Title
German GIS/LIS Standards (91-24)

Authors
Kuhn, Werner
Petersohn, Fritz K.

Publication Date
1991-08-01

NCGIA

National Center for Geographic Information and Analysis

German GIS/LIS Standards

by: Werner Kuhn

NCGIA, Department of Surveying Engineering
University of Maine, Orono, ME 04469

with contributions by

Fritz K. Petersohn
The BSC Group, Boston, MA 02210

Technical Report 91-24

August 1991

Simonett Center for Spatial Analysis
University of California
35 10 Phelps Hall
Santa Barbara, CA 93106-4060
Office (805) 893-8224
Fax (805) 893-8617
ncgia@ncgia.ucsb.edu

State University of New York
301 Wilkeson Quad, Box 610023
Buffalo NY 14261-0001
Office (716) 645-2545
Fax (716) 645-5957
ncgia@ubvms.cc.buffalo.edu

University of Maine
348 Boardman Hall
Orono ME 04469-5711
Office (207) 581-2149
Fax (207) 581-2206
ncgia@spatial.maine.edu

TECHNICAL PAPER 91-24

GERMAN GIS/LIS STANDARDS

By Werner Kuhn, Orono, Maine

Preface

The author had the opportunity to visit Germany twice, in November 1990 and in March 1991, in order to investigate cadastral and topographical information management and standardization efforts in this country. This technical report contains two separate accounts on these investigations. The first part concentrates on the situation in western states, while the second part deals mainly with perspectives for the five new states in eastern Germany. The contents provide information in English about some important European developments in the area of geographic information handling and were therefore considered to be of interest to a wider audience. Support from the National Science Foundation (NCGIA grant No. SES 88-10917) for this publication is gratefully acknowledged.

Table of Contents

Abstract

This report contains an update on recent developments in Germany's western states and an account on the situation in the five new eastern states, regarding topographic and cadastral information management. It is based on a week-long visit to Germany in March 1991 and constitutes a follow-up to an earlier report entitled "German Approaches to Topographic and Cadastral Information Management".

After a description of the context of this investigation, a summary of the historical roots of cadastral and topographical information management in Germany provides the necessary background for an understanding of today's situation and the corresponding major market potential for geoinformation technology. Section three reviews the current state of implementation of the standards for topographic and cadastral information in western parts of Germany. Section four contains a description of the situation in the five eastern states of Germany and a ideas on alternative approaches to land information management in this region.

1 Context

After a first round of investigations into western German approaches to land information management, a second team took a closer look at the land information needs of the five new states, i.e. former East Germany. The itinerary contained preparatory meetings at the surveying and mapping agencies of Hesse and North Rhine-Westfalia, site visits in the two new states of Saxony and Thuringia, and round-up discussions back in Hesse and in Rhineland-Palatinate, the current location of the chair of Germany's association of surveying and mapping agencies (Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland, AdV).

The visit was organized under the umbrella of the exchange of experts program which is supported by the German and U.S. governments and administered by the Atlantic Institute, as a member organization of the Institute for Land Information. The investigation team consisted of a representative of each, the private sector (Fritz Petersohn, BSC Group), high tech industry (John English, Intergraph Huntsville), and academia (Werner Kuhn, University of Maine). Thus, it constituted a delegation in the spirit of the Atlantic Institute's mission, representing all but one of its cooperating sectors. The government sector, while absent in the U.S. delegation, was all the more prominent and active on the German side.

The exchange of experts program clearly fulfills an important role in combining innovative research and development strategies in the U.S. with a highly educated marketplace in Europe. The German surveying and mapping agencies, supported by their respective ministries, are very interested to continue and extend this program. They demonstrate their interest not only by a perfect organization of these visits and a generous hospitality, but by taking concrete steps toward financial support of the exchange program in state budgets and by promoting the participation of additional states.

The focus of this investigation lay on the situation in Germany's five new states. The short time frame and the additional task of assessing recent developments in western states limited the possible breadth and depth. However, the accessibility and support offered by the Germans, as well as their warm and welcoming receptions made the visit both highly informative and personally gratifying.

Acknowledgements

The members of the investigation team gratefully acknowledge Intergraph Corporation for financial support, Dipl. Ing. Ralf Borchert (U.S.-Coordinator of AdV) for organizing and actively participating in the visit, as well as the following individuals and organizations for their support and for sharing their information and thoughts:

Landesvermessungsamt of Hesse,Wiesbaden:
Prof. Dr. Ing. Bartsch, President
Prof. Dipl.Ing. Goerlich, Vice President
Dipl. Ing. Knab, Head of the Section for Technology, Development, and Data Processing
Dipl. Ing. Grimm, Head of the Section for Cartography, Reproduction, and Printing
Dipl. Ing. Peters, Head of the Section for Cadastral Surveys

Ministry for Economy and Technology of Hesse:
Leitender Ministerialrat Dipl. Ing. Schröder, Head of the "Referatsgruppe Vermessung"
Ministerialrat Dr. Brüggemann, advisor to the state government of Thuringia

Landesvermessungsamt of North Rhine-Westfalia, Bonn-Bad Godesberg:
Dipl. Ing. Barwinski, Director
Dipl. Ing. Limbach, Public Relations and Marketing
Dipl. Ing. Brüggemann, Head of the Section for ATKIS
Dipl. Ing. Inden
Dipl. Ing. Michalsky, Head of the Department of Photogrammetry
Dipl. Ing. Irsen
Dipl. Ing. Wegener

Landesvermessungsamt Baden-Württemberg:
Dipl. Ing. Berberich, Vice President

Bund der öffentlich-bestellten Vermessungsingenieure (BDVI):
Dr. Ing. Schuster, Chair
Dipl. Ing. Lumma

State Surveying and Cadastral Office of the town of Grimma, near Leipzig:
Dipl. Ing. Thieme, Head of the surveying office

Dipl. Ing. Lehmann, Director of the Surveying Agency of Leipzig County
Dipl. Jur. Verm.Ing. Platschek, Associate director
Staff of the surveying office

Landesvermessungsamt of Thuringia, Erfurt:
Dipl. Ing. Bauer, Head
Staff of the cadastral renewal group

AdV (Working Committee of the State Surveying and Mapping Administrations):
Leitender Ministerialrat Dipl. Ing. Herzfeld, Ministry of the Interior, Rhineland-Palatinate; Chairman of AdV
Dipl. Ing. Stoffel

Intergraph GmbH, Germany
Dipl. Ing. Paeslack, Head of GIS Marketing

University of Maine
Dr. Tyler, Chair, Department of Surveying Engineering
Dr. Frank, Associate Director, National Center for Geographic Information and Analysis
Dr. Egenhofer, Research Professor, National Center for Geographic Information and Analysis.

The authors also wish to thank Dipl. Ings. Barwinski and Borchert for their helpful comments on an earlier version of the report.

Abbreviations

AdV — Working Committee of the State Surveying and Mapping Administrations (Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland)
ALB — Automated property register (Automatisiertes Liegenschaftsbuch)
ALK — Automated property map (Automatisierte Liegenschaftskarte)
ATKIS — Authoritative topographic-cartographic information system (Amtliches Topographisch-Kartographisches Informationssystem)

BDVI Association of licensed surveying engineers (Bund der öffentlich-bestellten Vermessungsingenieure)
CERCO Commité Européen des Responsables de la Cartographie Officielle,
ILI Institute for Land Information
ÖbVI Licensed surveying engineer (Öffentlich-bestellter Vermessungsingenieur)

2 Historical background (Fritz Petersohn)

In order to facilitate the understanding of the findings contained in this report, a few historical remarks are in order. They are oriented toward anybody interested in participating in the automation process of Germany's standardized and highly accurate survey controlled land information management system. They are intended to highlight the organization and structure of the institution and should give the reader an appreciation of the political, professional, institutional and public support which the development and maintenance of GIS and LIS enjoys in Germany.

