicable for large areas and small regions and can represent the terrain and 3D objects in different levels of detail simultaneously. Since either simple, single scale models without topology and few semantics or very complex multi-scale models with full topology and fine-grained semantical differentiations can be represented, CityGML enables lossless information exchange between different GI systems and users.
Chapter 2. Scope

This document provides Engineering Guidance on the use of the CityGML 3.0 Conceptual Model Standard.

The OGC Conceptual Model Standard specifies the representation of virtual 3D city and landscape models. The CityGML 3.0 Conceptual Model is expected to be the basis for a number of future Encoding Standards in which subsets of the Conceptual Model can be implemented. These Encoding Standards will enable both storage and exchange of data.

The CityGML 3.0 Conceptual Model Standard was designed to be concise and easy to use. As a result, most non-normative content has been removed. The purpose of this Users Guide is to capture that non-normative content and make it easy to access if and when needed.
Chapter 3. References

The following normative documents contain provisions that, through reference in this text, constitute provisions of OGC 20-010. 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 12-019 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),
- ISO: ISO 19111:2019, Geographic information – Referencing by coordinates
- OASIS: Customer Information Quality Specifications - extensible Address Language (xAL), Version v3.0
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 Best Practice.

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

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]

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

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

cryptocatal 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]

level 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]

**measurement**
set of operations having the object of determining the value of a quantity

**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]

**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]

## Abbreviated Terms

The following abbreviated terms are used in this document:

The list of acronyms needs to be reviewed once all sections have been updated.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2D</td>
<td>Two Dimensional</td>
</tr>
<tr>
<td>3D</td>
<td>Three Dimensional</td>
</tr>
<tr>
<td>AEC</td>
<td>Architecture, Engineering, Construction</td>
</tr>
<tr>
<td>ALKIS</td>
<td>German National Standard for Cadastral Information</td>
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<tr>
<td>ATKIS</td>
<td>German National Standard for Topographic and Cartographic Information</td>
</tr>
<tr>
<td>B-Rep</td>
<td>Boundary Representation</td>
</tr>
<tr>
<td>bSI</td>
<td>buildingSMART International</td>
</tr>
<tr>
<td>CAD</td>
<td>Computer Aided Design</td>
</tr>
<tr>
<td>COLLADA</td>
<td>Collaborative Design Activity</td>
</tr>
<tr>
<td>CSG</td>
<td>Constructive Solid Geometry</td>
</tr>
<tr>
<td>DTM</td>
<td>Digital Terrain Model</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>---------</td>
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<tr>
<td>DXF</td>
<td>Drawing Exchange Format</td>
</tr>
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<td>EuroSDR</td>
<td>European Spatial Data Research Organisation</td>
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<td>ESRI</td>
<td>Environmental Systems Research Institute</td>
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<td>FM</td>
<td>Facility Management</td>
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<td>GDF</td>
<td>Geographic Data Files</td>
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<td>GDI-DE</td>
<td>Spatial Data Infrastructure Germany (Geodateninfrastruktur Deutschland)</td>
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<td>GDI</td>
<td>NRW Geodata Infrastructure North-Rhine Westphalia</td>
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<td>GML</td>
<td>Geography Markup Language</td>
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<tr>
<td>IAI (bSI)</td>
<td>International Alliance for Interoperability (now buildingSMART International)</td>
</tr>
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<td>IETF</td>
<td>Internet Engineering Task Force</td>
</tr>
<tr>
<td>IFC</td>
<td>Industry Foundation Classes</td>
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<tr>
<td>ISO</td>
<td>International Organization for Standardisation</td>
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<tr>
<td>LOD</td>
<td>Level of Detail</td>
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<td>NBIMS</td>
<td>National Building Information Model Standard</td>
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<tr>
<td>OASIS</td>
<td>Organisation for the Advancement of Structured Information Standards</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>OGC</td>
<td>Open Geospatial Consortium</td>
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<td>OSCRE</td>
<td>Open Standards Consortium for Real Estate</td>
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<td>SIG 3D</td>
<td>Special Interest Group 3D of the GDI-DE</td>
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<td>TC211</td>
<td>ISO Technical Committee 211</td>
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<tr>
<td>TIC</td>
<td>Terrain Intersection Curve</td>
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<td>TIN</td>
<td>Triangulated Irregular Network</td>
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<td>UML</td>
<td>Unified Modeling Language</td>
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<tr>
<td>URI</td>
<td>Uniform Resource Identifier</td>
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<td>VRML</td>
<td>Virtual Reality Modeling Language</td>
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<td>W3C</td>
<td>World Wide Web Consortium</td>
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<td>W3DS</td>
<td>OGC Web 3D Service</td>
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<td>WFS</td>
<td>OGC Web Feature Service</td>
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<td>X3D</td>
<td>Open Standards XML-enabled 3D file format of the Web 3D Consortium</td>
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<td>XML</td>
<td>Extensible Markup Language</td>
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<td>xAL</td>
<td>OASIS extensible Address Language</td>
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Chapter 4. User Guide

4.1. Conceptual Modeling

NOTE | Under Construction

4.2. Spatial-Temporal Fundamentals

NOTE | Under Construction

4.3. Extensions

NOTE | Under Construction

4.4. Core

NOTE | Under Construction

4.5. Appearance

NOTE | Under Construction

4.6. Bridge Model

NOTE | Under Construction

4.7. Building Model

NOTE | Under Construction

4.8. City Furniture

NOTE | Under Construction

4.9. City Object Group

NOTE | Under Construction
4.10. Construction
NOTE | Under Construction

4.11. Dynamizer
NOTE | Under Construction

4.12. Generics
NOTE | Under Construction

4.13. Land Use
NOTE | Under Construction

4.14. Point Cloud
NOTE | Under Construction

4.15. Relief
NOTE | Under Construction

4.16. Transportation
NOTE | Under Construction

4.17. Tunnel Model
NOTE | Under Construction

4.18. Vegetation
NOTE | Under Construction

4.19. Versioning
NOTE | Under Construction
4.20. Waterbodies

NOTE Under Construction
## Annex A: Revision History

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<td>G. Editor</td>
<td>all</td>
<td>initial version</td>
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Annex B: Bibliography

Example Bibliography (Delete this note).

The TC has approved Springer LNCS as the official document citation type.

Springer LNCS is widely used in technical and computer science journals and other publications

• For citations in the text please use square brackets and consecutive numbers: [1], [2], [3]

– Actual References:

[n] Journal: Author Surname, A.: Title. Publication Title. Volume number, Issue number, Pages Used (Year Published)
