Chapter 13
Germany on the Way to 4D-Cadastre

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The Demand for 3D-Building Information

Energy Turnaround

In Germany the government targets at climate and environmental protection currently lead to extensive changes in the energy sector, the so-called energy turnaround. This includes the end of the use of nuclear energy by 2020, the reduction of greenhouse gases and other objectives (BlmSchG, 2012). As a result planning processes especially have to take into account the use of photovoltaic technology, geothermal energy, wind energy and the energetic isolation of buildings.

From the process view, data must be available to provide actual information of the environment and all energetically relevant topics. Very often this leads to a data collection or at least to a data processing task. Having the required information, the analysis and the evaluation will give a sustainable picture of the energy balance, including possible savings the use of renewals energies and energetic isolations of buildings (Fig. 13.1).

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Fig. 13.1 Photovoltaic map of the city of Dusseldorf

Fig. 13.2 Noise map of the city of Dusseldorf (*left*: during day time, *right*: at night)

Noise Protection

The 3D-geometry and semantics, particularly of buildings, are very important for simulating and mapping of noise expansion (Fig. 13.2). By a European directive every 5 years the member states of the European Union are obliged to determine and to document noise pollution in cities. In addition the progress of noise-reduction is checked.

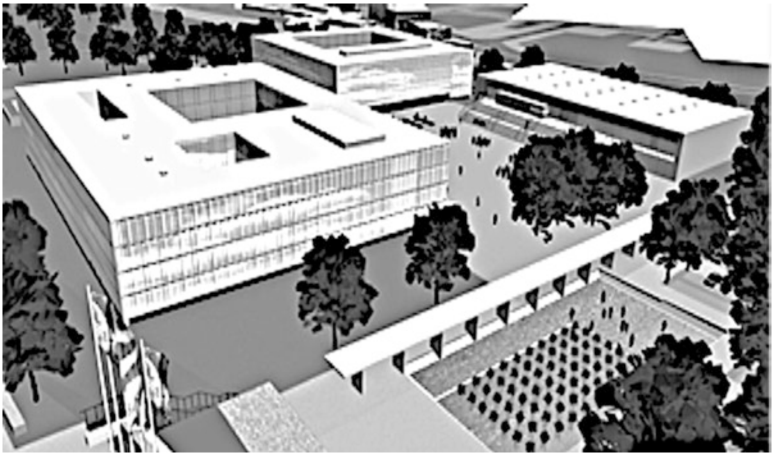


Fig. 13.3 Planned school in the county of Recklinghausen

Urban Planning

The use of cadastral information for urban planning was always essential in the 2D-world, especially to consider the property distribution. Nowadays 3D-information is a basic demand of the urban planning sector (Fig. 13.3). Demographic effects and other restrictions could be visualized in planning alternatives (Riecken and Seifert 2012).

Disaster Management

Increasingly 3D-information is used in the simulation of disasters, for example for evacuation and flood scenarios (Fig. 13.4).

Requirements for 3D-Building Information

Level of Detail (LoD) in the Cadaster

While 3D-building information in the LoD 1 are sufficient for applications like noise mapping (Fig. 13.2) many other applications like the aforementioned photo-voltaic map (Fig. 13.1) at least need a higher LoD 2 resolution (Oestereich 2014). As a consequence, so-called "city-models" were built up in many cities in Germany. Their basic goal was to support or even allow a visualization of special application scenarios (examples: Figs. 13.3 and 13.4). On the other side these models had not special quality or updating mechanisms. Often they used the cadaster as a data

Fig. 13.4 Air rescue – county of Recklinghausen

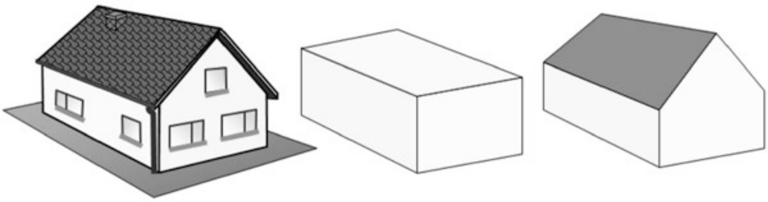


Fig. 13.5 Real World (*left*); LoD 1 (*centre*) and LoD 2 (*right*)

source (exact location/2D building information), but they never became part of the cadaster. To overcome this lack a proposal came up to expand the official cadastral AAA® - data model towards the third dimension (Fig. 13.5).