2.1. Philosophy and roots of the German cadastre

Germany has, like many western European nations, over time developed a cadastral institution based on an ancient[1] cadastral philosophy considering men's relationship with the land and its resources from a legal rights, a multiple use, and a preservation point of view. It is this cadastral institution which has brought about the political concept of a sustained *land economy* system in Germany, in contrast to North America's *land commodity* system, where speculation in land and resources dominates the socio-political scene.

This cadastral institution, or multi-purpose land information system, as German professionals prefer to call it, emerged over a period of approximately two hundred years from a single-purpose taxation cadastre to a legal parcel cadastre, to a multi-purpose infrastructural, environmental and planning cadastre. Coordinated through AdV, the individual states create and maintain an accurate and up-to-date land-related information system, unambiguous in nature and open to use and inspection by the general public at all times.

---

[1] Retraced to Sumerians, approx. 5000 years ago.

The earlier single-purpose taxation cadastres were, prior to 1871, administered by the then independent German states, such as Prussia, Bavaria, Hessen-Nassau, Saxony, to name just a few. The documentation existing at that time was similar to that in the United States of today: legal parcel descriptions and written documents on land-use.

After the unification of the German states under Bismarck in 1871, federal control was exercised to bring the cadastral taxation offices in line with each other. Rigid standards were imposed on surveying, mapping, and other recording procedures, yet allowing for slight differences in the data collection, recording, and displaying process. At that time, the legal parcel cadastre was established. Deeds were replaced by records of actual ground surveys to eliminate ambiguities in location and description of each parcel and to bring about a clean title system for the benefit of the individual citizen and society at large.

2.2. Toward a multi-purpose cadastre

After World War I, but especially during the period of 1920 to 1945, the multi-purpose land information management concept received major federal support. It was intended to deal more efficiently with an increase in farm and forest production, the development of a major federal transportation system (Autobahn), a complete electrification of the vast railroad system, the expansion of the industrial base, as well as land and housing development programs. Most of all, however, its goal was to provide information on a parcel by parcel level to deal successfully with the rapidly increasing pressure on the land from the many adverse building and land development procedures. At the same time, a rather uncontrolled expansion of coal and iron mines and chemical and synthetic industries created an early awareness to pollution of the environment.

It was during that period, in the early 1930's, when the concept of a large-scale (1:1000 and 1:2000) uniform cadastral map system was established, founded on an integrated surveying concept. This meant moving from the previous "island maps" to grid-oriented parcel maps, based on a highly accurate geodetic reference frame. In addition to the large-scale cadastral maps produced and maintained by an office operating at the county level, a federal agency (Reichsamt für Landesaufnahme) similar to the USGS produced various medium- to small-scale map series from 1:25,000 to 1:100,000.

With the establishment of the legal parcel cadastre, all surveys conducted by a private party, industry or a government agency to improve parcel geometry had to be executed in compliance with cadastral survey standards. Each lot corner had to be monumented above and below ground, the monuments had to be shown to and witnessed by owners and abutters, and all documents, (especially the certified original field notes) and computations had to be filed with the cadastral office. These field notes, known as the numerical survey record, are a major asset in the handling of a fully automated and unambiguous land tenure system.

2.3. Evolutions after World War II

Since 1945, this cadastral institution–Germany's land information management system–underwent major changes, not only because of its division into two separate entities, but also because of the different political systems behind these two parts.

Today's five "New States"–former East Germany–have been dominated for 45 years by a socialist doctrine, recognizing neither private ownership nor a free market economy. The concept of a legal cadastre had no role to play in such a system and was eliminated. All remaining surveying and mapping activities were engineering surveys, executed by a group of well-educated surveyors, organized under state supervision into a so-called "Kombinat" or "Volkseigner Betrieb" (VEB, enterprise owned by the people). These agencies were primarily serving industrial development and military mapping purposes. Today's state of affairs resulting from this recent history is described in section four.

The eleven western states organized under the name of the Federal Republic of Germany (FRG) retained a free enterprise system, honoring and guaranteeing private ownership. The former federally controlled surveying and mapping system was decentralized and organized by each of the eleven states. Thus, eleven state surveying and mapping agencies were created, with the county cadastral officers under their supervision and control. Since that decentralization, most surveying, mapping, and land information management functions have been housed in these state agencies - the "Landesvermessungsämter" (LVA).

All eleven surveying and mapping administrations are organized in the AdV. This organization is also coordinating other surveying and mapping activities with the German Railroads, the German Defense, the Ministry of Transportation and the Federal Ministry of the Interior. Thus, AdV is the trend setting consortium in any and all GIS/LIS related matters. All other state agencies, such as those for environmental protection, soils classification, census, property evaluation and taxation, follow GIS/LIS development guidelines of the respective surveying and mapping agency.

Visiting with three of the eleven state surveying and mapping agencies revealed that the development of a national land information infrastructure for Germany is professionally supported by an academically trained and experienced staff of surveying engineers (geodesists, photogrammetrists, remote sensing specialists, cartographers, engineering and cadastral surveyors, etc.). Each surveying and mapping agency has an approximate manpower of 400 to 500 people with additional staff at each county cadastral office of 30 to 50 people. Over 60% of the employees have an equivalent of a B.Sc., M.Sc., or Ph.D. from one of the many Technical Universities providing a degree in surveying engineering and/or from one of the even greater number of engineering colleges granting degrees in surveying engineering with an applied sciences orientation.

Beside the cadastral offices, the enterprises of approximately 750 privately operating surveying engineers are carrying out cadastral surveys. These are authorized to perform cadastral surveys and thus operate on an even footing with the director of the cadastral office, while all their work is subjected to scrutiny before its integration into the cadastral registers.

All this is indicative of a strong institutional arrangement, carrying the necessary political support. The arrangement furthers an unambiguous decision making process, based on a high quality land and resource information management system. The AdV, taking a strong interdisciplinary stance, sees the surveying and mapping agencies as catalysts for any kind of activities related to topographic and cadastral information management. This view has also largely been recognized by private enterprise and by state legislative bodies.

With unification, the traditional German belief in a sound and efficiently functioning multi-purpose cadastre supporting a viable land tenure structure, effective land management procedures, and a healthy land ethic has received renewed emphasis and gained additional political and public support.

3 Update on the situation in western states

3.1. Topographic information (ATKIS)

It was again highly stimulating to see state surveying and mapping agencies at the forefront of a society's build-up of an information infrastructure. Those in charge of these organizations and of their automation projects realize the potential of and the need for an entirely new kind of land information management. In fact, they point out that automation is a misleading term for their efforts, as they want to satisfy new and changing demands for land information, rather than deal with those from the past by new technology. ATKIS, the Authoritative topographic-cartographic information system (Amtliches Topographisch-Kartographisches Informationssystem) is a very promising step in this direction.

Traditional and novel demands are coming from state and federal agencies as well as from private enterprise. Environmental, forest management, and planning agencies; highway and tax administrations; railways, utility companies, and car manufacturers, represent just a few of the most pressing customers. For example, the German Railways (DB) want to use ATKIS data for the construction of new lines in the west and to the eastern states; the DRIVE project for a European Digital Road Map (EDRM) needs digital road data from ATKIS by 1992/93; a state law in Hesse requires electronic emergency dispatch service by 1992/93. Indeed, ATKIS has been declared the base information system for any GIS activities in this state.

