Cadastre 2020 – New Trends in Germany's Cadastre ?!

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Key words: Cadastre 2014, Official Cadastral Information System ALKIS®, 3D-Cadastre,Satellite Positioning Service SA*POS*®.

ABSTRACT

The FIG Commission 7 presented their vision of a Cadastre 2014 during the 1998 congress in Brighton (UK). Very often visions become overtaken by reality quite soon and some visions never become reality because of unpredictable developments. This paper describes the current developments in German cadastre and shows some new trends which could be important during the next few years, not only for Germany but for a lot of countries in the developed and the developing world. Cadastre as a basic information system has to save and widen its importance in the information society of the 21st century. So it will be able to play an important role for a sustainable development.

ZUSAMMENFASSUNG

Die FIG-Kommission 7 stellte 1998 das Papier Cadastre 2014 vor. Oft ist es so, dass Visionen durch die Realität schnell überholt werden, manche Visionen aber auch aus verschiedenen Gründen solche bleiben. Das Paper beschreibt die gegenwärtigen Entwicklungen im deutschen Liegenschaftskataster und zeigt einige Trends auf, wie sich die eingesetzten Informationssysteme weiter entwickeln lassen, damit das Liegenschaftskataster in der Informationsgesellschaft des 21. Jahrhunderts seine Position sichern und seinen wichtigen Beitrag für eine nachhaltige Entwicklung leisten kann.

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1. INTRODUCTION

Working Group 7.1 of FIG-Commission 7 started developing its paper CADASTRE 2014 in 1994 and introduced their visions of a modern cadastre looking 20 years ahead during the FIG Congress 1998 (Kaufmann, Steudler 1998). Based on studies of existing cadastral systems, the Working Group introduced six statements on the development of cadastre in the following twenty years.
Initially this paper was not significant for trend setting in the field of a cadastral reform in Germany but reflecting the developments in Germany during the last seven years a lot of the statements published in CADASTRE 2014 became reality.

Modern developments in object-oriented data bases, international standards and computer technology and the need to avoid inefficient work flows were the reasons for the German surveying authorities to follow a new and future oriented design of an Integrated Official Cadastral Information System ALKIS® in combination with a re-design of the Official Topographic and Cartographic Information System ATKIS®.

Statement 2 of CADASTRE 2014 'The separation between maps and registers will be abolished!', statement 3 'The cadastral mapping will be dead! Long live modelling!' and statement 4 'Paper and pencil - cadastre will have gone!' became or will become reality in German cadastre by 2005. Statement 5 'Cadastre 2014 will be highly privatised! Public and private sector are working closely together!' is reality in nearly all German states since many years. Statement 6 'Cadastre 2014 will be cost recovering!' is currently a point of big debates concerning as well the role of cadastre as a basic part of a National Spatial Data Infrastructure (NSDI for Germany). This issue will be discussed later in this paper.

The establishment of statement 1 'Cadastre 2014 will show the complete legal situation of land, including public rights and restrictions!' is not operational in Germany's cadastre and due to political and financial reasons will not be operational in the near and far future. Even if this idea is very old and discussed since many years and even if the benefits of a cadastre showing the complete legal and de facto situation of land tenure are evident, the structures of the German jurisdiction will not allow or at least makes it very difficult to succeed in this issue. The role of meta data bases and Geographical Data Servers which allow the access to different data via the World Wide Web will cover this lack of missing infrastructure in case the same basic Information System and its geometry is used in all these systems.

Some more developments in German cadastre will become important during the next years. The German Satellite Positioning Service SA*POS*® together with the establishment of the European Terrestrial Reference System 1989 (ETRS89) will allow cadastral surveying of high accuracy in three dimensions. Together with the development of software for 3D-terrain and city models it is only a short step towards a three-dimensional cadastral system. The introduction of the third dimension in mapping and in cadastral modelling will change the surveying and cadastral practice significantly during the next years.