Approach

Several investigations have proved that only a few additional information is needed to build up a 3D-spatial data set out of the existing 2D-spatial cadastral data and to keep the information up to date. What is needed are the number of floors, ridge direction, and the building height. Most of this information already exists in the planning process; additional data is collected during the cadastral survey. With this

Fig. 13.6a City model, Recklinghausen

Fig. 13.6b 3D-spatial data, Recklinghausen

approach and the integration of the aforementioned information, a future 3D-cadaster could be implemented.

These days the 3D approach is a “topographic” extension of the cadaster in Germany. The demand for taxation was the reason for the establishment of the cadaster in the beginning of the nineteenth century. One hundred years later the property cadaster was established. In the last decades the cadaster was increasingly used for other necessary mapping and planning issues – it became a so-called multi-purpose cadaster, at that time restricted to 2D. With the AAA® model modern technologies, XML-descriptions’ suitable software came up (Hawerk, 2002) and today the link to CityGML takes place (Gröger et al. 2012). With this the 3D-ability is included.

The pictures (Figs. 13.6a and 13.6b) show the additional contents of a city model compared to 3D-spatial data. While city models are often based on visualization, the AAA®-3D-spatial data are focusing on analysis. After the implementation of

AAA®-3D-spatial data, city models might be developed automatically as cadastral applications.

Standards

CityGML-Profiles and AAA®-3D-spatial Data

The following step-by-step approach is applied to realize nationwide 3D-geodata set in Germany.

Interim Solution CityGML-Profiles

Already today, there is a demand for 3D spatial information. The currently used AAA®-data model (version 6) is not able to store and to provide the expected 3D-information. The expanded AAA® version 7.0 will not be available before 2018 all over Germany.

Therefore the existing OGC standard CityGML (Gröger et al. 2012) for the representation and exchange of 3D-information is used. In March 2012, CityGML 2.0 was published as an international standard by the Open Geospatial Consortium (OGC). To realize the above-mentioned interim solution profiles were created from GML and CityGML taking into account the needs of 3D spatial information of the cadastral and surveying administration. As a result, the classes, attributes and values have been reduced to the maximum extent permitted by the product definition (Gerschwitz et al., 2011).

Figures 13.7a and 13.7b show that the AdV profile uses only parts of the CityGML-schema, especially mandatory requirements and quality indicators. The profiles are logical restrictions to CityGML-schema. The updating process of the described interim solution will be done by reprocessing of the existing/original data. An object based actualization does not exist yet.

AAA®-concept

The AAA®-concept is national standard for official spatial information in Germany. It was built up completely by specialization of international standards (Fig. 13.8) (AdV 2008a, 2008b). The AAA®-schema is a GML-application schema which represent the national standard for geospatial data of the surveying and cadastral administration in Germany. The model and external schema are completely embedded in existing standards of ISO and OGC.

According to size (number of citizens), Recklinghausen is the biggest county district in Germany and therefore comparable to a city like Cologne. In 2011 about

Fig. 13.7a CityGML Version 1.0

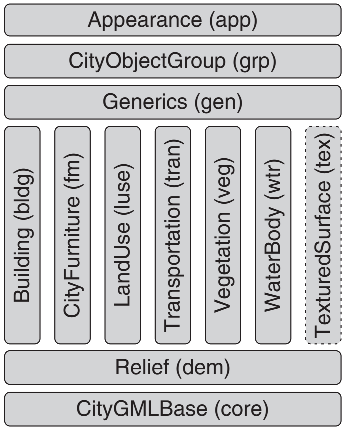
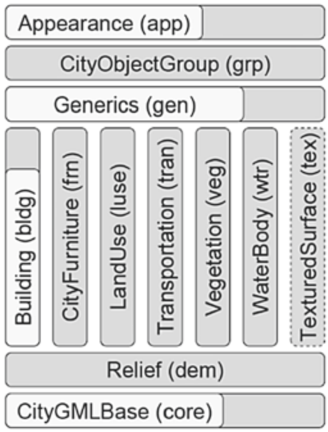