Private enterprises in any land-related business have largely recognized that sharing topographic (base) data provides competitive advantages in a common European market. Thus, they would generally be happy to go along with the pioneering standardization efforts of the surveying and mapping agencies. They may, however, have to use alternative technology for "quick and dirty" solutions to their data acquisition problems if they can't get data in time from the state agencies.

The emergence of a major secondary GIS/LIS market within and outside administrations depends on the ability of the surveying and mapping agencies to deliver on their ambitious modernization plans. They will only succeed if they can get the necessary tools in time. Clearly, the ATKIS standard imposes requirements which are a challenge for any "tool maker". Meeting these requirements in phases seems technologically feasible, however, if the tool maker and tool user communicate their needs and intentions early and often enough.

Contrary to many run-off-the-mill GIS projects, the data model requirements in ATKIS are largely fixed. The data acquisition and the database modules of a system will have to satisfy certain modeling and performance constraints. The challenge is not one of somehow modernizing a mapping or geographic data management process, but of implementing the specific data model defined in ATKIS-OK, the "object catalogue".

Given the character of ATKIS as a base information system, fidelity in the data modeling process outweighs all concerns about analytical or even mapping capabilities. While some customers acquiring ATKIS data for certain products may be satisfied with simpler data modeling capabilities, the agencies producing these data depend on a sophisticated front-end allowing, among other things, an (interactive) acquisition of topology.

This important distinction of base and application data ("Basisdaten" and "Fachdaten") limits the architectural choices for data acquisition and data management. From a surveying agency's perspective, information losses have to be avoided primarily during data acquisition: if the necessary information doesn't get into the system, it matters little that it could be preserved within the system.

Thus, the foremost need when building a substantial, long-term database like that of ATKIS is for suitable data modeling and data management tools. In ATKIS, "suitable" means that the tools must cope with data semantics beyond the power of the relational model and with data quantities beyond main memory capacity. The expected amount of data for only the first phase of ATKIS (DLM 25-1) in the state of Hesse is in the order of five Giga-Bytes.

Currently, data quantities appear to preclude the merging of separately digitized map sheets. A non-functioning merge procedure is the immediate practical stumbling block which needs to be removed. Merging, as well as any other "global" operations on data, will eventually require data management tools which are not main memory based, i.e. actual database management systems (DBMS). For an intermediate solution, however, a merging facility which operates correctly and reliably and features an appropriate user interface might be satisfactory. Given the multiply phased data acquisition procedure in Hesse, initial data quantities should not pose a major problem.

Since commercially viable object-oriented DBMS for spatial applications may not be immediately available, a possible intermediate solution is to support file-based persistent object storage, including clustering and spatial access methods[2].

3.2. Cadastral information (ALK/ALB)

The current state of data acquisition for the automated property map (Automatisierte Liegenschaftskarte, ALK) and the automated property register (Automatisiertes Liegenschaftsbuch, ALB) in the western states of Germany is in the range of 0-30% for ALK and 0-100% for ALB.

The bottleneck of data acquisition in ALK remains as described in the previous report. It is becoming increasingly clear that ALK needs alternative means of data acquisition in order to advance its implementation and make it affordable. A simple calculation of digitizing costs for, say, the state of Hesse (50 Million boundary points, costing roughly 100 Million DM) reveals this need for new solutions. While cost sharing with major customers (e.g. utility companies) is an approach already taken in Hesse, something has to be done for speeding up the process as well. Scanning of property maps is being pursued in several projects. Among them are tests in Rhineland-Palatinate and a scanning and recognition system implemented at the Technical University of Hannover[3].

---

[2] See, for example:

J. Eliot B. Moss, "Design of the Mneme Persistent Object Store". ACM Transactions on Information Systems 8(2), April 1990, pp. 103-139.

[3] see Andreas Illert, "Automatic Digitization of Large Scale Maps", Proceedings Auto-Carto 10, pp.

ALB is now being used in seven western states. A major effort has been undertaken to port the 500,000 lines of COBOL code to Unix. From an outside perspective, without detailed knowledge of ALB's inner workings, it is not clear what this code achieves that would not come essentially "for free" with a commercial database system. Project specialists agree that ALB's major functions are to generate data entry and query forms, check input data for consistency and plausibility, produce reports, and organize persistent and secure storage. Migrating to a commercial DBMS would preserve investments in data rather than software and facilitate an integration with ALK and ATKIS (as well as any other) databases. While this path may not currently be taken in the west, it ought to be considered for ALB implementations in eastern states.

3.3. European cooperation

Beyond the intensive national efforts in Germany and elsewhere in Europe, several major projects for European integration in the area of land information are under way. The organization of national survey organizations (Commité Européen des Responsables de la Cartographie Officielle, CERCO) is pursuing a project to link national topographic databases through a network, the Multipurpose European Ground-related Information Network, MEGRIN.

At the heart of this network will be the European Transfer Format (ETF) proposed by CERCO. The design of this exchange standard goes far beyond data formats. It proposes a multi-layered architecture with a conceptual model, a language definition level and a family of exchange formats appropriate to different domains and system environments.

MEGRIN takes up the philosophy behind the German and French national databases of distinguishing a digital landscape model and a digital cartographic model (DLM and DKM in ATKIS). The two models are further complemented by a digital image model, DIM. This idea might eventually be used in ATKIS as well. Considering the situation in the five new states, such an image model might actually play a very significant role in the build-up of both, topographic and cadastral information systems there (see 4.5.).

113-122.

4 Needs and trends in eastern states

4.1. General observations

The overall impression one gets these days from walking through the streets of eastern German towns and from talking to the population is that not much remains of the initial unification enthusiasm. The miserable and rapidly decaying state of all infrastructure (houses, roads, industry) and of the environment, combined with the massive unemployment due to enterprises going out of business by the hundreds, produces a very bleak picture. The instant elimination with monetary union of both the eastern European and the domestic market for east German products has accelerated the economic decline beyond any expectations. At the same time, western investment has remained far below expectations. This is particularly the case for non-German companies which are now actively encouraged by officials to move into eastern Germany.

The absence of a functioning real estate market remains one of the major and most often cited obstacles to economic recovery. More than one Million Germans in both parts of the country have filed claims on property expropriated by the communists. Many of these claims are extremely vague. Some western citizens claim rights based on memories of their grand parents' accounts of possessions. A reconstruction of these situations is often impossible.

The lack of resources and legal bases to deal with this avalanche of claims combines with speculation and social problems to hold back investments. Pressure is mounting, however, to move for a rapid resolution based on financial compensations rather than on returning the land. This would be particularly appropriate in rural areas, where only 5% of the claims ask for the land anyway. Still, given the constitutional guarantee of property rights in Germany's "Grundgesetz" ("basic law", i.e. constitution), this matter is bound to end up at the Supreme Court and will therefore take a while to be resolved.

Whatever the outcome of this political and judicial struggle will be, the problem of rapidly establishing a cadastral information infrastructure and coping with the massive demand for re-surveys has to be addressed immediately. With massive environmental clean-up measures and immense planning tasks lying ahead, the need for digital topographic information comes in only slightly behind the cadastral needs.

4.2. Organizational renewal

The former "popularly owned" enterprises for geodesy and cartography are being transformed into western-style surveying and mapping agencies (LVA's). Thus, in contrast to many other domains, privatization is not the primary issue here. Topographic, cartographic and cadastral surveying will essentially be in the hands of (or supervised by) the new states. The administrations for these states, however, have to be created from scratch and are obviously entirely different from the former central government in Berlin.