2. ALKIS®

The Land registration system in Germany is a duplex system. The legal situation of each parcel is described in the land register called "Grundbuch". The geometric description of all boundaries in the Automated Cadastral Map (ALK), field records and textual records in the Automated Property Register (ALB) are in the hand of the cadastral authorities. Only Grundbuch and cadastre in combination give a complete overview about legal and de facto land tenure. Both registers must be constantly updated and kept in correspondence with each other (DVW 1993).

The roots of the ALB and ALK systems date back to the 70s and 80s of the last century. Further development of these software systems seems not to offer future oriented solutions. Therefore the ‘Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland’ (AdV) (Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany) decided to design a new and future oriented system ALKIS® in combination with a re-design of the Official Topographic and Cartographic Information System ATKIS® (Hawerk 2001).

ALKIS® in combination with ATKIS® is designed to:

– Process all necessary cadastral and topographical data for a parcel based map and register of land owners, land use and more unified basic data for the entire Republic,

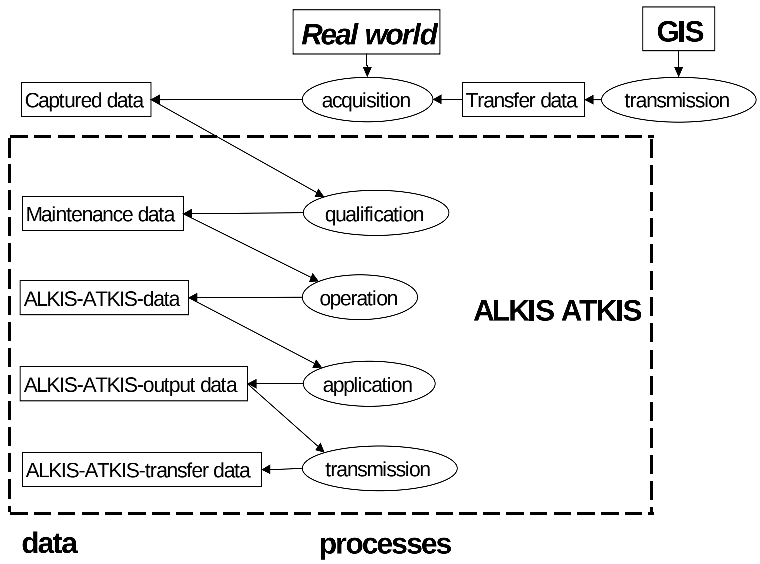
– Control the use and maintenance of the system and to

– Enable the use of the entire geographical data of the surveying authorities for all users via a meta data system including quality information for all data and a standardised data interface for ALKIS® and ATKIS®. Of course links of the users’ specific data they already linked to ALK, ALB or ATKIS® still have to be possible in the new systems without reasonable new investments on their side. They shall trust in the sustainability of their investment in data.

2.1 Data and Process Modelling

Initially ALKIS® was modelled by using the draft documents of the data base description language EXPRESS developed by CEN, EXPRESS-L for the lexical and EXPRESS-G for the graphical part. New developments on the fields of international standards forced AdV to reshape the description on the ISO standard Unified Modelling Language (UML) and for the definition of the data interface Extensible Markup Language (XML).

Picture 1:ALKIS®-ATKIS® data and processes



ALKIS® defines the processes data acquisition, qualification, operation (setting up and maintenance of data), application and data transfer.

Relations between data and processes in AdV-terminology are shown in Picture 1. By definition through AdV the data acquisition process and the results of this process in form of captured data shall not be modelled by ALKIS® because this process may be designed individually by each German.

