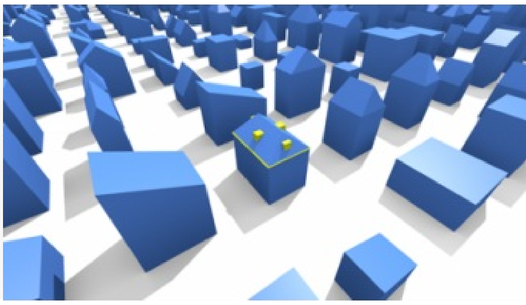
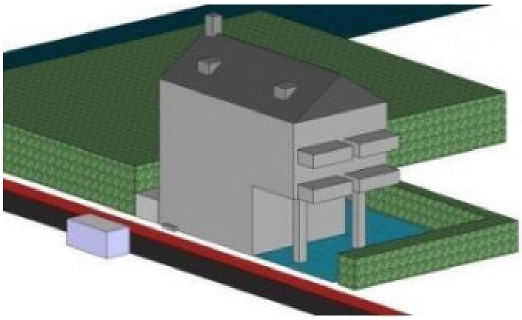
IMPROVEMENT OF THE LOD CONCEPT FOR 3D CITY MODELS

Redefining the Level of Detail for 3D Models



	3D City Model LOD specification				LOD i			
General metrics	Feature complexity				0.4 m			
	Appearance resolution				0.3 m/px			
	Semantics				Yes, full spatio-semantic coherence			
City objects and elements	Object	Feat. C.	Attributes	Elements	Feat. C.	Dim.	Appearance	Attributes
	Buildings		+ Occupancy + EnergyRating	Wall		2		+ Material
				Roof	0.2 m	3		None
				Roof.Dormer	0.2 m	3		None
				Chimney	0.2 m	3		None
				Balcony		3		None
				Pier		3		None
				Opening		2		None
				Interior				
				Storey		3	None	+ Use
	Roads		+ RoadUse	Traffic area- Cars		2	Black	+ SpeedLimit
				Traffic area- Bicycles		2	Red	None
	Street lights	1 m	+ PowerConsumption	Pole		3	None	None



Cities are increasingly adopting 3D city models for 3D visualisation, computing solar panel potential of roofs, and other applications. In a similar way to traditional maps, 3D models are an abstraction of the real world: certain elements are simplified or omitted. The amount of detail that is captured in a 3D model, both in terms of geometry and attributes, is collectively referred to as the level of detail. The CityGML standard from OGC defines five different LODs, but the specification is not very precise. In this article, the authors propose an improved specification for defining the level of detail in a 3D city model.

(By Filip Biljecki, Hugo Ledoux and Jantien Stoter, Delft University of Technology, The Netherlands)

The level of detail (LOD) is a concept in 3D city modelling which is used to indicate how thoroughly 3D data should be surveyed and how much detail should be modelled. For instance, a municipality will specify an LOD when tendering 3D modelling work to a company. The most popular LOD classification is the one found in the CityGML OGC standard. This defines five LODs, ranging from a simple 2.5D model of footprints to a detailed architectural model containing indoor features such as rooms and furniture (Figure 1). Higher LODs do not only increase in their geometric complexity but also in their semantic richness, that is the description of the geometry. Practitioners actively use the LOD designations as shorthand of the specification and for expressing the fineness of a 3D model, and it has become a de facto standard even when models are not related to CityGML.

Shortcomings of LOD in CityGML

The geospatial industry relies on the CityGML LOD definition for communicating the design quality of 3D data. However, the standard defines the LODs only narratively, without clear specification of the requirements for each. As a result, ambiguities and misunderstandings are possible.

Because CityGML's LODs are not strictly specified, the standard allows a high degree of freedom in the acquisition of the models. Hence, two models of significantly different complexities may still be considered as the same LOD. A prominent example is LOD2. In practice, if an LOD2 model is ordered, it is not certain if semantics are defined and if dormers are present, which might be important for the intended application (Figure 2). Due to this shortcoming in the standard, the data behind an LOD2 model could be almost anything. This hinders the use and exchange of models in practice. In particular, it is difficult to estimate and compare costs if the definition of an LOD is not clear. On the other hand, the LOD concept provides too little granularity to describe a model which exactly suits the user's needs.

LOD-defining Parameters

The authors examined dozens of specifications of 3D data, internal practices of companies and tenders, and spoke with users about their views on the LOD concept. The LOD concept has been decomposed into six defining metrics, as follows:

1. Presence of features: the real-world objects and their elements that are to be included
2. Feature complexity: the complexity of the geometry of the features and the minimum size of the real-world features
3. Spatio-semantic coherence: the richness of the semantics
4. Texture: whether features have to be textured, and if so to which level of quality
5. Dimensionality: the dimension of the geometry of each feature
6. The list and values of the attributes that are required for each feature.

Thanks to this decomposition, and because each of the metrics can be quantified, it is possible to define the LOD unambiguously for each model.

New Specification

During the research, it became apparent that it is difficult to uniformly specify requirements for each of the six metrics. Different applications rely on different types of models, and thus the metrics may vary. The authors therefore developed a specification format (Figure 3) intended for industry use for precise specification of the requirements prior to the acquisition of a 3D city model.

Based on the framework developed, the authors constructed their own series of 10 precisely defined LODs which do not leave much ambiguity or gaps between them in order to address the shortcomings of the CityGML concept. A visual example can be seen in Figure 4, which shows the LOD6 and LOD7 of the series side by side.

Standardisation

The developed framework enables each stakeholder to define their own series of LODs. It is hoped that this will lead to unambiguous specifications and clear procurement of 3D models, eliminating many potential misunderstandings. Because of the influence that the CityGML LOD concept has in the industry, the authors regard it as a high priority to improve it. OGC has also recognised the need for refining the concept, and relevant efforts are already underway. The authors of this article are involved in the CityGML Standards Working Group which is currently developing the new version of the standard, due in 2016.

Biographies of the authors

Filip Biljecki is a PhD researcher in GIS at Delft University of Technology. Previously he worked in business development at Geofoto (Zagreb, Croatia).

Hugo Ledoux has been an assistant professor of GIS at Delft University of Technology since 2008. He is particularly interested in combining the fields of GIS and computational geometry.

Jantien Stoter is a professor of GIS at Delft University of Technology. She obtained her PhD degree (3D cadastre) in 2004. Jantien combines her professorship with jobs as a researcher at both the Kadaster and Geonovum.

Further reading

Biljecki, F. et al., 2013. Revisiting the concept of level of detail in 3D city modelling. Proceedings of the ISPRS 8th 3D GeoInfo Conference & WG II/2 Workshop. Istanbul, Turkey, pp. 63–74.

Biljecki, F. et al., 2014. Formalisation of the level of detail in 3D city modelling. *Computers, Environment and Urban Systems*, 48, pp. 1–15.

Stadler, A. & Kolbe, T.H., 2007. Spatio-semantic coherence in the integration of 3D city models. Proceedings of the ISPRS WG II/7 5th International Symposium Spatial Data Quality with the theme: Modelling qualities in space and time. Enschede, The Netherlands.

Löwner, M.-O. et al., 2013. New concepts for structuring 3D city models – an extended level of detail concept for CityGML buildings. Proceedings of the 13th International Conference Computational Science and Its Applications – ICCSA 2013. Ho Chi Minh City, Vietnam, pp. 466–480.