Fig. 13.7b CityGML-Profile of AdV



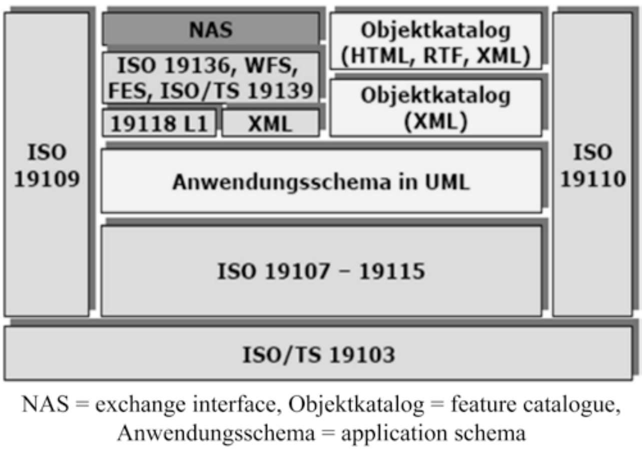


Fig. 13.8 AAA®-embedding existing international standards (AdV 2008a, b). *NAS* exchange interface, *Objektkatalog* feature catalogue, *Anwendungsschema* application schema

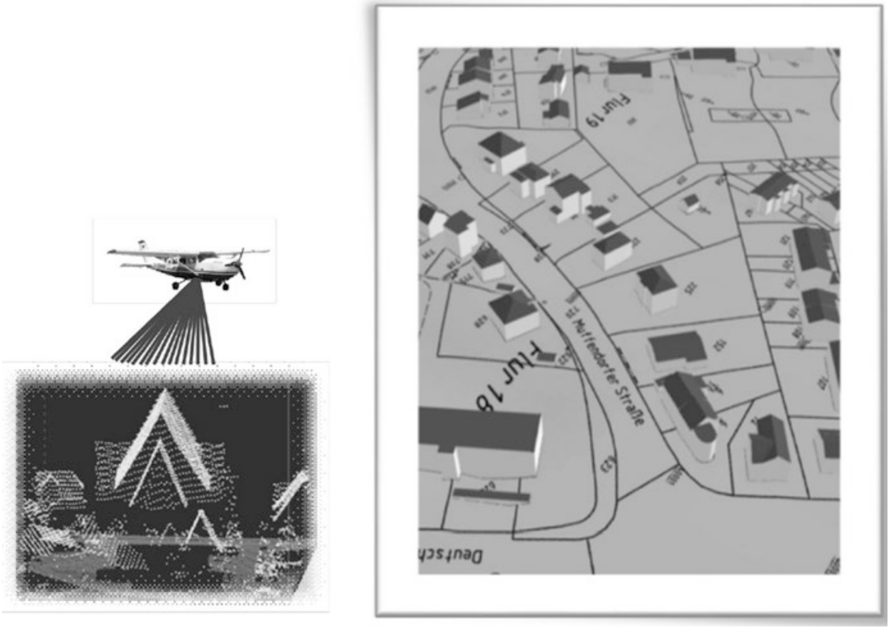


Fig. 13.9 3D-building model

1600 cadastral surveys took place with respect to buildings. For Recklinghausen, as in general for the German cadaster with over 50 million buildings, it is therefore of fundamental interest to store actual 3D-building information conform to the AAA® standard and consistent to 2D- and 3D-cadastral object information (in general: 2D-property building layer identical to 3D building footprint) – the so-called "vertical integration concept".

This "vertical integration concept" takes into account the source of the data and the production process. The "legal" 2D-property building layer as a major cadastral information is merged with the 3-dimension from laser scan as a topographic source. The result is a "legal" 3D-building model (Fig. 13.9).

