Germany on the Way to 3D-Cadastre

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Key words: 3D-cadastre, solar and noise cadaster, CityGML, vertical data integration

SUMMARY

In Germany property taxation was the reason for the establishment of the cadaster in the beginning of the 19th century. One hundred years later (1900) the property cadaster was established. In the last decades the cadaster was increasingly used for a lot of other mapping and planning issues - it became a so called multi-purpose cadaster as a geo-basis Land Information System (LIS) and nowadays as a part of the Naional 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 realize 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® cadaster standard takes into account the international standardization of ISO and OGC to include 3D-geodata.

The cadaster 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 cadaster 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 cadaster. For that reason the Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany[1] (AdV) gives recommendations for nationwide cadastral standardization. The AAA® - data model which ensures the interoperability between cadastral and surveying and mapping data is the result of this standardization process.

During the last years the information systems of surveying and mapping and cadaster 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 AdV came up with the following decision: "The collection, data modeling and quality management of buildings for the geo-topographical surveying and for the cadaster are main tasks of the official German cadaster. This also includes the third dimension".

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

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[1] Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland (AdV)

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1. THE DEMAND FOR 3D-BUILDING INFORMATION

1.1 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. 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.

Photovoltaic map of the city of Dusseldorf

1.2 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 determine and to document noise pollution in cities. In addition the progress of noise-reduction is checked.

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

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1.3 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. Demographic effects and other restrictions could be visualized in planning alternatives.
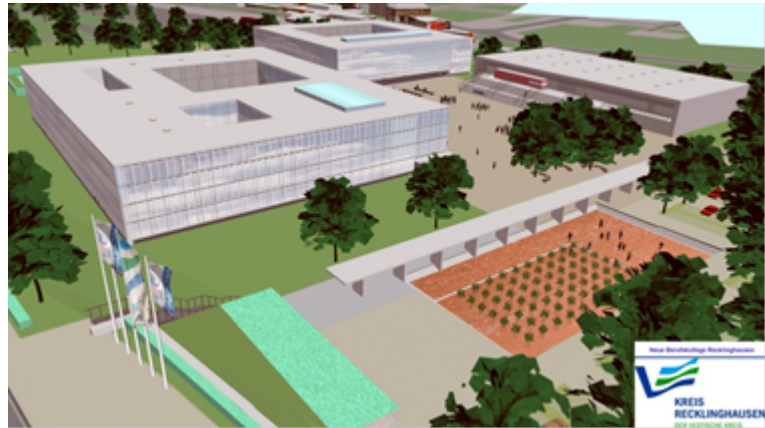
Planned school in the county of Recklinghausen

1.4 Disaster Management

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

Right: Air rescue – county of Recklinghausen

2. REQUIREMENTS FOR 3D-BUILDING INFORMATION

### 2.1 Level of Detail (LoD) in the Cadaster

While 3D-building information in the LoD 1 are sufficient for applications like noise mapping (1.2) many other application like the aforementioned photovoltaic map (1.1) at least need a higher LoD 2 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 visualization of special application scenarios (examples: 1.3, 1.4). On the other side these models had not special quality or updating mechanisms. Often they used the cadaster as a data 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.
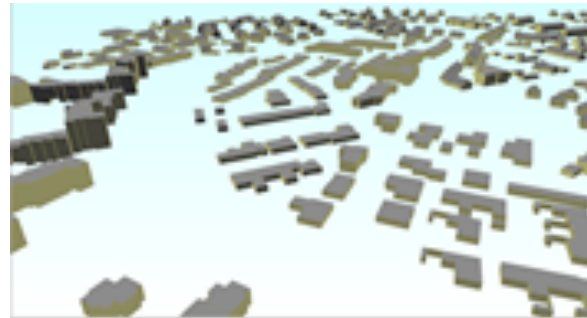
| Real World | LoD 1 | LoD 2 |
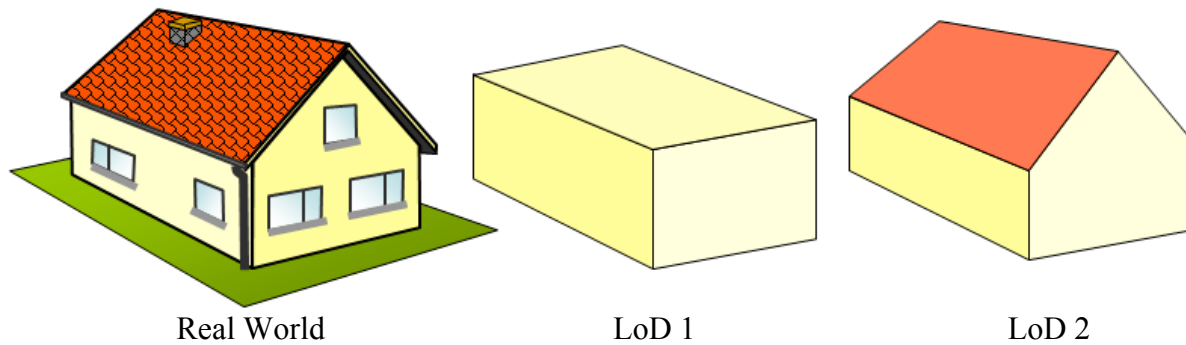
2.2 Approach

