Germany on the Way to 3D-Cadastre

Ulrich Gruber, Jens Riecken and Markus Seifert

Summary

During the last years the information systems of national mapping and cadastre were focusing demands for three-dimensional applications, e.g. environment protection, planning, energy supply and disaster management. The basic request of coverage and actuality was defined for the third dimension. In 2009, the Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany (AdV) came up with the following decision: "The collection, data modelling and quality management of buildings for the geo-topographical surveying and for the cadastre are main tasks of the official German cadastre. This also includes the third dimension".

This paper will focus on this process and will show benefits and applications.

Zusammenfassung

Der vorliegende Beitrag wurde aus der Mitte des DVW-Arbeitskreises 2 »Geoinformation« als deutscher Beitrag für die FIG-Working Week 2014 in Kuala Lumpur, Malaysia eingereicht. Er beschreibt die aktuellen Entwicklungen in Deutschland hinsichtlich der Integration der dritten Dimension im Liegenschaftskataster als Teil der AAA-Standardisierung. Für die zfv wurde er redaktionell überarbeitet.

Keywords: 3D-cadastre, solar and noise cadastre, CityGML, vertical data integration

1 Introduction

In Germany property taxation was the reason for the establishment of the cadastre in the beginning of the 19th century. One hundred years later (1900) the property cadastre was established. In the last decades the cadastre was increasingly used for a lot of other mapping and planning issues – it became a so called multi-purpose

DOI 10.12902/zfv-0028-2014

cadastre as a geo-basis Land Information System (LIS) and nowadays as a part of the National Spatial Data Infrastructure (NSDI).

Nowadays 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 realise sustainable conceptions for 3D-geodata, focusing on fast and economic solutions. In this context, national and international standards, infrastructures and activities had to be considered. The German AAA®-cadastre standard takes into account the international standardisation of ISO and OGC to include 3D-geodata.

The cadastre in Germany is a parcel-based system, i. e. information is geographically referenced to unique, well-defined units of land. These units are defined by formal boundaries marking the extent of land. Each parcel is given a unique parcel-number. In addition the buildings are collected and updated. Buildings are represented geometrically (2D) and semantically. They are a basic component of the cadastre and basis for tasks of the administration, economy and science. Because of the federalism in Germany, the states and local authorities are responsible for the cadastre. For that reason the AdV gives recommendations for nationwide cadastral standardisation. The AAA®-data model which ensures the interoperability between cadastral and surveying and mapping data is the result of this standardisation process.

2 The Demand for 3D-Building Information

2.1 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 (Fig. 1). 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. 1: Photovoltaic map of the city of Dusseldorf

2.2 Noise protection

The 3D-geometry and semantics, particularly of buildings, are very important for simulating and mapping of noise expansion. By a European Directive every five years the member states of the European Union are obliged to

Fig. 2: Noise map of the city of Bonn. Top: for 24 h, bottom: at night

determine and to document noise pollution in cities. In addition the progress of noise-reduction is checked. For North-Rhine Westphalia the Ministry for Climate Protection, Environment, Agriculture, Nature Conservation and Consumer Protection is providing a noise map in the internet (www.umgebungslaerm-kartierung.nrw.de, last visit 23.05.2014) (Fig. 2).

2.3 Urban planning

The use of cadastral information for urban planning was always essential in the 2D-world, especially to consider

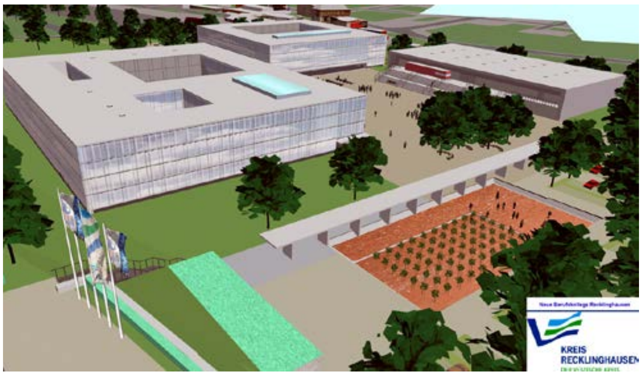

Fig. 3: Planned school in the county of Recklinghausen

Fig. 4: Air rescue – county of Recklinghausen

the property distribution. Nowadays 3D-information is a basic demand of the urban planning sector (Fig. 3). Demographic effects and other restrictions could be visualised in planning alternatives.