2.2 State and Future Development of the Project

AdV's activities in modelling ALKIS® and ATKIS®, the definition of standard output products based on a XML interface and the meta data catalogue based on UML are

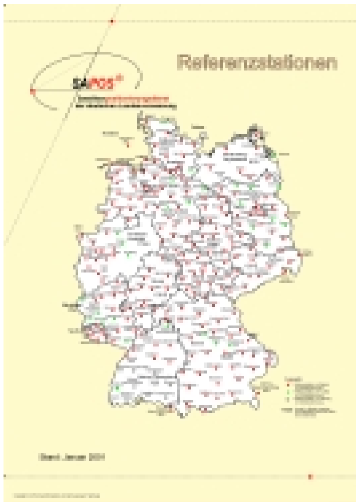
completed. The member states in AdV agreed upon the basic contents of ALKIS® to guarantee a unique standard for the system and data in ALKIS® for the entire country.
An AdV Task Force of representatives in co-operation with the Ministries of Justice developed a data interface for the data exchange between ALKIS® and the Grundbuch systems in order to enable data exchange and direct update of both data bases.
The leading GIS companies introduced already ALKIS® prototypes. Most of these prototypes have been developed with OGC simple features using Oracle 8i spatial. The results shown there confirm that ALKIS® seems to be an excellent cadastral model for the next decade.
Some states in Germany are already on the track to establish ALKIS®, most states are planning and preparing the migration process. All states committed themselves to start with the implementation of ALKIS® not later than 2005.

3. NEW GEODETIC REFERENCE SYSTEM BASED ON ETRS89 IN CADASTRE

3.1 SA*POS*® - Satellite Positioning Service of the German National Survey

SA*POS*® is a public Service for real time and post-processing differential GPS (DGPS) applications. Its development has been carried out within a co-operation of the responsible state survey authorities by a group of experts in AdV. The main reason for establishing SA*POS*® in Germany was simply the outcome of a cost-benefit analysis concerning the replacement of traditional geodetic activities by DGPS techniques. So it is possible to use

DGPS and Real Time Kinematic techniques (RTK) almost throughout the entire country (Weber 2001).



Picture 2: SA*POS*® reference stations

For a complete coverage of Germany, 250 permanent GPS stations are intended to be established with separating distances of 40 to 70 km. The current status is shown in Picture 2.

SA*POS*® offers different services on different levels of accuracy ranging from 1 to 3 m for navigation to sub cm services for engineering surveys. For cadastral purposes a service called HEPS (High Precision Real Time Positioning Service) is most relevant. HEPS allows RTK applications with an accuracy from 1 to 5 cm which is sufficiant for cadastral surveys.

The correction data are transmitted in the 2 m band via the National Survey's own stations. The data can be called in also via telephone, the internationally introduced standard RTCM SC-104, version 2.1 serving as format. The data are transmitted at intervals of a second; a decoder module of the AdV is required.

In different areas an extended service will be offered in future. Several GPS reference stations work on an interlinked basis and can thus record site-dependent error influences from orbits, ionosphere and troposphere. Specific position-dependent correction values are supplied to the user, which means a further increase in reliability and accuracy.

3.2 The Implementation of ETRS89 in Cadastre

ETRS89 has been derived from the global reference system IERS Terrestrial Reference Frame (ITRF), (IERS = International Earth Rotation Service). The ETRS89 and the World Geodetic System 1984 (WGS84) agree with each other to 1-2 m. The AdV decided in 1991 to introduce this reference system for the sectors national survey and real estate cadastre. In 1995 it confirmed this decision and established the Universal Transversal Mercator projection (UTM) as projection system.

All German states agreed to implement the new reference systems in cadastre as soon as possible. This is not an easy task in Germany because it has to be taken into consideration that Germany's cadastre has been introduced about 150 years ago with the surveying systems and accuracy of that time and was and still is constantly updated and improved with modern methods. This historically grown cadastre therefore is a patchwork of sometimes only very small homogeneous areas with tensions between different areas from different origin. Additional to these problems often boundary coordinates from surveys are different from the presentation coordinates in the cadastral maps. High accurate tension-free DGPS results so often do not fit together with the old coordinates.

