CityGML is the standard for 3D geo-information in the Netherlands

In consumer-technologies, popularity of 3D is on the rise. Governmental agencies however, are reluctant to introduce three-dimensionality in their daily processes. The potential of 3D beyond nice visualizations is not easy to identify. What is 3D GIS? What does it make possible? What are the do's-and- don'ts in domain of 3D? Instead of exploring these questions individually, it is better to address the issues around 3D centrally. This has been done in the Dutch 3D Pilot NL of which phase 1 was completed in June 2011.

Geonovum, Kadaster, the Netherlands Geodetic Commission (NCG) and the Dutch Ministry of Infrastructure and Environment initiated the 3D pilot to advance the use of 3D in the Netherlands. In the pilot (run from March 2010 till June 2011) more than 65 private, public and academic organizations collaborated on a test area, a testbed and use cases to ultimately develop a standard for 3D geo-information in the Netherlands. The pilot brought together an informally organised network for 3D in the Netherlands, where various areas of expertise come together. Besides an optimal environment for product development, the network provided a strong support for 3D in governmental datasets as well as the developed 3D standard NL.
Four working groups (WGs) have run in parallel to realise the aims of the pilot. The WGs are: a) Generation of 3D information; b) Establishment of 3D Standard NL; c) Developing and running 3D test bed; d) Defining and executing use cases.

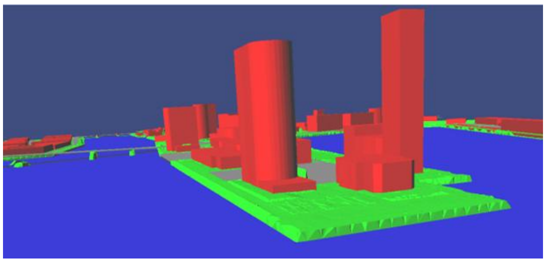
The findings and results of the pilot are presented in five reports available at www.geonovum.nl/dossiers/3D-pilot (in Dutch). This article provides a brief overview of the pilot results.

WG 1 Generation of 3D information
Many data suppliers have provided their (often specifically for the pilot acquired) 2D and 3D data of the test area '*Kop van Zuid*' in Rotterdam. Examples are: 2D topographical data at scale 1:500 and 1:10k, 3D geological data of the subsurface (voxels of 100x100x0.5m), two high density laser point datasets (the Height Model of the Netherlands, called *Actueel Hoogtebestand Nederland* (AHN2), point density 10 pts per m2 and a dataset with 30 pts per m2, acquired by Fugro for Municipality of Rotterdam), a 2.5D large scale topographical dataset of Rijkswaterstaat, Cyclomedia orthophotos and panoramic imagery, high resolution point data of terrestrial laser scanners integrated with panoramic photographs (Topcon Sokkia), panoramic video (Horus Surround Vision), recordings by Imagem etc. These input datasets formed a rich starting point for 3D modelling activities of the test area. Several pilot participants have processed these data in different types of 3D models. Some examples are shown in Figure 1.
The insights gained in this WG have been structured in the final report which gives a good overview of the 3D data already available, including information such as cost, nationwide availability etcetera. Also, the existing techniques have been described for (semi-) automatically generation of 3D information, possibly based on 2D information including the (financial) effort required for the generation.

All 3D pilot test data integrated in one environment, by Bentley

Assigning z-values to TOP10NL vertices by Kadaster

3D City model from laser point data, by IT-Pro-People (with Bentley software Terra Solid)



3D TOP10NL as integration of TOP10NL and laser point data, by ITC U Twente (Oude Elberink and Vosselman, 2009)

CityGML buildings and trees by iDelft and Alterra

CityGML-LOD2 including trees by Toposcopie

Fig. 1: Examples of further processed data in the 3D pilot

WG 2 Establishing a 3D standard NL

This WG studied and developed the 3D standard NL based on experiences of the other WGs.
The explicit choice for CityGML by this group is one of the main results of the pilot. A data standard is very abstract and therefore not interesting for many 3D users. However without agreements on technical details and on meanings of information, 3D information cannot be exchanged. Therefore it was decided to develop a 3D geo-information standard, which connects to both the Dutch 2D standardisation framework and international 3D standards. After comparing the main 3D GIS and CAD standards, CityGML was selected as the optimal standard to align to. It provides the best support in terms of semantics, objects, attributes, geo-referencing and use via the web.
The OGC standard CityGML has its roots in the German academic world and is often seen as an exchange format. However more often it is used as an information model for representing spatial objects in urban environments. It distinguishes both at geometric and semantic level between

thematic concepts (buildings, vegetation, water, land, etc..). In addition, per class different Level of Details (LOD) are distinguished. For example a building object can range from a simple block model to a fully detailed interior model, with or without texture information.
There are drawbacks to using CityGML as standard without further refinements and agreements. The standard is generic, does not contain object definitions and it does not support complex geometries as used in the CAD domain. Other problems are the focus on above ground objects, uncertainty about when to apply which LOD, and lack of support for geometry validation. In addition, there is little support for CityGML in the commercial GIS systems, although this support increased during the course of the pilot.
The big advantage of using the standard CityGML, however, is that the connection to this standard ensures interoperability: If the Dutch geo-information is encoded in CityGML, then this data is available to CityGML clients. Other countries, including the United States, are working on connecting to CityGML. And also INSPIRE connects to CityGML in the specifications for buildings (see Figure 2).

