

# A 3D MODEL FOR GEO-INFORMATION IN THE NETHERLANDS

E. Verbree<sup>a</sup>, J. Stoter<sup>a,c</sup>, S. Zlatanova<sup>a</sup>, G. de Haan<sup>b</sup>, M. Reuvers<sup>c</sup>, G. Vosselman<sup>d</sup>, J. Goos<sup>e</sup>, L. van Berlo<sup>f</sup>, R. Klooster<sup>g</sup>

<sup>a</sup> Section GISt, OTB Research Institute for the Built Environment, Delft University of Technology, Jaffalaan 9, 2628BX, Delft, the Netherlands

<sup>b</sup> Computer Graphics & CAD/CAM group, faculty of EEMCS, Delft University of Technology (e.verbree, j.stoter, s.zlatanova, g.dehaan)<sup>b</sup>@tudelft.nl

<sup>c</sup> Kadaster, Apeldoorn, the Netherlands

<sup>d</sup> NCG & ITC, University Twente, Enschede, the Netherlands

<sup>e</sup> Municipality Rotterdam, Rotterdam, the Netherlands

<sup>f</sup> TNO, Delft, the Netherlands

<sup>g</sup> Municipality Apeldoorn, Apeldoorn, the Netherlands

## Commission IV

**KEY WORDS:** 3D, CityGML, DBMS, Spatial Infrastructures, use cases

### ABSTRACT:

This paper presents the work in progress of a research project that aims at establishing a reference model for 3D geo-information in the Netherlands. The research project is initiated by four national organizations: 1) Ministry of Housing, Spatial Planning and the Environment, 2) Kadaster, 3) Geonovum, and 4) the Netherlands Geodetic Commission. These four organizations responsible for geo-information in the Netherlands recognized the urgent need for a standardized approach and therefore initiated a 3D pilot. In the 3D pilot, a uniform approach for 3D geo-information modeling is explored in collaboration with a large number of stakeholders ultimately resulting in national agreements and a national standard, extending CityGML, for use of 3D geo-information. The final aim of the 3D pilot is to evoke a breakthrough in the use of 3D geo-information in the Netherlands. In the pilot providers and users of geo-information closely collaborate, which ensures that the providers are familiar with precise requirements of the users. This pilot aims also at an improved accessibility to 3D geo-information and the supporting technologies, which may push advances in 3D applications.

The paper will present the scope of the pilot, the methodology and the first results of the investigations with the four working groups. The first working group investigates questions such as generation of a 3D reference model from different data sources, such as point clouds and images from airborne and terrestrial sensors, 2D data from above and below the surface, and 3D models from the building domain (CAD/AEC/BIM/IFC models). The second working group concentrates on defining a 3D standard for the Netherlands, considering international and national developments. The third working group is responsible for organizing of a 3D testbed to study the bottlenecks in organizing the 3D information in a database system. The fourth working group investigates the use of 3D geo-information in various applications, with the goal to define and execute appropriate use cases.

## 1. INTRODUCTION

This paper presents the work in progress of a research project that aims at establishing a reference model for 3D geo-information in the Netherlands by extending existing 2D and 3D national and international standards.

The research project is initiated by four national organizations: Ministry of Housing, Spatial Planning and the Environment, the Kadaster (the Dutch national cadastre and mapping agency), Geonovum (the National Spatial Data Infrastructure executive committee in the Netherlands which develops and manages the geo-standards) and the Netherlands Geodetic Commission (co-ordinates and initiates fundamental and strategic research in geodesy and geo-information in the Netherlands).

These four organizations observed that 3D information in the Netherlands is only used in specific applications and that there is a need for a uniform approach to advance in the domain of 3D applications. In addition the existing OGC standard for 3D models (CityGML) is rarely used. In the project a uniform approach for 3D geo-information modeling, exchange and use is empirically explored in collaboration with many stakeholders ultimately aiming at national agreements and standards.

This paper presents the scope of the project as agreed by all participants (Section 2); the methodology of the project (Section 3) and the different activities that realize the project objectives (Section 4). Section 5 concludes on the work in progress.