Several investigations have proved that only a few additional information is needed to build up a 3D-spacial 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 and the integration the aforementioned information a future 3D-cadaster could be implemented sustainable.

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 19th 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. 2011). With this the 3D-ability is included.
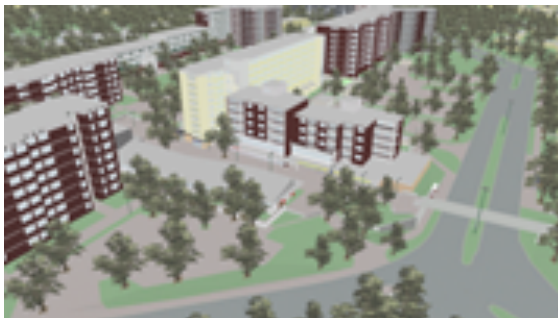
City model, Recklinghausen   3D-spatial data, Recklinghausen

The pictures above show the additional contents of a city model compared to 3D-spatial data. While city models 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.

3. STANDARDS

### 3.1 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 (Groeger 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[2]).


CityGML Version 1.0	CityGML-Profile of AdV
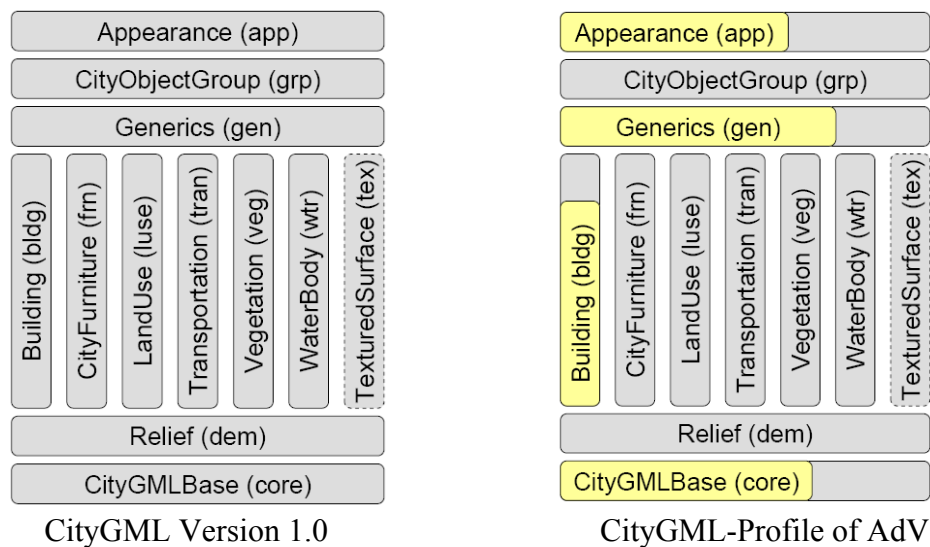
The diagrams above show that the AdV[1] - profile uses only parts of the CityGML-schema, especially mandatory requirements and quality indicators[2]. The profiles are logical restrictions to CityGML-schema.

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.