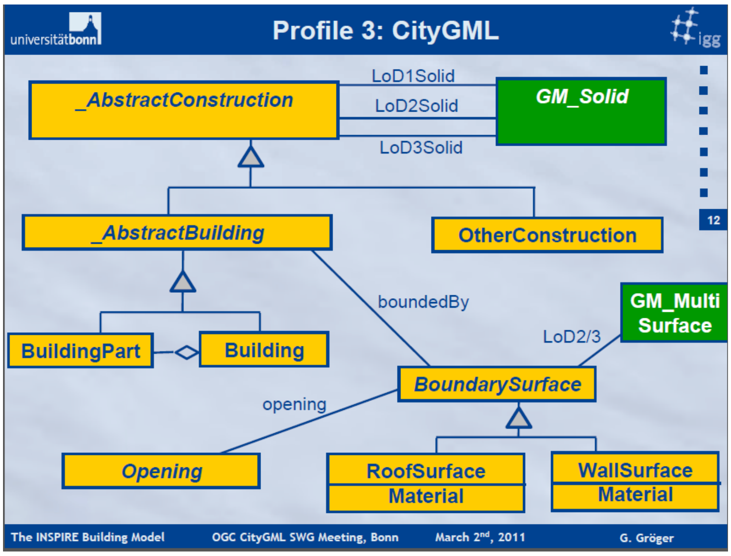


Figure 2. Proposal for an (optional) profile for the building data in a European context, can be exchanged (INSPIRE).

In a next step the working group has worked on a CityGML implementation profile. Because the Dutch information model on large scale topography (IMGeo) resembles CityGML the most, the first focus has been on integration IMGeo and CityGML into one standard. Therefore the concepts as defined in IMGeo 1.0 have been remodeled as subclasses of CityGML classes. For concepts for which not an equivalent class could be found either the IMGeo concept was remodeled into another class or CityGML has been extended with an extra class. In addition extra attributes, code list and code list values have been added. Also additional agreements have been made to implement the generic standard CityGML into the national context . Based on experiences with CityGML-IMGeo other domain information models will be enhanced with 3D concepts if appropriate.

WG 3 The 3D Testbed
The 3D test bed examined the techniques to support 3D information in general and CityGML in particular, based on the data made available by the participants of the Rotterdam test area. The Section GIS technology of TU Delft implemented a specially designed test bed environment which could be used by all participants. Apart from a file-based data server with the test data, the test bed offered a DBMS implementation, i.e. the 3DCityDB. This database is an open source 3D geo-database,

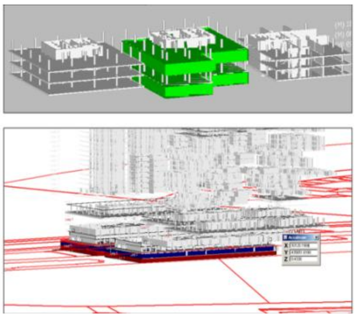
developed by TU Berlin, that implements the CityGML data model in a relational database (Oracle Spatial 11g in our case) (TU Berlin, 2011). The database was (and is still) available for all pilot participants to upload, validate and export CityGML data.
The feedback of test bed experiences to the participants during the 3D pilot led to a better understanding of CityGML, as did the free CityGML course that this WG offered in March 2011 (recorded and available at http://collegerama.tudelft.nl/mediasite/SilverlightPlayer/Default.aspx?peid=7b440617cd1342b0b5b006fc0f6563ef1d).
Therefore the use of the 3DCityDB increased during the 3D pilot, which was also stimulated by better CityGML support by systems such as Bentley, ESRI and Intergraph.