The most dramatic change in the surveying and mapping agencies is the necessary reduction of staff. Thuringia's agency in Erfurt had to reduce its work force of 850 by approximately 200 employees. Half of its employees had been specialists for engineering surveys. These people have either transfered to the private sector or are being retrained on the job for work at the new cadastral offices in counties, which are badly understaffed for the upcoming workload.

Becoming decoupled from the central administration in Berlin also meant losing the funding source for the agencies. Therefore, some agencies are trying to use their expertise in engineering surveys as a temporary source of income. With engineering surveys now a private business, however, state agencies are no longer supposed to do any work in this domain.

Since mapping institutions have been closely associated with the military and the secret police under the old regime, a strong showing of civic usefulness is a political necessity for the new agencies. The agency in Erfurt is doing this in an admirable way. First of all, it has been very successful in purging its leadership from all influence of the former regime and thereby gaining the trust of its employees. It also seems to have benefited from a combination of a highly skilled and respected new leadership, motivated and dedicated employees, a competition among western partner states for assistance, and pure luck in some financial arrangements. Finally, the agency's public relations activities are well designed and effective. An exhibit in its lobby displays a wide range of large and small scale maps being produced and sold in house, from general purpose topographic maps to those serving tourism, planning, and environmental protection. Within six months, the agency has revamped its whole map production and marketing process. The income from map sales is already exceeding production costs.

In visiting with two of the five new states, it became evident that retraining employees and reconstructing a cadastral system will constitute major challenges. Given the generally high state of education and the unexpectedly well preserved state of the previous cadastral surveys, however, these goals seem achievable. A healthy competition among the surveying and mapping agencies of different states, as it exists among western states, is emerging in the east. Thuringia and to some extent also Saxony seem to be among the luckier states so far, for a variety of reasons. The geodetic and cartographic agencies of other states, such as Saxony-Anhalt, were limited to engineering surveys in the past and are expected to face more severe problems in their renewal.

4.3. Topographic information

The socialist state had produced a uniform 1:10,000 topographic map series of the entire area of East Germany over a period of approximately ten years. It existed in a military version for strictly confidential use and in a so-called "economy" version for limited use by government agencies, industry, and some non-governmental users such as labor organizations (for recreational purposes). The non-military version simply shows large blank spaces in the area of military or significant industrial installations. Infrastructure details with any potential military significance were altered, e.g., sewer treatment plants could be shown as swamps. A major amount of time was apparently spent on doctoring this map version so as to mislead the "enemy of the people".

With the military version of this map, the five new states dispose over a high quality basis for establishing digital topographic information systems. It has regularly been updated and appears to be in good shape. Given this situation–which is in some respects (homogeneity, currency) preferable to that in the west–it has in principle been decided that the eastern states will implement the ATKIS standard, using the 1:10,000 map as the primary data source.

The lack of resources and the urgent needs in the cadastral domain are, however, likely to delay an automation of topographic information management for some time. This will allow eastern states to benefit from western experiences with ATKIS implementations. Successful pioneering implementations in the west are sure to find a subsequent market in the new states.

4.4. Cadastral information

Legal property surveys had essentially ceased under the socialist regime. Cadastral offices at the county level were largely ignored and understaffed, with normally four to eight employees. On the other hand, they had not much work to do either, given the absence of property transactions. (There was only the limited possibility to acquire the right to use a piece of land.) Despite the fact that they were often charged with tasks completely outside the cadastral domain, some cadastral offices seem to have used this "economic niche" to maintain pre-war documents and to update them with the rare boundary modifications.

The visit to a former cadastral office of Grimma near Leipzig revealed a treasure of preserved old cadastral island maps and ownership records. Most surprising was the preservation of all numerical cadastral survey records, i.e. field sketches of surveys, containing complete measurement data. In the state of Thuringia, which seems to have similarly well preserved documentation, these measurements are now being used in the recreation of the old parcel cadastre.

While the surface monuments of parcels were ordered to be destroyed by the socialist regime, some monuments remained in place, such as those along highways and most underground monuments. Thus, by relocating three to four original monuments above or below ground at both ends of an area of interest, it is possible to restake previous lot corners and to recreate the original parcel structure.

The major lack of information is concerning recent buildings. Very few socialist constructions have actually been mapped at the cadastral level. It is not clear how much up-to-date information on buildings is contained in the 1:10,000 topographic maps. Possibly, this information could be used as a start for the cadastre. This would establish a flow of information in the opposite direction than it is planned in the western states, where it is hoped that building data for ATKIS can be taken from ALK.

Thuringia's new surveying and mapping agency has created a section for cadastral renewal. Two DECStations 3100, together with digitizers, alphanumeric terminals, and a plotter, as well as a Siemens WS2000 are in intensive use. The program system DAVID (see first report) is being run on the DECStations for digitizing the cadastral maps. Relocated monuments are used as passpoints in transformations. Due to this tedious digitizing process, updates of parcel data are expected to proceed manually for the next two years.

Since some of the new states are aggregates of different parts of pre-war Germany, they have to deal with different cadastral traditions. Thuringia integrates seven different systems, with all kinds of insular and grid maps. These maps were generally not based on geodetic control. In order to introduce a reference frame, the Erfurt agency plans to combine reduced cadastral maps with enlarged 1:10,000 maps in an analogue fashion. Surprisingly, the topographic maps seem to be based largely on terrestrial measurements. If these measurements were still available, they could also prove very useful for cadastral renewal.

Given its official suppression, the legal cadastre was not part of the automation efforts which had been going on for the past decade in East Germany's surveying and mapping institutions. However, there has been a successful attempt at automating descriptive cadastral information, under the name of COLIDO (Computergestützte Liegenschafts-Dokumentation; computer assisted parcel register). This information system contains alphanumeric land use and land cover data–no ownership information–at the individual parcel level for entire eastern Germany. The data are kept in a centralized database in the city of Halle. Apparently, it has been decided to translate these data into the ALB standard. Apart from its large-scale use, COLIDO looks like a useful source of land use data in ATKIS.

In some respects, the existing cadastral information in the eastern states comes closer to a multi-purpose cadastre than that in the west, as the property and land registers had been integrated. The dominating influence from western partner states (in particular from the legal profession) has now, however, led to the institutional separation of these registers. In many cases, the two offices will at least be housed in the same building, hopefully facilitating the necessary interchange at an informal level.

While there seems not much chance to do something against the separation of the property and land registers, it would be unfortunate to preclude an integration of geometric and descriptive parcel data. Only such an integration can provide the necessary spatial reference for the descriptive information. The current solution in ALB of storing coordinates of an interior parcel point (which isn't even mandatory) is not really satisfactory for spatial access.

4.5. Alternative approaches

According to some experts in the west, it is still largely undecided by which means the eastern states will renew their cadastre and implement digital information systems. In some discussions with people in the new states, however, a certain frustration could be sensed over rigidly imposed western standards, irrespective of different start conditions. While a land information infrastructure of equal quality as that being built up in the west is an undisputed long-term goal, it would in deed seem inappropriate to conclude that the means to this end should be the same in both cases.

At least in those western surveying and mapping agencies which participated in this visit, serious thought is given to alternative approaches. As an example, North Rhine-Westfalia is studying a novel approach to large-scale mapping. They think about producing 1:1000 orthophoto maps for the entire five new states from high-resolution aerial photography. For many rural areas, a medium-scale mapping at 1:5000 may even be sufficient at the beginning. Brandenburg, for example, which is North Rhine-Westfalia's partner state, has about one fifth of its population density. Total costs are estimated to lie in the order of 750 Million DM. Therefore, an orthophoto production seems to be economical.