## 2. SCOPE OF THE PROJECT

The starting point for the 3D standard in our research project is the international 3D standard: CityGML (Emgård and Zlatanova, 2008; Gröger et al, 2008; Gröger et al, 2006). The suitability of CityGML is studied compatible to the national standards for 2D geo-information, other 3D standards (Collada, IFC, KML, 3ds) and Building Information Models. In addition it is studied if CityGML extensions are needed to realize a generic national 3D standard-NL. These extensions may contribute to Application Domain Extensions (ADE) of CityGML in development, such as underground constructions, cables and pipelines and to integration with Building Information Models.

The national standards for 2D information are based on the NEN3610 model of which the OGC compliant version was finalized in 2005. The aim of this model (a new version is currently being established) is to have common definitions for object classes in the geo-information domain at generic level. Geo-application domains have built and are building their specific domain models on this generic model (see Figure 1).

Examples are information models for physical planning (IMRO), for cables and pipelines (IMKL), for soil and subsurface (IMBOD/IMBRO), for water (IMWA), for large-scale topography (IMGeo) (Geonovum, 2010).

These 2D information models have enabled the integration of geo-information from different sources and have also improved accessibility of geo-information by different types of clients. The 3D research aims at a 3D standard compatible to the 2D information models.

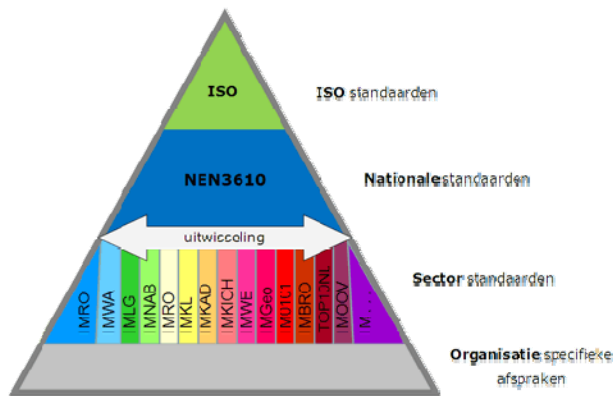


Figure 1. 2D standardisation framework in the Netherlands: Common definition through generic ISO, National, and Sector Standards to Organizational specific agreements

## 3. METHODOLOGY

To meet the high ambitions of the project, i.e. to establish a national 3D standard, it was clear from the start that (many) suppliers and users of geo-data and geo-information as well as of 3D technologies should be involved. Therefore a call

was launched in January 2010. About 90 people from about 45 organizations responded to the call (see Table 1). Most of the motivations that the respondents were asked to write, confirmed the observation that 3D geo-information is currently only used in ad hoc and specific applications. In addition many of the motivations expressed an urgent need for a uniform approach for 3D modeling.

To meet the aims of the project in collaboration with so many organizations and companies four activities were defined. These activities are executed in coherence with each other and jointly realize the objectives (see Figure 2). The four activities, which will be further detailed in section 4, are:

1. Identifying the availability of 3D geo-data and geo-information and sourcing test data as well as identifying best practices for 3D geo-information acquisition
2. Investigating and defining 3D standard-NL
3. Designing and implementing 3D testbed
4. Specifying needs for 3D geo-information and technologies through use cases and evaluation of prototypes

4innovations	Gemeente Amsterdam	Nedgraphics	I&C Science, University Utrecht
4sight	Gemeente Rotterdam	Neo	TUD Computer Graphics
Aerodata	Gemeente Tilburg	Nat. Lucht en Ruimtevaart laboratorium	TUD GIST, OTB
AGIV	Geodan	Object Vision	TUD Lucht en Ruimtevaart
AHN	Geodelta	Architect Oosterhuis_Lénárd	Alterra Wageningen UR
Bentley	Geonovum	Oracle	
LSV GBKN	Grontmij	Oranjewoud	
BLOM NL	Hansa Luftbild	Politie KLDP	
Cebra	Horus surround Vision	Provincie NB	
Crotec	iDelft	RWS	
Cyclomedia	Intergraph	StrateGIS	
ESRI	ITC - U Twente	TNO Bouw en Ondergrond	
Eurosense	Kadaster	TNO Defensie en Veligheid	
Fugro	KPG, Polen	TNO ICT	
Gemeente Apeldoorn	MERKATOR	TOPOSCOPIE	

Table 1. Participating organizations in 3D-NL project

All the participants have subscribed for one of the four activities. This approach provides the possibility that all participants can work on their own expertise and interest while together realizing the aims of the 3D project.