WG 4 Use cases

Which 3D information is needed? What added value does the use of 3D information have? What is the state of the art? To answer these questions six use cases have been defined and executed (see Figure 3). These are:

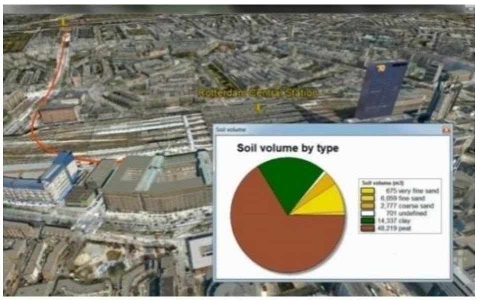
1. 3D cadastre: recording of property located above and below each other
2. Generation, maintenance and distribution of 3D topography
3. Applying voxel data for GIS analyses
    a. Integration of voxels (3D grids) with 3D objects
    b. Integration of surface and subsurface data
4. 3D data integration in construction processes: How to use design data (IFC/CAD/Collada) in GIS applications and how to use 3D geo-information in building information applications (BIM)?
5. 3D for spatial planning: generating 3D virtual environments based on architectural models for communication with citizens
6. 3D change detection

It soon became clear that knowledge about 3D technologies is indeed scarce. This was often even a bigger problem than the technology itself. Technological problems did occur however. For example it was not easy to generate CityGML data that contained the desired information.
Moreover, the conversion of 3D data from one software to another was not straightforward, because not all aspects of the data (geometry and semantics) are automatically converted. The urgency of an interchange format for 3D geo-information was thus evident.
A specific conclusion for the BIM-GIS case is that both domains are complementary. Therefore it is better to look for connection than for a generic model that serves both domains. The connection enables to use GIS data as reference for BIM and vice versa BIM data can serve as a source for 3D geo-information. However it is also important to respect the differences: geographic information covers larger areas with lower level of detail, while BIM is characterised by a local and highly detailed approach needed for reliable constructions calculations.

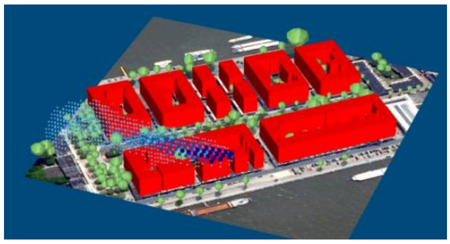


3D Kadaster (Dutch Kadaster and Bentley)

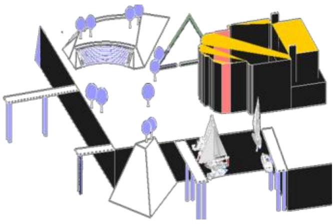
Tree model generated by Alterra for use case 3D topography



Calculation of soil volumes (voxels) at the location of a planned tunnel, by ESRI and TNO

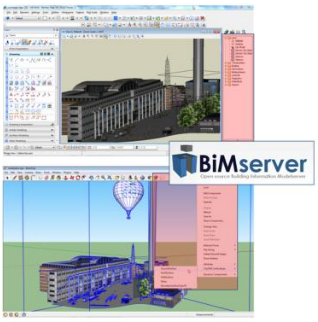


Realtime interactive airstream simulation with voxels, Alterra

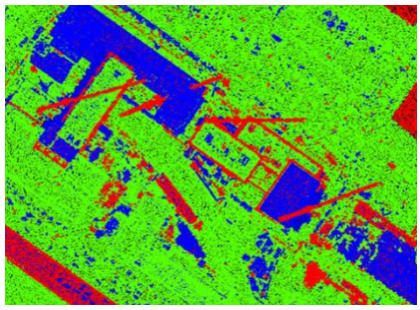


Spatial planning objects in CityGML, Crotec

3D change detection, NEO BV



Integrating design models in virtual environments , Gemeente Apeldoorn



3D Change detection based on differences between two point clouds, U Twente

Figure 3. A selection of the use cases

Next phase of 3D Pilot

Some pertaining research questions have not been solved in the 3D Pilot. It is for example still not possible to generate 3D objects fully automatically. Regarding 3D databases the support for 2.5D/3D topology and geometry needs further attention.
Also new research questions were formulated as to how to connect to and exchange with other disciplines as architectural design, planning and construction: how to balance between tight arrangements and flexibility? And how can a workable collaboration be encouraged between disciplines such as geo-information, planning, design, and BIM management.
In addition an unclear cost-benefit relationship requires further attention for organisational solutions. Often other departments than the department that makes the costs, benefits from a 3D approach. In addition often there is more insight in the costs of 3D than in the actual benefits.

To address the still open issues, a follow-up project will look at a generic approach to 3D within governmental organizations including generating and maintaining CityGML-IMGeo data and linking to other disciplines. Based on those experiences the further development of CityGML implementation for Dutch applications will get further attention. A new project group is currently being set up (about 90 participants already agreed to contribute) to study these topics and to further work on the results of the first phase to make them ready for use in practice. Addressing the still open 3D issues in a collaborative and experimental setting where expertise of universities, industries and governmental parties are brought together, offers the optimal conditions for 3D being actually picked up by practice, as was shown by the first phase of 3D pilot.