2.4 Disaster management

Increasingly 3D-information is used in the simulation of disasters, for example for evacuation and flood scenarios (Fig. 4).

3 Requirements for 3D-Building Information

3.1 Level of Detail (LoD) in the cadastre

While 3D-building information in the LoD1-resolution are sufficient for applications like noise mapping (2.2) many other application like the aforementioned photovoltaic map (2.1) at least need a higher LoD2 resolution (CityGML 2012). 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 visualisation of special application scenarios (examples: 2.3, 2.4). On the other side these models had not special quality or updating mechanisms. Often they used the cadastre as a data source (exact location/2D building information), but they never became part of the cadastre. To overcome this

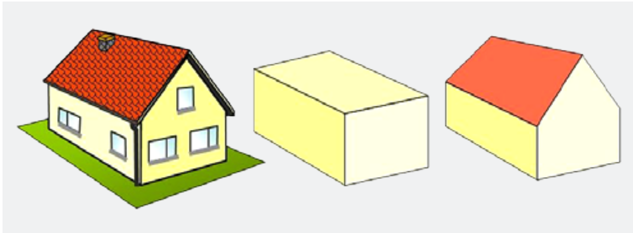

Fig. 5: Real World, LoD1, LoD2

lack a proposal came up to expand the official cadastral AAA®-data model towards the third dimension (Fig. 5).

3.2 Approach

Several investigations have proved that only little additional information is needed to build up a 3D-spatial data set out of the existing 2D-spacial 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 approach of data collection during the survey a future 3D-cadastre could be implemented sustainable.

"Germany on the way to 3D-cadastre" is a "topographic approach" to extent the content of the cadastre. The demand for taxation was the reason for the establishment of the cadastre in the beginning of the 19th century. One hundred years later the property cadastre was established. In the last decades the cadastre was increasingly used for other necessary mapping and planning issues – it became

Fig. 6: City model, Recklinghausen and 3D-spatial data, Recklinghausen

a so-called multi-purpose cadastre, 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. 2011). With this the 3D-ability is included.

The pictures in Fig. 6 show the additional contents of a city model compared to 3D-spatial data. While city models often based on visualisation, 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.

4 Standards

4.1 CityGML-Profiles and AAA®-3D-spatial data

The following step by step approach is applied to realise 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.

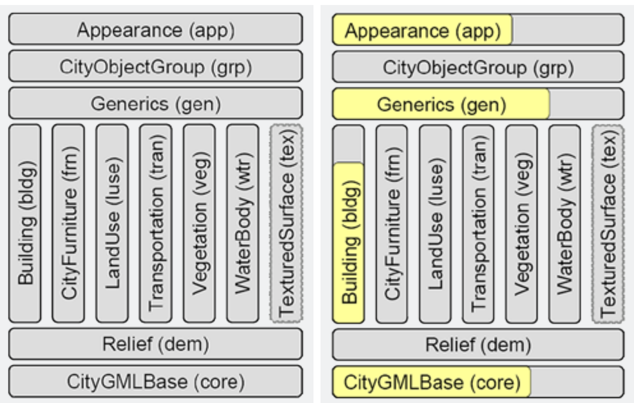

Fig. 7: CityGML Version 1.0 and CityGML-Profile of AdV

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 realise 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: „Um die umfangreichen Freiheitsgrade von CityGML-Daten zu reduzieren und eine erste, durchgreifende Datenprüfung mit Schemavalidierungen durchführen zu können, wurde ein CityGML-Profil erstellt. Darin wurden die Klassen, Attribute und Werte auf den zulässigen Umfang aus der Produktdefinition reduziert und abweichende Kardinalitäten festgelegt.").