The four activity-leaders (who co-author this paper) take care of the coherence between the activities. Every two months the progresses of the activities are discussed and

aligned in plenary sessions, while every activity has its own intermediate working sessions.

A digital working environment has been set up for supporting the collaboration, consisting of a Wiki, a data server and a LinkedIn group.

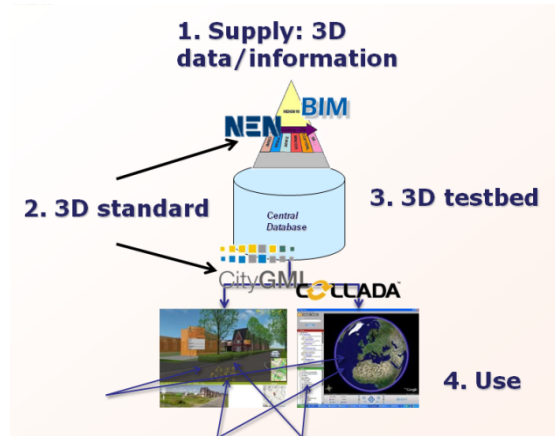


Figure 2. Schematization of four activities of the project

#### 4. THE ACTIVITIES

This section describes the activities of the project in more detail by listing the main research question(s) and subtasks for every activity.

**Activity 1 ‘Supply of 3D geo-information’** works on the following research problems: How can 3D information compliant to the 3D reference model be generated from different data sources, such as point clouds and images from airborne and terrestrial sensors, 2D data from above and below the surface, and 3D models from the building domain (CAD/AEC/BIM/IFC)? Five major tasks are defined:

- 1.1 Selecting rural (for less detailed data) and urban (for more dynamic and detailed data) test areas to support varying use cases. See figure 3 for impression of urban test area: Kop van Rotterdam.
- 1.2 Sourcing many different 3D test data sets for the selected test areas: small and large scale, isolated areas and covering larges areas, below and above the surface; detailed and less detailed; terrain and building.
- 1.3 Generating 3D information from raw data as well as combining already existing data sets (for example laserscan and topographic data) to generate (new) 3D information.
- 1.4 Inventory of available techniques for 3D geo-information generation (conform the standard) and of available techniques to enrich 2D data to 2.5D and 3D information.
- 1.5 Making test data available in the 3D standard, also with metadata. If this is not possible, in another accepted standard while shortcomings of CityGML are documented.



Figure 3. Urban test area ‘Kop van Rotterdam’ in LOD1

The main research question for **Activity 2 ‘Investigating and defining 3D standard’** are: What will the standard for 3D geo-information-NL look like? Which concepts (objects and their properties) should be defined and how? How should geometry and topology be defined? What is the link with established 2D information models and with 3D models in other domains? Four major subtasks are defined within this activity:

- 2.1 Evaluation of available 3D standards for exchange and web visualization such as CityGML, IFC, Collada, KML, indicating the positive and negative characteristics and making this knowledge available within the project via a workshop
- 2.2 Motivated selection of a 3D standard for the testbed (most probably CityGML)
- 2.3 Definition of required semantic extensions of selected standard based on studying CityGML in relation to 3D models in other domains and in relation to established Dutch 2D information models. Also the experiences in applying CityGML to the different use cases in the 3D testbed will influence the required extensions
- 2.4 Recommendations for changing/extending/innovating CityGML (or other standard) to fit the Dutch needs as a 3D standard.

Some definitions of testbed reads: ‘Quality control tool that provides powerful source code testing and analysis facilities for the validation and verification of software applications’, ‘Dedicated research environment where services and data can be experimented upon, results can be evaluated and outcomes shared with the wider community.’, and: ‘A place equipped with instruments for testing under working conditions. In this 3D-Pilot the kernel of **Activity 3 ‘3D testbed’** is the database. A first version of the database has been made available by Section GIS technology, Delft University of Technology. This database implements CityGML in Oracle according to <http://opportunity.bv.tu-berlin.de/software/projects/3dcitydb>. This database will be further developed in the project based on growing insights from working with the data from the database on the use cases.