Thus, the idea of quickly achieving a complete coverage appears to have some perspective of realization. In the topographic domain, an orthophoto map could supply a Digital Image Model, DIM, as it is now proposed as an extension to ATKIS. A DIM would serve a variety of purposes in combination with the existing 1:10,000 map coverage. Specifically, it could be used to acquire current land use and building data.

A cadastral layer could be reconstructed on the basis of an orthophoto map. The crucial question is how to continue from such a medium-scale coverage with the cadastral renewal process. Whether it makes sense to first manually upgrade existing cadastral maps and then scan and overlay them is not clear at all. The orthophoto base should rather make it possible to integrate new cadastral data immediately, instead of having to wait for the completion of an ALK-conformal basis.

This points to the central problem faced by the eastern states: The major difference between western and eastern automation requirements for the cadastral domain lies, contrary to common opinions, in the requirements for *maintenance* rather than in the availability of information. A brief comparison of western and eastern requirements should help to assess the feasibility of proposed automation approaches.

The western cadastre has been in place as an institution, based on analogue media, for a long and uninterrupted time (see section two). In order to satisfy the needs of the legal cadastre alone, it would be possible to continue on this basis. This situation, together with comparatively strong personnel resources, allows western agencies to build up a digital system in parallel with maintaining the analogue system. While maps are being digitized and rectified, maintenance continues on an analogue basis. ALK is clearly a standard for automating an existing, well-functioning analogue cadastre. The fact that updates cannot be integrated continually with the digitized data is a severe drawback, but does not preclude an eventually successful automation.

Does this hold for the new states as well? For two main reasons, the answer is probably no: First, there is an immediate need for a functioning cadastre, which can currently not be met. Thus, day-to-day operations cannot proceed independently of automation, especially given the shortage of qualified personnel. Second, the maintenance patterns will be entirely different for these states, given the massive numbers of constructions and property conveyances which have already started. While update rates for an average western state might lie in the order of 10% of all parcels per year, they will easily reach an order of magnitude more in the east. Thus, any automation process with a prolonged initial data acquisition phase before any updates can be handled has to run into major difficulties.

It seems indicated to counteract a (historically understandable) tendency toward a

Prussian, high-precision cadastre for this region. Rapid completion and immediate maintainability have to take priority over precision, if eastern Germany is to benefit from surveying and mapping information in its reconstruction process. The professional standards and institutional arrangements in German-style cadastral systems have traditionally assured that any uncertainty in their information was reduced to a level of insignificance. This reduction, however, is a very costly process, both time- and money-wise. It is neither affordable nor necessary for eastern Germany.

What are possible alternatives? An approach to automation is needed which combines set-up and maintenance, while establishing an immediately operational system. The system has to accommodate digitized or scanned map data and existing old measurement data as well as measurements and boundary definitions from ongoing surveys. The digitized or scanned maps serve as "sketches", defining the topology and approximate metrics. Precise metrics are incrementally supplied by measurements and passpoint coordinates.

If a system can accept other data than just "final" coordinate values for points, current measurements can be acquired and don't have to remain outside the system until they are integrated (i.e. adjusted) with existing data. Digitizing existing maps is then not even necessary as a previous step and can be done only where desired.

Producing output data in an ALK-compatible format (described by EDBS or any other exchange standard) would pose no special problems, since all necessary information (and more) is contained in the system. Conversely, accepting digital map data from any other sources is just as easy as accepting them from an in-house digitization.

5 Conclusions

A common theme of our findings in western and eastern parts of Germany was the high level of political support for improving the management of topographic and cadastral information. A consequence of this support is that the technology chosen by the surveying and mapping agencies to implement their information management standards is likely to find a substantial secondary market within other administrations as well as in the private sector.

The major surprise in eastern Germany was to find cadastral surveying information preserved and maintained to a high degree. This contradicted the impressions gained from western media reports. While we could witness this state of affairs in the cadastral office of Grimma and in the surveying and mapping agency of Erfurt, we were told repeatedly that these were no exceptions. The physical condition of maps and registers is often poor and rapidly decaying, but not as poor as to preclude manual or even automatic data acquisition where appropriate. Blackening out of cadastral information during the socialist times seems to have been the exception rather than the rule.

The conclusions from the overall situation in eastern Germany are that there is a need for technological solutions which are different from those in western states. The reasons for this difference are mostly of an organizational nature. There can be little doubt that eastern Germany will eventually meet western cadastral and topographical information standards. However, it may have to take another road to get there, given the entirely different point and time of departure as well as the demands facing it along the road.

A measurement-based approach seems even more appropriate after this opportunity to assess requirements on site, and particularly after discovering the wealth of preserved measurement information. It would allow eastern states to benefit from experiences over the past two decades in the west, taking into account the considerably different start conditions, while offering the same type of cadastral base information as provided by ALK. It would focus on the priorities of rapid availability of cadastral information, while controlling and upgrading data quality over time.

The notion of incrementally building cadastral information systems and upgrading their quality over time is attractive for any automation strategy with an emphasis on early returns on investment and on maintenance. While it looks as if eastern Germany is actually in better shape than most of the U.S. regarding the availability and quality of cadastral and topographic information, solutions developed for eastern Europe will be transferable to the U.S. as well as to many other parts of the world.

GERMAN APPROACHES TO TOPOGRAPHIC AND CADASTRAL INFORMATION MANAGEMENT

Report on a visit to Germany in November 1990

Werner Kuhn
NCGIA, Department of Surveying Engineering
University of Maine, Orono, ME 04469

National Center for Geographic Information and Analysis

Abstract

The findings contained in this report are the results of a two-week visit to Germany in November 1990. The objectives of this visit were to

- study the *current state* of automating the acquisition, management, and dissemination of land data in Germany;
- assess the requirements and possibilities to *improve technological support* for these activities.

The study focused on German approaches to establish and implement standards for land information handling in the topographic and cadastral domain[0]. These standards are, in the order of emphasis put on them for this study, the authoritative topographic-cartographic information system (Amtliches Topographisch-Kartographisches Informationssystem, ATKIS[1]), the automated property map (Automatisierte Liegenschaftskarte, ALK), and the automated property register (Automatisiertes Liegenschaftsbuch, ALB).

After providing some background information, the report discusses ALK, ALB, and ATKIS in this chronological order. Each of these sections begins with a conceptual overview, continues with a presentation of the current state of implementation, and ends with an assessment. Data exchange standards, having not been a primary object of this study, are briefly discussed in section six.

[0] For the sake of simplifying expressions, this report uses a few terms in a slightly more general sense than usual: *Land information* refers to any information about the location, status, use, and ownership of land, independently of scale. *Cadastral information* is used for any parcel-related, i.e., "large-scale" information. *Topographic information* refers to land information at a resolution or scale generally smaller than the parcel level.

[1] A list of the abbreviations used is supplied at the end of the report.

1 Task Description

The author had the opportunity to visit the surveying and mapping agencies (Landesvermessungsämter) of two German states (Länder), North Rhine-Westphalia and Hesse. The visit was part of the exchange of experts program supported on the German side by the Working Committee of the State Surveying and Mapping Administrations (Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland, AdV) and the Association of Licensed Surveying Engineers (Verband der Öffentlich-bestellten Vermessungsingenieure, ÖbVI); and on the North-American side by the Institute for Land Information (ILI) and the Atlantic Institute.