It defines the AdV product "3D building model". As a consequence, the demand, especially of the economy, for official (administrative) 3D-building information could be fulfilled. In addition this data participates in the existing national and international spatial data infrastructure (SDI), for example through simple export to the defined INSPIRE topics (INSPIRE Thematic Working Group Building 2012).

In contrast to CityGML, which is designed as an external interchange format and for the easy use of 3D-data, the AAA®-concept defines a standard: application schema, feature catalogue and exchange interface (Fig. 13.10).

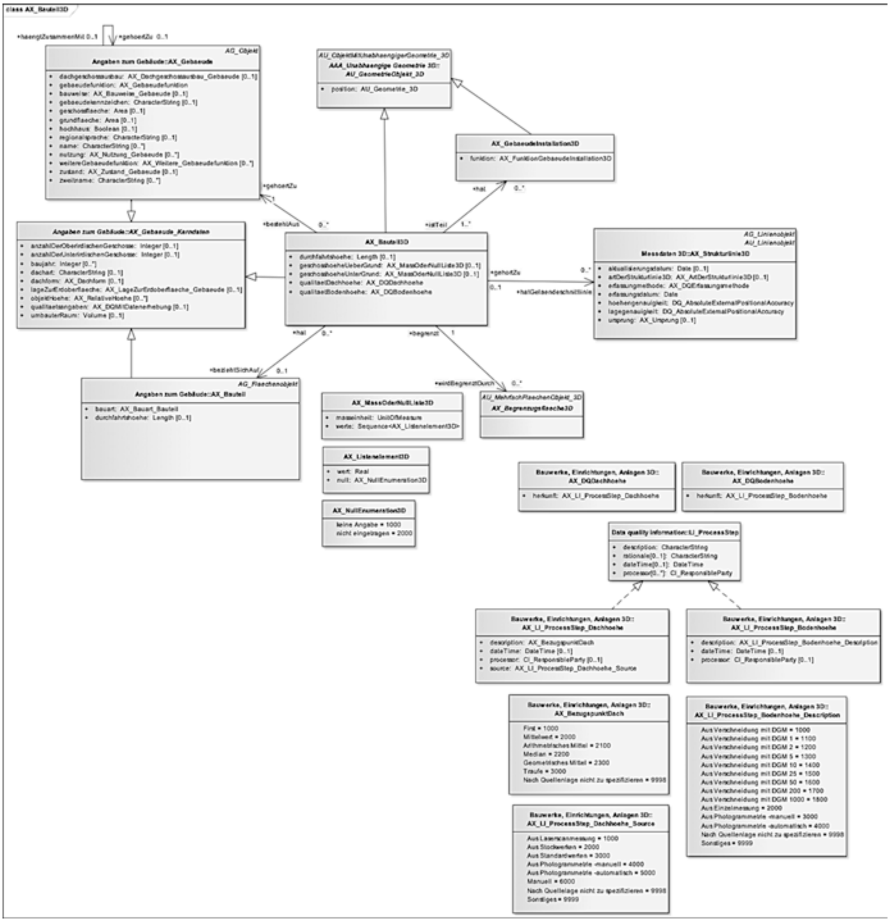


Fig. 13.10 Specification to the building 3D-AAA®-schema

Modelling Aspects

Basic Schema

The AAA®-schema is logically divided into several packages, essentially into the thematic independent basic schema and the thematic schema, which is based on the basic schema. 3D-classes, which are necessary, are integrated into AAA®-schema in three new packages:

- AAA_SpatialSchema 3D,
- AAA_Unabhaengige Geometrie 3D, and
- AAA_Praesentationsobjekte 3D.

The package “AAA_SpatialSchema 3D” contains additional information of the existing AAA®-schema in accordance with the specifications for 3-dimensional objects of the ISO-norm “191XX”. The package “AAA_Unabhaengige Geometrie 3D” provides all necessary geometric shapes (dot, line and surface) for the AAA®-3D-schema objects with independent geometry. In the package “AAA_ Praesentationsobjekte 3D” the modelling of presentation objects is described.