The implementation of coordinates in ETRS89 therefore mostly goes hand in hand with a transformation from the old system via a number of local control points having coordinates in both systems. So tensions may be identified and compensated. The coordinates of the boundary points in the neighbourhood of the control points can be improved by adequate mathematical procedures (Benning, 1995).

The implementation of ETRS89 in cadastre is a big task but only taking this big step ahead will help to earn the benefits of SA*POS*® for all users of official geodata. Especially the use of modern data acquisition methods for cadastral and mapping purposes inside the public surveying authorities like DGPS, airborne digital photogrammetry or laserscanning can only be cost-effective by establishing a tension-free cadastre with exact coordinates of boundaries and accurate digital maps with a correct geometry.

In addition to these aspects the implementation of a European reference system and the transformation of each country's coordinates into this system is essential for all users of geodata on an international level.

4. 3D CADASTRE, DIGITAL TERRAIN MODEL, VIRTUAL REALITY

4.1 Virtual Reality

As soon as hard-and software will allow comfortable processing of 3D-data, demands will follow asking for virtual reality applications via the World Wide Web (WWW) for cadastral as well as for topographical data. The technical problems that have to be solved are the same in cadastral systems as for topographical mapping.

Navigation in digital terrain models and flights through this cyber space are theoretically no problem. The next or second next car navigation systems will have a 3D displays showing a 3D-model of terrain and cities with textures on buildings and landscape. The requirements on digital maps from the customers' perspective will change. Highly cryptic 2D maps modelling complex 3D features will not be necessary in future. 3D maps and 3D perspective images will replace these maps in many fields of practical work.

The visualisation techniques for three dimension models have been developed rapidly during the last few years even for the WWW (Okubo 2001). Architects and other planners as well as the real estate market will require 3D data for their purposes if it is city planning or the administration of bigger real estate complexes, advertising and a lot more applications.
These changes in topographical mapping will not leave out the cadastral sector with its more legal aspects, even when the topographical and the cadastral information systems ATKIS® and ALKIS® are based on the same object structures.

4.2 3D City Models

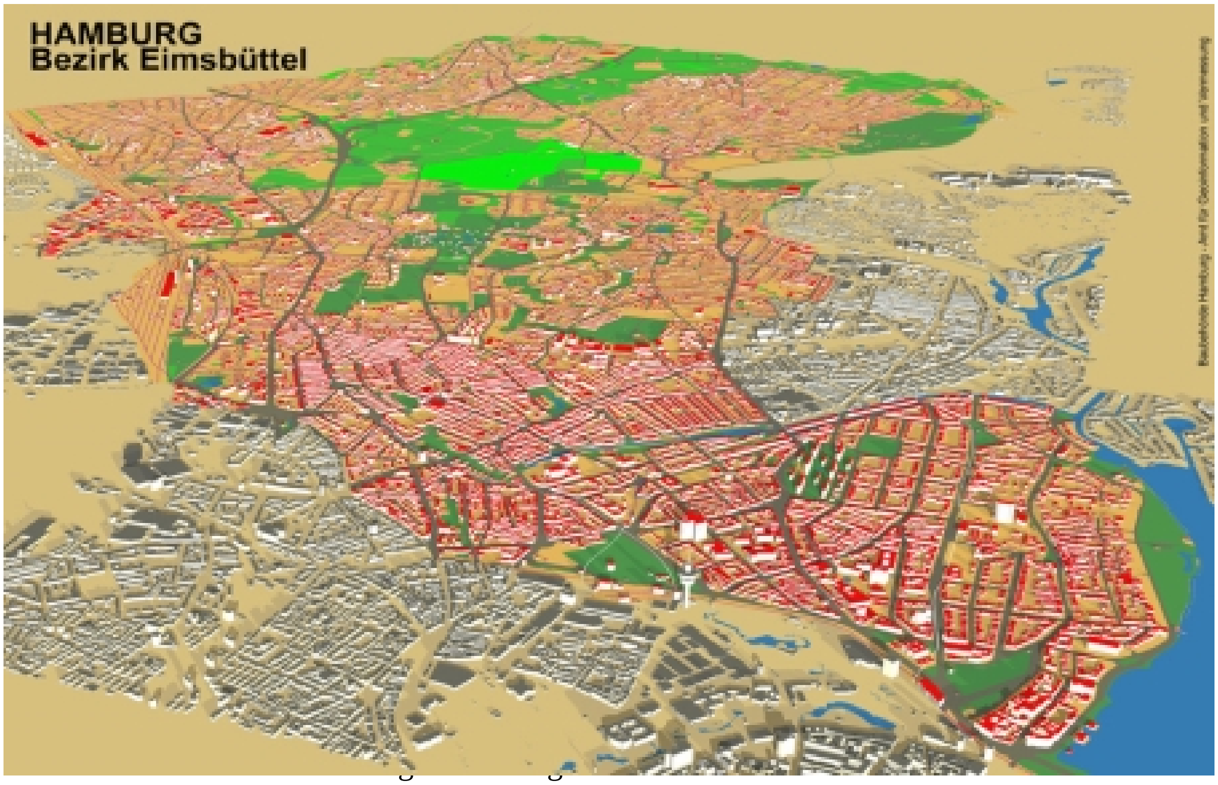
An increasing number of municipalities are currently establishing 3D city models to increase the quality of their planning processes especially in urban areas. These models are frequently basing on a Digital Terrain Model (DTM) with high accuracy data from Laser scanning results. By adding the missing 3D information about buildings the 3D city models are produced.