Test data is being imported in this database where it is structured and maintained and in a next step disseminated

via several ways (see Figure 4). Import and export is done via ETL (Extract Transform Load) tools, like FME and RCP Transformer. The result is that data is stored once while it can be accessed by any user or system multiple times.

Through empirical research (i.e. while doing) all tools are studied which are needed to realize this testbed: the optimal database implementation; CityGML viewers (such as Aristoteles, CityViewer, LandXplorer, FZK Viewer), CityGML converters, Web Services for access as well as tools for 'direct' access independent of the software systems (Kolbe, 2008).

Specific attention is being paid to validation of CityGML data other than schema checking, since this is currently not available. This geometrical validation yields tests like: What is a correct 3D object? Does it touch or overlap with another 3D object? (Ledoux et al., 2009).

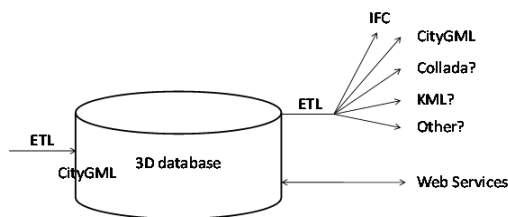


Figure 4. 3D testbed

The main research questions of the 3D testbed activity are: How does the physical model for 3D geo-information look like and how can a CityGML file be converted to it? How can 3D geo-information be structured and managed in an integrated manner, as part of generic information flows? How to validate 3D information and data? How to update 3D information? How to interact with 3D geo-information stored in database or CityGML? What is the performance of 3D techniques?

The subtasks are:

- 3.1 Defining specifications for 3D testbed
- 3.2 Design and implementation of environment to store, integrate, manage 3D information including geoweb environment to access the data
- 3.3 Importing and dissemination of test data in and from 3D database
- 3.4 Supporting data- and technique-suppliers to link to 3D testbed
- 3.5 Consolidating the improved and final version of the 3D testbed, while reporting technical issues met in the execution of the testbed.

**Activity 4 'Realizing pilots via use cases'** concentrates on the following research question: Which applications ask for what type of 3D information (content, precision, geometry)? Six tasks are defined in this activity:

- 4.1 Defining use cases as collaborations of different stakeholders
- 4.2 Creating story boards for use cases
- 4.3 Defining a template to specify and evaluate the requirements for the selected use cases

4.4 Running use cases on 3D testbed

4.5 Evaluating results of use case tests

4.6 Studying visualization and interaction possibilities of 3D data

During the project, representative use cases have been selected. They are all centered on three main applications in the complete cycle of spatial planning and management (from idea, via planning and realization to maintenance). They are:

*3D Data integration:*

- Serious Gaming – 3D input for real time simulation of meteorological processes.
- 3D data integration within design and building processes (BIM-IFC-CAD).
- Integration of 3D data above and below the surface for infrastructural planning.

*Communication*

- Virtual city for communication with citizens.
- 3D spatial planning.

*Supplying 3D information*

- 3D Cadastre: from 3D fieldwork to 3D cadastral map.
- 3D base set topography for the Netherlands. This use case studies both the required content and accuracy of such a base dataset, as well as the possibilities to automatically generate the dataset combining existing data sources such as high resolution laserscan data (AHN2, see [www.ahn.nl](http://www.ahn.nl)) and 2D large scale topography.

## 5. WORK IN PROGRESS

The work on the different activities is running in parallel. One of the test areas where the use cases will be carried out is municipality Rotterdam, which is the owner of many different 3D data sets. 3D test data had been prepared for the test areas. Several of the Dutch 2D standards (Information models) are investigated and compared for the semantic and types of objects that they support to see how they fit in a 3D extension (see also Tegtmeier et al, 2009). In addition information models as IFC, BIM and CityGML are studied for possible integration (see also Isikdag and Zlatanova, 2009; Isikdag and Zlatanova 2009b; Emgård and Zlatanova, 2008).

The pilot is currently entering the execution phase in which the use cases have become the engine behind the pilot. Execution of the use cases will be a collaboration of stakeholders within the use case, 3D data and 3D technology providers. The experiences of the use cases will be used to further develop the 3D standard-NL as well as to improve the 3D testbed.