The primary object of study were Germany's efforts to establish federal standards for cadastral and topographic information management and to implement them in individual states. These standards are ATKIS (Amtliches Topographisch-Kartographisches Informationssystem, authoritative topographic-cartographic information system) for topographic or small-scale information and ALK (Automatisierte Liegenschaftskarte, automated property map) and ALB (Automatisiertes Liegenschaftsbuch, automated property register) for cadastral or large-scale information.

In addition to learning about the status of ATKIS, ALK, and ALB, the author received first-hand accounts of the surveying and mapping problems facing the five "new states" of Germany's East. These impressions made it seem appropriate to expand the objectives of the mission to include some preliminary considerations on how to approach those problems.

The report is based on the limited exposure to two out of formerly eleven and now sixteen states, though these two are among the most advanced in the realization of ATKIS, ALK, and ALB. While time constraints (less than four days at each site) restricted the achievable depth of the investigation, the opportunity to meet extensively with key personnel was very beneficial in aiming at a broad perspective and at some insight into specific issues. The assessments in this report are based on these discussions and on information gathered from project documentation and other publications, but may have been affected by the author's misinterpretations.

Acknowledgements

The author gratefully acknowledges Intergraph Corporation and the following individuals and organizations for their support:

Director Klaus Barwinski, Dipl.-Ing. Heinz Brüggemann, and staff of the Landesvermessungsamt of North Rhine-Westphalia

President Ekkehard Bartsch, Dipl.-Ing. Ralf Borchert, and staff of the Landesvermessungsamt of Hesse

Dipl.-Ing. Günter Herzfeld and Dipl.-Ing. Eckhart Lotz, Ministery of the Interior, Rhineland-Palatinate

Dipl.-Ing. Helmut Paeslack and staff, Intergraph GmbH, Grasbrunn-Munich

Amt für Militärisches Geowesen (AMilGeo), Euskirchen-Bonn

Dipl.-Ing. Fritz Petersohn and M.Sc. Cliff Petersohn, The BSC Group, Boston

Dr. David Tyler, Chair, Department of Surveying Engineering, University of Maine

Dr. Andrew Frank, Associate Director, National Center for Geographic Information and Analysis.

2 Background and General Impressions

In Germany, as in most nations of Western Europe, the surveying and mapping profession has traditionally been the primary agent for gathering, maintaining, and distributing land information at all scales. This has led to the establishment of organizational structures for (non-automated) land information management at all levels of state government and in the private sector. Public surveying and mapping is under the legislative power of the individual states and the state surveying and mapping agencies cooperate in AdV to ensure coordination in this decentralized organization.

Public surveying and mapping traditionally consists of two broad domains, dealing with cadastral and topographic needs respectively. The property cadastre is the only (analogue) land data collection completely covering the area of western Germany. It describes approximately 55 Million parcels and one Billion boundary points. Over two centuries, experience has been gained in establishing and maintaining this analogue cadastral information system as well as the topographic maps at various scales. More information on the organization of Germany's surveying and mapping activities can be found in [AdV 1984].

A statistical comparison highlights the magnitude of the information market which corresponds to this tradition of land information handling: Sweden spends about 100 times as much in public funds per areal unit for land data acquisition as the United States [Widmark 1986] and Germany would seem to make comparable if not exceeding investments.

Automation efforts, which began already in the 60's, have benefited from an early recognition that the decentralized nature of Germany's surveying and mapping organization as well as the diversity of producers and consumers of land data require some basic decisions and organizations at a political level. There can be no doubt that the only way to attack the huge automation tasks is incremental and distributed, which in turn requires a common backbone organization to set standards. The AdV provides this organizational support in a very effective manner.

The major overall impressions from this highly informative visit are the sophistication of and the dedication behind the approaches to automating topographic and cadastral information handling. A pro-active style and high levels of competence and initiative dominate throughout the organizations visited. There is a firm determination to rapidly implement and continually upgrade these approaches in order to remain heavily involved in the business of managing land information.

Those in charge are clearly aware of important and sometimes unresolved issues in maintaining and exchanging large collections of land data, geometric modeling, and cartographic generalization. Significant efforts are undertaken to deal with these issues. There is a genuine interest in establishing a fruitful collaboration between industry, agencies, and universities through organizations like the Atlantic Institute.

Currently, the dominating issue is how to cope with very *large data quantities*. Due to its earlier conception and its higher degree of implementation, ALK is naturally more affected by this issue than ATKIS. But the accumulating data volumes cause problems in both ATKIS and ALK, at all stages of data handling:

- data acquisition (tedious manual digitizing, costly clean-up procedures)
- storage (lack of suitable database systems, centralized conceptions)
- access (no database support for clustering, buffering etc.)
- processing (expensive computations involved in ALK)
- merging (excessive main memory demands)
- maintenance (access problem in ALK; lacking flow of information in ATKIS)
- data exchange (delayed availability, insufficient currency).

From a technical perspective, the most pressing need in both ATKIS and ALK is for appropriate *data management tools*. Most of the above problems, however, require technical as well as organizational solutions. The emphasis on one or the other may be different for ATKIS and ALK. Consider, for example, the problem of maintaining large data collections: While existing institutions and procedures in the cadastral domain generally support the necessary flow of information from where change occurs to where it is registered, the technical and organizational complexity of updates requires system architectures going beyond centralized databases and terminals. On the other hand, while updates tend to be less frequent and less complex for topographic data, institutional arrangements have yet to be found for an appropriate flow of information in that domain.

Crucial for successful solutions to these issues is an understanding of automation as primarily a change in *information management* rather than as an automation of engineering computations. For historical and professional reasons, ATKIS and ALB tend to be more in line with this thinking than ALK. However, cadastral surveying and mapping are in transition from a measuring and computing business to one of information management. Unfortunately so far, the needs for data management, exchange, and integration have evolved much faster than the tools.

As for the situation in the East, the major impression gained is the presence of a *rare opportunity of political support* for creating cadastral and topographic information systems. An internationally coordinated effort to deal with the urgent needs for land information in these states could presumably count on significant support from a variety of sources. An important consideration for such an effort is that it will hardly be possible to build up information systems in the traditional buttom-up manner, starting at the parcel level. The experience with ALK and ATKIS in the West has shown that, even when a strong analogue basis is available, this procedure is too tedious. The key to success in the East could be a strategy to refine the resolution and accuracy of land data over time. This idea is the thrust of the approach sketched in section seven.

3 ALK

Conception

The automated property map (Automatisierte Liegenschaftskarte, ALK) was conceived in the early 70's to play the role of a uniform cadastral database in each state. The main contents are parcels, buildings, utility lines, and surveying points. ALK is to be provided not only as the source of cadastral data but also as digital base map for thematic data of any kind produced or held by any agency or enterprise. Thus, rather than just being an information system for the property cadastre, ALK is intended to provide the basis for a multipurpose cadastre.

The traditional users of cadastral information are the land registry offices (Grundbuchämter), some utility companies, planners, statisticians, and construction companies. ALK will also be used by additional customers, among them electric utilities. Existing and potential customers are in some cases contributing to the development and implementation of ALK. For instance, Hesse's electricity corporation (Hessische Elektrizitäts-AG, HEAG) performs the digitization of maps for certain areas.

ALK's architecture consists of two major parts for storage and processing. These parts are linked through the uniform database interface (Einheitliche Datenbank-Schnittstelle, EDBS; see section six). EDBS is also the common data exchange format for any users or providers of ALK data. While the data model imposes logically centralized data, physical distribution is theoretically possible; however, it has not been attempted so far.