A very quick result and for overview purposes very helpful model of buildings can be produced by using the information of the geometry of buildings from the cadastral maps and the information about the use and the number of floors of each building from the textual records. The result is a model with a block structure not containing information about the form and structure of roofs and the exact height of the buildings. An example is shown in Picture 3.

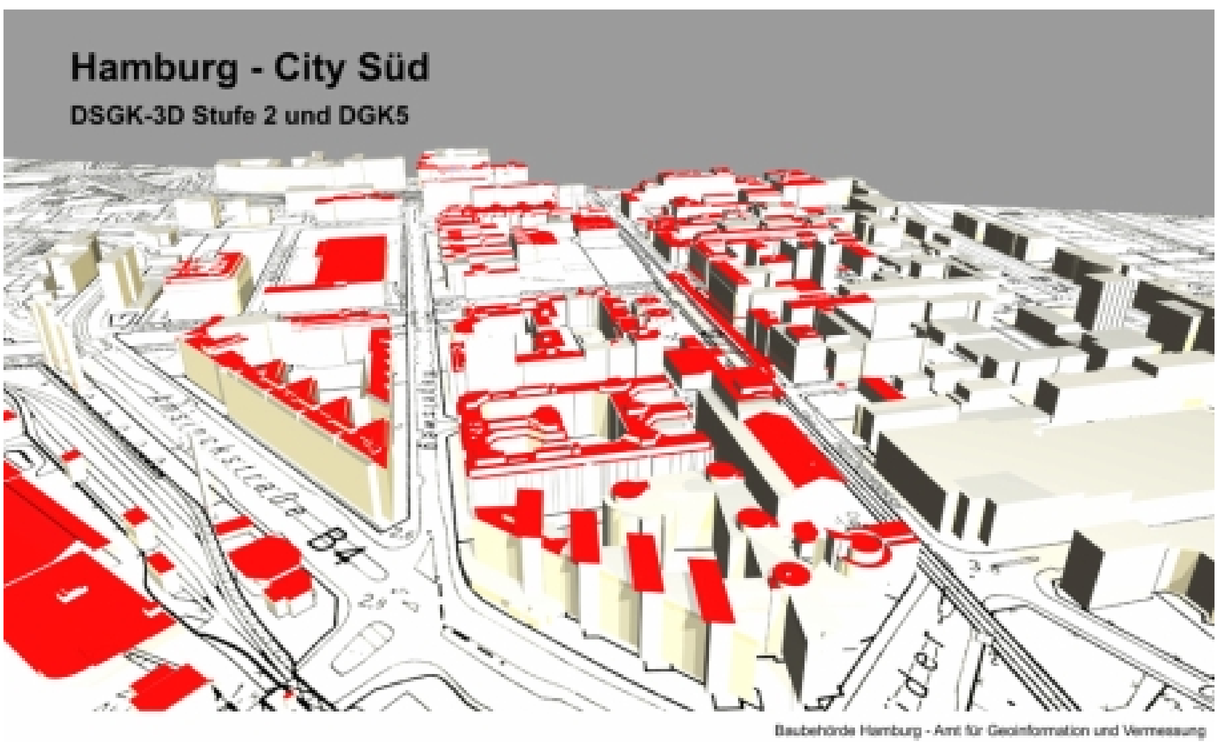
The next step is the combination of a DTM with a precise photogrammetric measurement of the roofs shown in Picture 4. This is a quite costly process but the appropriate way to produce such a model because laserscanning in urban areas are not able to produce satisfying results.