Thematic Schema

The AAA®-application schema defines object classes for storing 3D-information: The 2D-classes “AX_Gebaeude” and “AX_Bauteil” as well as the 3D-class “AX_ Bauteil3D” which have a common upper class “AX_Gebaeude_Kerndaten”. The multiface possibilities of occurrence of geometry of 3D-objects in “AU_ Geometrie_3D” are limited by constraints (SIG 3D 2012).

The storage of quality information is an important part in the German cadaster. Therefore information of quality is modelled conforming to ISO-19115 Metadata. Furthermore the relevant modelling in the INSPIRE[11]-building-topic was considered, which also requires quality information, especially the source of data. As a consequence it will be possible to provide semantics match between the AAA®-model and INSPIRE. This allows the realization of the exchange and conversion of data. The INSPIRE data model, especially the profile extended3D, is one special profile of CityGML, in a similar way to the AAA®-3D-e

The 3D-building model of the AdV describes buildings in terms of the cadastral view as well as for topographic surveying (LoD 1-3, chapter 2). It does not take into account the modelling of interior rooms (LoD 4), or city topography. The 3D-building is an expansion of the “Hausumringe” (hose foot prints) in the third dimension, accumulated with attributes of associated cadastral 2D-objects. Currently the product standard describes building resolutions conform to LoD 1 and LoD 2 (Gruber, 2012).

The Fourth Dimension

Traditionally, in the German cadastre every change of a parcel (e.g. subdivision) is documented by surveying sketches and textual documentations. The development of the cadastral map is continuously monitored and every change over time can be restored in case of cadastral disputed, but usually using non-digital paper documents. Therefore, modern possibilities for inquiries were also a technical requirement for the AAA®- standard. Besides this more internal cadastral

[11] Infrastructure for Spatial Information in Europe: A European Directive, see http://inspire.jrc.ec.europa.eu/

use-case, there are lots of further requirements for the time-related cadastral information, such as:

- Monitoring the development of cities and villages over time
- Statistic of changes of land use and land cover
- Planning purposes
- Historical archiving
- Monitoring cultural heritage.

The AAA®-data model requires for each object a unique identifier together with a designated time stamp for creation and deletion of an object. However, once an object has to be deleted during an updating process the object will not be physically removed from the data base. Only the life cycle of the thematic relevance has ended, but not the existence of the object as an instance. A "deleted" object is then considered as a historical information which can be easily distinguished from the actual information. Sometimes there are changes in an object which do not require the deletion of the object (e.g. only a name of the person changes). In that case also the different versions of an object can be stored. Within the AAA®-data model this approach is therefore called "versioning concept". Since every object carries life cycle information the storage of historical objects and versions of objects is not limited to any specific object type.

Within the AAA®-data model this approach is used for providing historical information as well as for the incremental updating of secondary used information systems.

Conclusions

Availability of LoD 1 und LoD 2 in Germany

Due to the constitutional responsibility of surveying and mapping, the responsibility for cadastral data is on the state level. As mentioned above the Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany (AdV) defines nationwide cadastral standards AdV (2009). In addition a nationwide access point was established in North Rhine-Westphalia to distribute about 21 million house coordinates (coordinates of buildings with an official address), about 50 million 2D-"Hausumringe" (house foot prints), LoD 1 and LoD 2 - data for Germany (for more information: www.adv-online.de).

Economy, science and administration have an increasing demand for official three-dimensional spatial information (3D-geodata) as a base for multiple applications. The surveying and mapping administration in Germany has accepted this demand as a challenge to develop and realize sustainable conceptions for 3D-geodata, focusing on quick and economic solutions. In this context, national and international standards, infrastructures and activities had to be considered. The German AAA®

cadaster standard takes into account the international standardization of ISO and OGC to include 3D-geodata as an economic solution for guidance and continuation. The approach of the vertical integration of 3D-geospatial into the cadastral standard guarantees an interface to the German and European spatial data infrastructure. Especially consistent regulation of modelling, actualization concepts and the quality management are activities which have to be finished in the next years.

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