The database part contains the "primary data" (Primärdateien), the order-book (Auftragsbuch) which is a register of administrative actions, and meta data for database management. The processing part contains the programs for data acquisition, maintenance, and processing. The primary data were initially planned to consist of coordinates, graphical parcel and building descriptions, and measurements. Due to excessive storage and acquisition costs, the measurement database has since been abandoned. Thus, coordinates have de facto replaced measurements as the determining quantities in boundary surveys. ALK's data model is hierarchical, dating from the time when the relational model was yet unknown and network databases were only in a research state. The primary data are structured according to different sub-themes (layers), but maintaining an integrated, redundancy-free geometry.

Current State

The AdV has assigned special development tasks for ALK to three states: Lower Saxony has been charged with the development of the database software, North Rhine-Westphalia with that of the workstation software (ALK-GIAP), and Hesse with that of the programs for off-line data acquisition (program system FLUKA).

Development of the ALK database software (with the hierarchical UDS system) seems to have run into difficulties. The major problem is in the architecture itself: A centralized ALK database could in some cases take over the resources of an entire state computing center. Tests at Hesse with ADABAS have failed, too, mostly due to excessive access times.

Decentralized solutions are now being sought for the database part. Hesse is already switching to a decentralized concept, where the cadastral offices maintain their own database and deliver copies to the central database at the data processing center. Rhineland-Palatinate is expected to follow this path.

The processing part of ALK has been implemented on various platforms. The most widely used implementations are ALK-GIAP (Graphisch-Interaktiver Arbeitsplatz) which is supposedly hardware-independent and a module of the Siemens SICAD system. The cadastral offices (Katasterämter) will eventually be equipped with workstations running these or other software packages. ALK-GIAP is being adopted by the states of Baden-Württemberg (where it has been developed) and Schleswig-Holstein.

ALK-GIAP is written in Fortran77, using GKS for the graphics parts, and has been in practical use since 1987. Its modular architecture allows for an ongoing modernization of parts. ALK-GIAP contains itself a database, and connections to commercial databases are currently being studied. The most recent implementation platform for ALK-GIAP are DECStations 5000 (Ultrix).

As a part of ALK-GIAP, a so-called mapping language (Kartiersprache) has been developed and is being extended. It has a multiplicity of purposes: geometric constructions, computational geometry, and map design. In fact, its developers envision it to become a general-purpose interaction and prototyping language for ALK as well as ATKIS.

Hesse has, together with the TH Aachen, developed the program system FLUKA for digitizing property maps and processing digitized data. This program merges digitized insular maps (Inselkarten), performs coordinate transformations and substitutions based on pass points, and satisfies constraints on straightness, parallelism, and orthogonality.

Currently DAVID, a more recent program system for capturing and preprocessing digitized cadastral data, is being tested in Hesse and Rhineland-Palatinate as a successor system to FLUKA. Its major advantage is that it runs on workstations, eliminating the huge data processing costs. It has been licensed by Siemens for Sinix MX300 workstations.

Data acquisition for ALK began in 1986. The realization is naturally most advanced in the three states which were leading its development. Even in these states, however, the vast majority of the data acquisition task lies still ahead. Bavaria, Berlin, Bremen, Hamburg, and Schleswig-Holstein are not, or not entirely, implementing ALK.

Assessment

ALK was a very early, thorough approach to the conversion of analogue to digital mapping in the cadastral domain. By now, however, the pioneering efforts of the early 70's are sometimes more of a burden than a help. The fundamental shortcoming of ALK from today's perspective is the computation- instead of information-centered conception. Even recent additions, such as the program system DAVID, seem still more concerned with computation than with information management. The mapping language developed in North Rhine-Westphalia may be more flexible in this respect.

A completion of ALK cannot be expected for any foreseeable time. The major obstacle is the enormous amounts of data to deal with. This problem gets aggravated by the 20 year old system architecture. The initial conception of a central database at each state's data processing center has proven unrealistic and has become unnecessary. Reasons are not only the massive data volumes with which these data centers would be charged, but the tremendous cost of running the data acquisition and clean-up software externally. FLUKA computations for the first cadastral district (Gemarkung, i.e., a few thousand parcels) captured in Hesse cost between 0.5 and 1 Million DM. Additional two to three years' work of four people are expected to be required for cleaning up the data.

The huge data quantities affect all phases, despite the possibility to use some local databases, such as SICAD's GDB. Particularly affected are the clean-up procedures which have to deal primarily with the boundary of two map sheets. Most workstations currently in use for ALK cannot handle the volume of two digitized map sheets.

Some estimates of ALK data volumes (point and parcel data only) prior to implementation projected 70 KB per hectare for a prototypical small town, 700 MB for the state of Lower Saxony and 40 GB for Rhineland-Palatinate; however, Hesse reports 200 MB of actually captured data for that single cadastral district and its digitizing efforts are already running two years behind schedule. Novel approaches to data acquisition, such as the scanning of parcel maps tested in Rhineland-Palatinate, might become indispensable for a completion of ALK within reasonable time limits.

Unfortunately, even a successful data acquisition does not guarantee current data. A particular problem in this respect are building data, whose currency is already insufficient in the existing analogue cadastre.

Data integration and data quality are emerging as crucial problems, for example, when faced with conflicts between "bad" cadastral and "good" photogrammetric data. Due to its computation-orientation, ALK does not yet provide much support for these problems.

On average, 5% of a state's area are assumed to require updates per year. Maintenance, when it becomes a routine operation, will require new approaches to organization (decentralized), data management (databases with spatial access methods), and human-computer interaction (higher-level interaction languages and editors). Interactive updates are now precluded by the fact that all data for one cadastral district reside on one tape. The cadastral offices are supposed to keep manual records of updates and periodically (every six months) enter them into ALK's central database.

Interaction is currently an unsolved problem, not only for updates, but for queries as well. Furthermore, the separation of ALK and ALB (see next section) precludes important querying and analysis capabilities, such as simple owner queries in ALK, given that only ALB has owner information. Thus, an integration with ALB is likely to become more pressing. From a technical point of view, it should not create unsurmountable difficulties if suitable database systems are employed in ALK.

As implied by its name, ALK comes closer to a digital map than to a full-fledged land information system. Without the abandoned measurement database, it is essentially a graphic database of property maps, with text stored as graphics and virtually no notion of topology or of the third dimension. This will to some degree restrict its usability for utility applications and for planning purposes in urban areas.

One should keep in mind, however, that actual implementations of the database and processing parts may improve on many shortcomings. For example, the ALK-GIAP data model is generally closer to the data model of ATKIS than to that of ALK. Among other improvements, it distinguishes geometry from graphic symbols and handles the latter by a separate presentation manager.

4 ALB

Conception

The automated property register (Automatisiertes Liegenschaftsbuch, ALB) contains essentially non-spatial parcel-related information like parcel identifier, location, owner, area, land use, census tract, and street address. A limited form of historical information is supported by not deleting obsolete parcel data during updates.

The information of ALB is valuable for planning and statistical purposes. Main customers include town and financial administrations, the German railways (Deutsche Bundesbahn, DB), and transportation departments.

ALB's data structure is hierarchical. Standard access is by parcel identifier, owner name, address, or census tract. ALB also provides a spatial reference independently of ALK: The coordinates of one central point in each parcel allow for spatial queries, though only in batch mode. Links to other land data collections, particularly to ALK, are provided primarily by these coordinates and by the parcel identifier.

ALB data reside centrally at the state data processing centers. Access is provided by terminal links over IBM's Standard Network Architecture, precluding substantial interactive output. (Larger output lists have to be printed at the data centers and mailed to users).