The customers for these very detailed models were found in the planning sector, the mobile telephone companies for position planning of the antennas for their services, the telematic sector for navigation, the security sector (police and fire brigades), tourism and an increasing number of real estate brokers for faciltiy management and advertising and a lot more.
These more topographical models can as well be understood as a first step in the direction of a 3D cadastre. The design of the data base behind the visualisation allows to add data to each building and even parts of each building.

Picture 3: 3D city model (District Eimsbuettel in Hamburg, Germany), block structure



Picture 4: 3D city model of an office district in Hamburg, Germany with detailed roof structure



4.3 3D Cadastre

Until now the spatial information system that is used to register the legal status of land is a two dimensional system: parcels are defined by 2D juridical boundaries. In areas with an increasing pressure on land, there is a growing interest in using space under and above the surface (e.g. underground constructions and infrastructure, growing number of cables and pipes). Therefore, 3D information becomes increasingly important in registering today's world (Stoter, Zevenbergen, 2001).

In order to meet the visions of the Cadastre 2014 paper (Kaufmann, Steudler, 1998) the need for a 3D view on the approach of this vision is evident because with traditional 2D parcel based information systems constructions above and under the surface are divided into parts that match with the parcels partitioning the surface. The objects under or above the surface are normally not modelled as objects as such. A pipeline for example cannot be defined in cadastre as a linear object itself. It is only registered administratively as an attribute to a number of defined parcels.

A complete 3D spatial information system would be a solution for the problems met by the cadastre. Also incorporating the new 3D functionality into the present system, into the work processes and into the present legislation are important factors for contemplation.

Future solutions should allow 3D approaches where they are necessary as in most urban but maybe not in remote rural areas. But with the increasing use of DGPS equipment in cadastral surveying 3D information will received automatically. The Digital Cadastral Data Bases should be able to handle these data together with descriptive data as well in graphic as in textual records.

5. NATIONAL AND GLOBAL SPATIAL DATA INFRASTRUCTURE AND STANDARDS

5.1 ISO and OGC Activities and Standards for a Digital Cadastral Data Base

The current activities of the OpenGIS Consortium (OGC), a commercial body representing the manufacturers of GIS hardware and software, and the providers of geographic data have an important impact to future GIS software solutions. OGC is working towards the adoption of open standards, allowing the flow of data between different GI systems.

Together with the very important tasks of TC211 which will have an important impact to our future business the OGC activities are very interesting and will hopefully make life a little easier in future, both fields in which FIG-Commission 7 could contribute effectively.