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[2] „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."
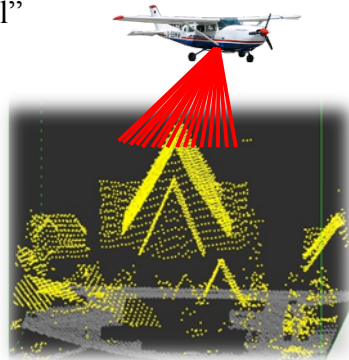
AAA®-concept

The AAA®- concept is national standard for official spatial information in Germany. It was built up completely by specialization of international standards (AdV 2008). 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
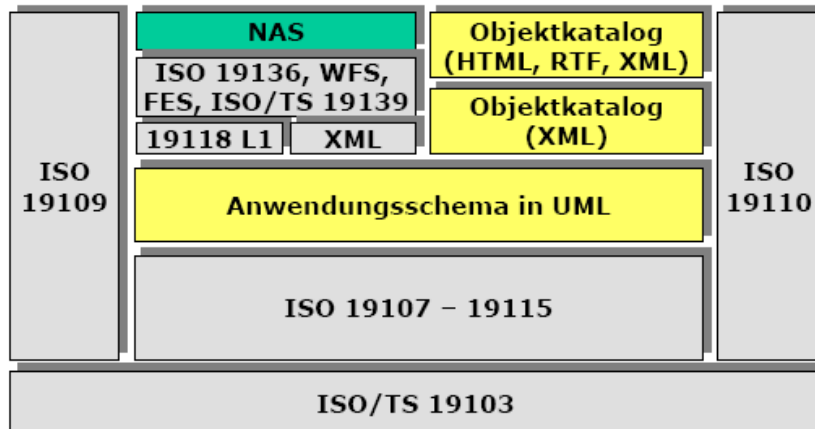
AAA®- embedding existing international standards (AdV 2008)[3]

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 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.

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[3] NAS = exchange interface,   Objektkatolog = feature catalogue,   Anwendungsschema= application schema

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It defines the AdV[1] 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.

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[3].

3.2 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 3 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.
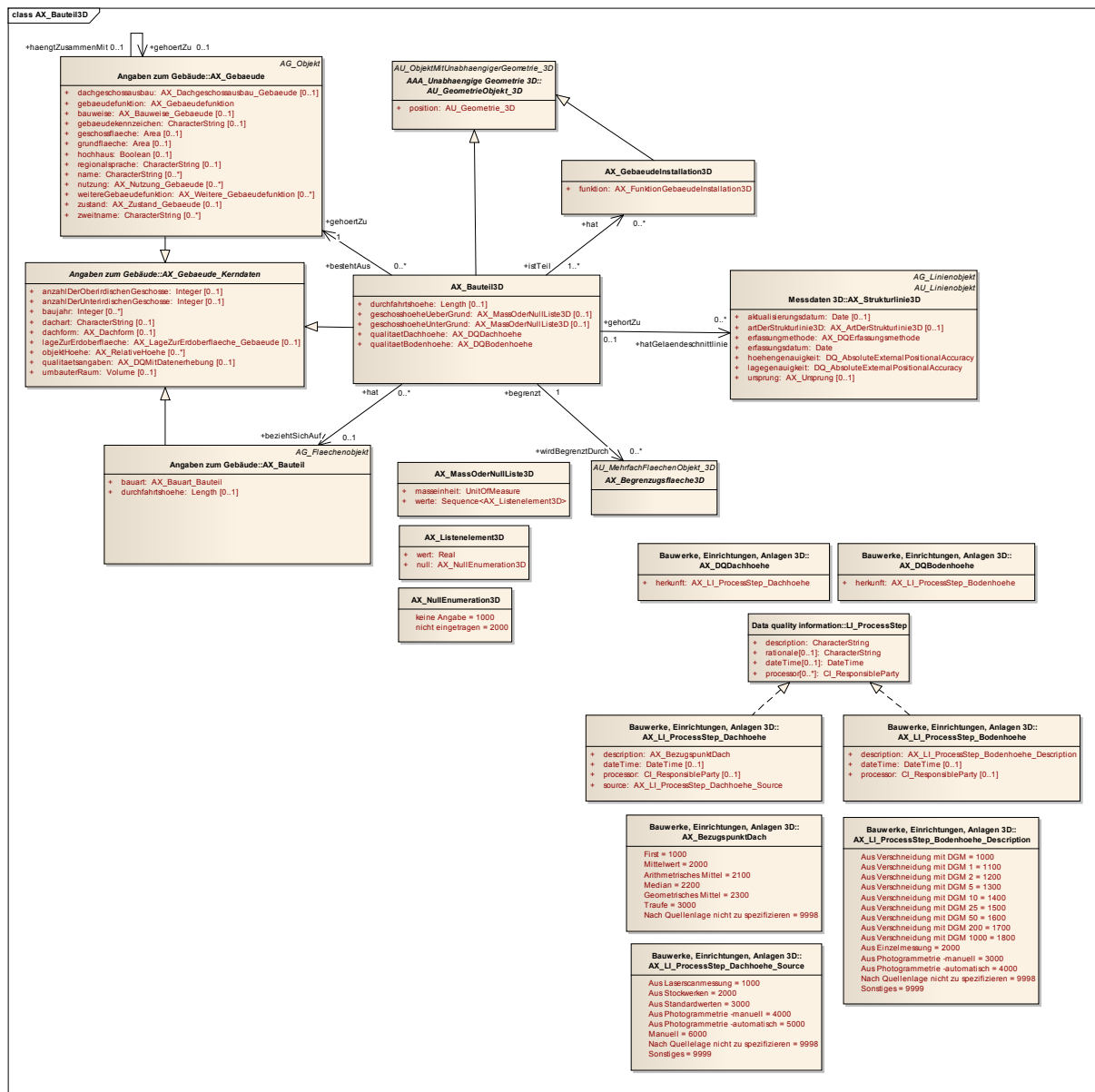