The project will finish in spring 2011. Among the end results are: use case descriptions of a selection of 3D applications, publicly available test data for two test areas, an operational 3D testbed, demonstrators prototyping the selected use cases, recommendations for 3D geo-information use and 3D technologies as well as for further developing CityGML compatible with 3D standards in other domains and with established 2D information models.

These results will be presented during a conference which will be open for everyone.

The experiences so far have shown the importance of studying the 3D standard from a dual perspective, i.e. from both the supply and demand perspective. At the one hand the 3D applications should be demand-driven to optimally meet users needs. At the other hand the users can better understand their needs if they know what kind of 3D data and technologies are available. This chicken-egg problem is explicitly addressed in the project. Suppliers and users of geo-information and the supporting technologies work closely together. Suppliers are provided with precise requirements of the users. At the same time growing awareness of available 3D geo-information and the supporting technologies may push the use of 3D information.

### ACKNOWLEDGEMENTS

We are deeply grateful to all 85 participants of this project who actively contribute to the activities and discussions.

### REFERENCES

- Emgård, K.L. and S. Zlatanova. 2008. Design of an integrated 3D information model. [red.] Rumor, Fendel and Zlatanova Coors. London, UK : Taylor & Francis Group. Urban and regional data management: UDMS annual 2008. pp. pp. 143-156.
- Geonovum, 2010, [www.geonovum.nl](http://www.geonovum.nl)
- Gröger G, T. Kolbe, C. Nagel and A. Czerwinski. 2008. Open Geospatial Consortium City Geographic Markup Language. CityGML Encoding Standard document version 1.0.0, adopted international standard. <http://www.opengeospatial.org/standards/citygml>. [Online] 2008. OGC 08-007r1.
- Gröger G, T. Kolbe and A. Czerwinski. 2006. OpenGIS CityGML Implementation Specification. [http://www.citygml.org/docs/CityGML\\_Specification\\_0.3.0\\_OGC\\_06-057.pdf](http://www.citygml.org/docs/CityGML_Specification_0.3.0_OGC_06-057.pdf). [Online] 2006.
- Isikdag, U. and S. Zlatanova (2009) A SWOT Analysis on the Implementation of Building Information Models within the Geospatial Environment, In: Krek, Rumor, Zlatanova, Fendel (Eds.); Urban and Regional data Management, UDMS Annuals 2009, Taylor & Francis/CRC Press, pp. 15-30
- Isikdag, U. and S. Zlatanova (2009b) Towards defining a framework for automatic generation of buildings in CityGML using Building Information Models In: J. Lee and S. Zlatanova (Eds.); 3D Geo-Information Sciences, Springer, 2009, pp. 79-96
- Kazar, B.M., R. Kothuri, P. van Oosterom and S. Ravada. 2008. On Valid and Invalid Three-Dimensional Geometries: Chapter 2. Advances in 3D Geoinformation Systems. Springer, 2008, pp. 19-46.
- Kolbe, T.H. 2008. Representing and exchanging 3D city models with CityGML. [red.] J. Lee and S. Zlatanova, 3D Geo-information Sciences, pp. 15-31 Springer Verlag, 2008.
- Ledoux,H., E. Verbree and Hang Si, 2009, Geomatic Validation of GML Solids with the Constrained Delaunay Tetrahedralization, In: De Mayeer, Neutens, De Rijck (Eds.); Proceedings of the 4th International Workshop on 3D Geo-Information, November 2009, Ghent, pp. 143-148
- OGC. 2009. CityGML specification document version 0.4.0, approved Best Practice Paper. <http://www.opengeospatial.org/standards/bp>. [Online] 2009. OGC 07-062.
- Tegtmeier, W., S. Zlatanova, P.J.M. van Oosterom, and H.R.G.K. Hack. 2009. Information management in civil engineering infrastructural development: with focus on geological and geotechnical information. [red.] T. Kolbe, H. Zhang and S. Zlatanova Kolbe. Berlin, Germany, 2009. Proceedings of the ISPRS workshop, vol. XXXVIII-3-4/C3 Commission III/4, IV/8 and IV/5: Academic track of GeoWeb 2009 conference: Cityscapes International archives of photogrammetry, remote sensing and spatial information sciences.