The diagrams in Fig. 7 show that the AdV-profile uses only parts of the CityGML-schema, especially mandatory requirements and quality indicators (Gerschwitz et al. 2011). 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 actualisation does not exist yet.

AAA®-concept

The AAA®-concept is national standard for official spatial information in Germany. It was built up completely by specialisation of international standards (AdV 2008) (Fig. 8). The AAA®-schema is a GML-application schema which represents 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.

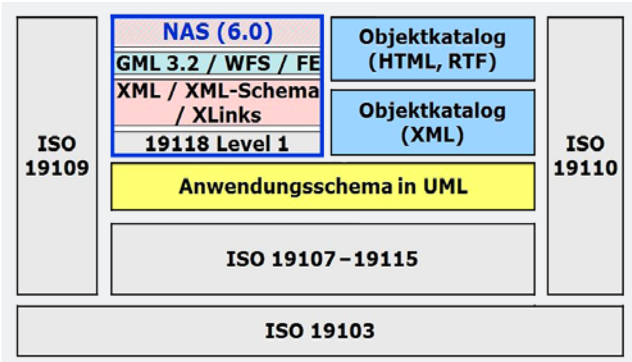

Fig. 8: AAA®-embedding existing international standards (AdV 2008) (NAS = exchange interface, Objektkatalog = feature catalogue, Anwendungsschema = application schema)

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 1,600 cadastral surveys took place with respect to buildings. For Recklinghausen, as in general for the German cadastre 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" (Fig. 9).

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.

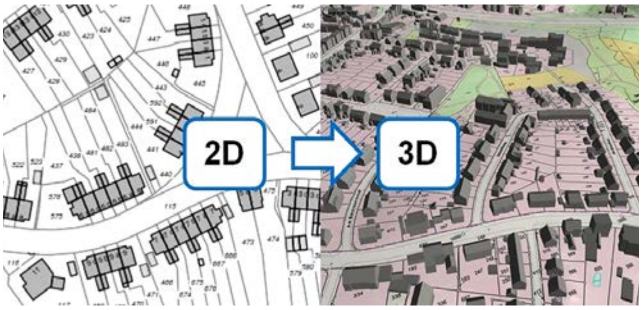

Fig. 9: Vertical integration – Cadaster 2D and 3D

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 (Infrastructure for Spatial Information in the European Community: European Directive, see http://inspire.jrc.ec.europa.eu).

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.

4.2 Modeling 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,
- 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 modeling 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" 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.

The storage of quality information is an important part in the German cadastre. Therefore information of quality is modeled conform to ISO-19115-Metadata. Furthermore the relevant modeling in the INSPIRE-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 realisation 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-expansion.

"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 modeling of interior rooms (LoD4), or city topography. The 3D-building is an expansion of the "Hausumringe" (house foot prints) in the third dimension, accumulated with attributes of associated cadastral 2D-objects. Currently the product standard describes building resolutions conform to LoD1 and LoD2 (Gruber 2011: „Das 3D-Gebäudemodell der AdV enthält ausschließlich Gebäude im Sinne des Liegenschaftskatasters sowie wenige Bauwerke der topographischen Landesaufnahme im LoD 1–3. Sie umfassen z.B. keine Innenräume (LoD 4), Geländeform oder Stadtmöbel. Das 3D-Gebäude ist eine Erweiterung des Hausumrings um die dritte Dimension, angereichert mit Attributen des dazugehörigen 2D-Objektes des Liegenschaftskatasters. Der Produktstandard beschreibt derzeit 3D-Gebäude/-Bauwerke in LoD1 und LoD2").

5 Coverage, Availability

5.1 LoD1 und LoD2 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 AdV defines nationwide cadastral standards. 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), and LoD1/LoD2-data for Germany (Fig. 10) (for more information see AdV 2014).