Thematic schema

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 cadaster. Therefore information of quality is modeled conform to ISO-19115 - Metadata. Furthermore the relevant modeling in the INSPIRE[4]-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-expansion.

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

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„Specification to the building 3D"/AAA®- schema

"The 3D-building model of the AdV[1] 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 (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, U., 2011)[5].

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[5] „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

4. COVERAGE, AVAILABILITY

4.1 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. 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).

4.2 INSPIRE

INSPIRE (Infrastructure for Spatial Information in Europe) is the central European directive in the field of spatial information and will speed up the harmonization 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.

5. 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 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 modeling, actualization concepts and the quality management are activities which have to be finished in the next years.

Dimension, angereichert mit Attributen des dazugehörigen 2D-Objektes des Liegenschaftskatasters. Der Produktstandard beschreibt derzeit 3D-Gebäude/-Bauwerke in LoD 1 und LoD 2."

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BIOGRAPHICAL NOTES

Ulrich Gruber is working for the county of Recklinghausen, Germany. From 2002, Ulrich Gruber is member of the Special Interest Group 3D (SIG 3D) of the Spatial Data Infrastructure of Germany (GDI-DE). He is chair of the working group "ALKIS® 3D", member of the working group "CITYGML" and vice chair for the aforementioned SIG 3D.

Since 2009, Ulrich Gruber is chair of the ALKIS®-department of Recklinghausen and in addition responsible for 3D- spatial information in the county. He is member of the group "3D building models" of the Surveying Authorities of the States of the Federal Republic of Germany (AdV) and is actively working on the development of the AAA® - standard, version 7.0. Ulrich Gruber is a member of the DVW eV - Society for Geodesy, Geoinformation and Land Management in Germany and member of the working group "Geoinformation".

Jens Riecken works for the Cadastral and Surveying and Mapping Administration of North-Rhine Westphalia. Jens Riecken was one of the main actors in the SDI developments and was member of several state and federal working groups and the EU expert group INSPIRE. From 2008 on, when the Surveying and Mapping Agency of North-Rhine Westphalia became the department "GEObasis.nrw" in the Cologne District Government, Jens Riecken was chair of "Data Standards, Geodetic Reference". He was in charge for the standardization of spatial information (especially cadastral information) and in addition for the realization of the geodetic reference. From 2010 on he was working for two years in the Ministry of Interior of North-Rheine Westphalia. He was responsible for GIS-developments and products. Jens Riecken is Vice-President of the DVW eV in Germany - the Society for Geodesy, Geoinformation and Land Management and represents Germany in CLGE.

Markus Seifert is head of the project team "SDI Standards" of the Surveying Authorities of the States of the Federal Republic of Germany (AdV) and is working on the conceptual schema of the AAA data model. Furthermore he represents the Bavarian Organization for surveying and cadaster in several national working groups concerning the standardization of public geospatial data. On behalf of the AdV he is the head of the German delegation at ISO/TC 211 and CEN TC 287 and was chair of the INSPIRE Working Groups "Orthoimagery" und "Protected Sites". He currently is also in charge with the implementation of the spatial data infrastructure in Bavaria and Germany as head of the SDI office in Bavaria. Markus Seifert is member of the DVW Working Group "Geoinformation" and is national delegate to FIG Commission 7 "Landmanagement"

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