The approaches aiming at GIS interoperability like the ones which are coming up from the concepts of the European Standardisation Body CEN and ISO and especially from the Open GIS Consortium OGC play an important role for future decisions (AdV 1999). The German Cadastral Authorities followed these developments very early when designing the ALKIS® system.

ISO TC211 has been producing a standard Unified Modelling Language (UML) and for the definition of data interfaces Extensible Markup Language (XML), documented in ISO standards 15046.

Germany’s new cadastral database ALKIS® is modelled by using UML and XML. It is the first database which is described by using UML and XML. ISO therefore established a test-bed for ALKIS® in order to test the modelling languages in practise. This could be a future oriented example as well for FIG, not looking on ALKIS® from a technical perspective on practicability of a description language, but focussing on legal aspects. Developments and experiences from other countries in the same field could be collected by FIG-Commission 7 and will be a well accepted contribution for the future work in ISO.

Countries in Europe grow closer together. The establishment of our new currency is just one example. European activities will start to develop a European network of laws and regulations in the field of land registration and land management in future. These activities have started slowly, but in a growing European Union it will become a dynamic process - only a question of time.

5.2 National Spatial Data Base

A Frost & Sullivan study of the market volume for the use of geo-coded data in 1996 published an amount of 660 million € for Europe with a predicted growth of 130 % until 2004. For the reason of the SDI initiative of the previous President the growth in the USA is even much higher.

Politicians in Germany have noticed these development late but since 1998 an inter-ministerial board on federal level called IMAGI was established to support the political and commercial conditions for the use of spatial data. Primarily this motion focussed on the increasing use of topographical data in environmental planning, a sustainable development and telematics, but cadastral data play a more important role in this field specially with the introduction of ALKIS® and ATKIS® model.

ALKIS® and ATKIS® are the standards for basic geodata and a National Spatial Data Infrastructure (NSDI) in Germany. The task for the surveying authorities in Germany will be to provide the customers with appropriate data for an agreeable price. The ongoing discussion about the pricing policy for these data is controverse. Shrinking budgets on the federal, state and local municipal level cause hard discussions about tax income, project financing and cost recovering activities in the public sector. A unique pricing system for data and seervices has to be found and established.

5.3 Standards for GPS

Neither today's RTCM nor RINEX standards seem sufficiently sophisticated to satisfy all needs of networked RTK. The use of calibrated antennas is a must when aiming for cm-accuracy. Today, RTCM does not allow the transport of antenna calibration data. Definitions should be extended to allow the transport of these and other additional information for networking reference stations. A co-operation of all interested parties is necessary considering experiences available (Weber, 2001).

6. HARD- AND SOFTWARE DEVELOPMENT

Object oriented data capture in the field using integrated GIS/GPS equipment for an instant online maintenance of the Digital Cadastral Data Base (DCDB) is not science fiction. The technical devices exist and will soon be normal tools in daily work. Customers‘ demands can be met much faster than now.

Pocket PCs with Web facilities, GPS receiver and integrated mobile phone will be operational for professional purposes latest when the UMTS standard in the mobile phones sector will be established. This will allow a transfer of the necessary data in a reasonable time from the original data base to the computer in the field and back. This standard will be in operation in a few years.

The further development in the technical sector for a period of 10 or more years is very hard to predict but will influence the services of the cadastre in many ways. The trends besides the technical trends smaller, faster, better are

- More mobility
- Integration of services
- World wide standards for data and interoperability of different data
- High resolution satellite images
- 3D cadastral maps and other geo-referenced data
- GPS based navigation systems.

7. CONCLUSION

The cadastre, the products and services for the customers in the public and private sector in this field will change dramatically in the next few years. Beneficial effects will result from new technologies with RTK equipment, ETRS89, 3D modelling of data and very important national and international standards for processes and data as well as new technical developments in the field of telecommunication.

The technical development can only be established and successfully operated when the legal framework allows this. Technical feasibility is not always the appropriate solution. Sometimes less is more.

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