Fig. 10: Data availability for North Rhine-Westphalia – LoD1/2007 and LoD2/2014

5.2 INSPIRE

INSPIRE is the central European Directive in the field of spatial information and will speed up the harmonisation of spatial information in Europe. With the AAA®-application schema, the AdV is already sufficiently prepared for the INSPIRE-compliant data submission (AdV 2008). It was evaluated whether AAA®-instances could be provided for INSPIRE by applying a schema transformation. A demonstration client was developed and a mapping table was defined. It was proved, that the 3D-AAA®-features can be transformed to INSPIRE-compliant instances without loss of information.

6 Conclusion

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 realise 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®-cadastre standard takes into account the international standardisation 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 modeling, actualisation concepts and the quality management are activities which have to be finished in the next years.

References

AdV: Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany: GeoInfoDok (ALKIS®), main document Version 6.0, 2008.

AdV: Preliminary report “Digital Surface Models, architectural models” of the working groups “Geotopography” and “cadastre” for 120th Committee sessions of the Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany on 10 to 11 September 2008, 2008.

AdV: Final minutes of the 121st Committee sessions of the Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany of 9 to 10th September 2009.

AdV: Informationsmaterial zum Download (DE/E), Stand 2013 – www.adv-online.de/Veroeffentlichungen/3D-Gebaeudemodelle-LoD, last visit 22.05.2014.

BImSchG: Law to protect against harmful effects of air pollution, noise, vibration and similar phenomena, as amended by the 03.15.1974 26.9.2002, as last amended by Article 2 of G v. 06/27/2012 (Gesetz zum Schutz vor schädlichen Umwelteinwirkungen durch Luftverunreinigungen, Geräusche, Erschütterungen und ähnliche Vorgänge, vom 15.3.1974 i.d.F. vom 26.9.2002, zuletzt geändert durch Art. 2 G v. 27.6.2012), 2012.

Gerschwitz, A., Gruber, U., Schlüter, S.: Die dritte Dimension im ALKIS®. In: Kummer, K., Frankenberger, J. (Ed.): Das deutsche Vermessungs- und Geoinformationswesen 2012. Wichmann Verlag, Berlin/Offenbach, p. 279–310, 2011.

Gröger, G., Kolbe, T.H., Nagel, C., Häfele, K.-H. (Ed.): OGC City Geography Markup Language (CityGML), Encoding Standard, Version 2.0, OGC Doc No. 12-019, Open Geospatial Consortium, 2012.

Gruber, U.: Die dritte Dimension im amtlichen Vermessungswesen Deutschlands. In: Löwner, M.-O., Hillen, F., Wohlfahrt, R. (Ed.): Geoinformatics “Mobility and Environment” 2012. Proceedings of “Geoinformation conference 2012” of 28.–30.03.2012, Braunschweig, p. 303–309, 2012.

Hawerk, Winfried: Cadastre 2020 – New Trends in Germany’s Cadastre?!, FIG XXII International Congress, Washington, D.C. USA, April 19–26 2002.

INSPIRE Thematic Working Group Building: D2.8.III.2 Data Specification on Building – Draft Guidelines. Version 3.0rc3, 2012.

Oestereich, Marco: Das 3D-Gebäudemodell im Level of Detail 2 des Landes NRW, NÖV 1/2014.

Riecken, J., Seifert, M.: Challenges for the multi purpose cadastre, FIG Working Week 2012.

SIG 3D (2012): Quality concept: www.sig3d.org/index.php?catid=2&themaid=8777960, Last visit 23.05.2014.

Authors’ addresses
Dipl.-Ing. Ulrich Gruber
DVW Working Group “Geoinformation”
County of Recklinghausen, Germany
ulrich.gruber@kreis-re.de

Dr.-Ing. Jens Riecken
DVW Vice President
Cologne District Government, Germany
jens.riecken@dvw.de

Dr.-Ing. Markus Seifert
DVW Working Group “Geoinformation”
Bavarian Agency for Digitization, Fast Internet and Surveying, Germany
markus.seifert@lvg.bayern.de

This article also is digitally available under www.geodaesie.info.