Current State

Like ALK, ALB has been conceived in the early 70's. Unlike ALK, however, it is now completed for many states or for parts of them (95% in North Rhine-Westphalia, 100% since 1984 in Lower Saxony). In some cases, the data are incomplete, often lacking the parcel center coordinates and thus the spatial reference. Average data quantities amount to roughly 1 KB per parcel, i.e. 10 GB for a state like Baden-Württemberg with 10 Million parcels.

ALB's software, entirely written in COBOL, has been used since 1983 in most states. Subsequent program maintenance has produced state-specific program versions. It is up to the states to use database management systems.

The major current problems lie in maintenance: land use modifications are difficult to keep track of (lacking an institutionalized update mechanism) and keeping up with parcel modifications would require more personnel capacity. Apart from maintenance, land use data are also affected by the unfortunate fact that planners and statisticians use different land use classification schemes from that in ALB. The federal bureau of statistics is pushing its own statistical land use information system (Statistisches Bodeninformationssystem, STABIS), based on photogrammetric data. STABIS has also a significant overlap with ATKIS.

Goals for future developments include an integration with ALK, improved screen presentations, interactive update facilities, additional historical data (e.g., on land use), and the handling of access rights. There are already attempts in some states (e.g., in Hesse) and towns to integrate ALB and ALK or to rewrite ALB in other ways. A new overall implementation of ALB as well as a separate building register (Automatisiertes Gebäudebuch) are in the works, but ALK and ATKIS have national priority.

Assessment

The advanced state of ALB's implementation clearly demonstrates the advantage of not having to deal with graphics or geometric data when implementing an information system. The flip side of this coin, of course, is the absence of this geometric information. ALB is a successful information system as far as administrative ("attribute") data are concerned. It obviously needs to be integrated with spatial data, primarily those of ALK. Also, institutional changes will be required to improve and simplify maintenance, particularly of land use data.

5 ATKIS

Conception[2]

The authoritative topographic-cartographic information system (Amtliches Topographisch-Kartographisches Informationssystem, ATKIS) is the German information system standard for digital topographic data at scales of 1:25,000 and smaller. ATKIS responds to the demand from planning and environmental agencies as well as from the military for such data. Its potential customers are those who do not need the resolution and accuracy of ALK or who cannot afford to wait until ALK data are available.

ATKIS consists of two major parts, the Digital Landscape Model (Digitales Landschaftsmodell, DLM) and the Digital Cartographic Model (Digitales Kartographisches Modell, DKM). Users can access data from both, DLM and DKM.

DLM contains information on topographic objects and the relief. Its contents are described in ATKIS-OK, the object catalogue listing all objects and attributes. The data model is basically relational, but with a strong object flavor. It distinguishes object themes, object groups, objects, and object parts. (The first three categories correspond to themes, composite features, and base features in TIGRIS.) The geometric information of all themes is integrated in a separate topological data structure for each, DLM and DKM. Object themes are control points, settlement, transportation, vegetation, hydrology, land use, and relief. The relief constitutes a digital terrain model, DTM, with a resolution of generally 40 Meters. All other themes constitute the so-called digital situation model, DSM. Currently, car navigation system developers are the most pressing customers.

---

[2] In view of the existence of a detailed report in English on ATKIS [Hesse 1990], this is only a brief description of its design.

A DKM contains the topographic information represented by cartographic symbols for specific scales. Its contents are defined in ATKIS-SK, the catalogue of symbols. Multiple DKM's can be derived from each DLM.

DLM and DKM are implemented for several ranges of resolution. Originally, one DLM was intended to cover the whole range of scales between 1:5000 and 1:1 Million. Now, three DLM's are produced at separate scales: DLM 25, DLM 200, and DLM 1000, corresponding to the contents and resolutions of the topographic maps TK 25 (1:25,000), TÜK 200 (1:200,000), and the UN world map 1:1,000,000. The scales are to be understood as scale ranges, i.e. DLM 25 ranging from 1:25,000 to at least 1:100,000. The scale of 1:5000 has been abandoned due to the excessive data acquisition requirements and in the hope that ALK will close the gap. Military and car navigation requirements have imposed an accuracy standard of 3 Meters for the highest resolution.

DLM 200 (and probably also DLM 1000) will be produced for the whole nation by the Institute for Applied Geodesy (IfAG) in Frankfurt. IfAG has dealt with these scales in an analogue environment and is already building up a digital cartographic database of Europe (EURODB) at 1:1 Million. They are trying to use ArcInfo for DLM 200.

Current State

DLM 25 is being implemented in phases. Phase one captures transportation, hydrology, vegetation, and administrative boundaries for DLM 25. It is scheduled to be completed by 1995. The principal sources of information used in this phase are the topographic base map 1:5000 (Deutsche Grundkarte, DGK), orthophotos at this scale, and special-purpose (city, military, railway) maps.

North Rhine-Westphalia relies primarily on the DGK, as this map is available for the whole state. The printed map sheets are manually augmented from other sources with phase one information (e.g., on road widths) and subsequently digitized.

Hesse, with less than 10% current DGK sheets, uses primarily orthophotos at 1:5000 which are produced in a five year cycle for analogue map updates. The whole state of Hesse is covered by 5400 such orthophotos. They are getting manually augmented by the necessary data for phase one and subsequently digitized. It takes approximately three days to augment a photo and one day for digitizing it. Scanning as an alternative route is being studied. Hesse also has a complete DTM on a 40 Meter raster, which will be integrated with the DSM to produce the full DLM 25.

While North Rhine-Westphalia decided to capture the complete contents of phase one for each digitized DGK, Hesse intends to proceed theme-oriented, capturing those themes first which are most likely to find immediate applications, such as road data which are to be completed state wide by 1992.

North Rhine-Westphalia expects to have captured phase one data for 30% of the state by the end of 1990. Hesse has not yet started actual data production. It plans to involve large engineering companies in data acquisition on whatever platform Hesse chooses. Only two states have actually decided so far on an implementation platform for ATKIS: North Rhine-Westphalia (ALK-GIAP) and Lower Saxony (SICAD).

Buildings are not part of phase one and it is yet unclear from what source this information will be taken. One would hope for the availability of ALK's building data at that time, in order to avoid duplication of efforts. On the other hand, the currency of cadastral information on buildings is far behind that on boundaries. Scanning and photogrammetry are contemplated as alternative solutions. So far, attempts to scan maps or photos have failed because of the software not being advanced enough. Photogrammetry was too expensive for data acquisition, but may be used for updating. Generally, the trend (or at least the intention) seems to be towards increasing use of direct observation rather than relying on existing models for the construction of the DLM series. SPOT data are considered as a source for DLM 200.

The data volume was originally estimated to be 140 KB per km2 for DLM 25. Experience in Hesse shows that a quarter of a TK25 (i.e., 25 km2) produces 3 MB of data for phase one. Federal cost estimates a few years ago came to 200 Million DM for data capture and 30 Million DM for maintenance per year.

Assessment

Due to its later conception, ATKIS is obviously a more modern approach to land information management than ALK or ALB. The major technical problems at the moment lie in the rapid acquisition of current data and in cartographic generalization. An important institutional question is how to deal with changing custodian roles over elements of land information.

The magnitude of data acquisition tasks for ATKIS as well as for ALK seems - understandably if somewhat paradoxically - to push for a decoupling of ATKIS from ALK. While the information of ATKIS had been intended to represent to some extent a generalization from ALK, it has become clear that ALK data will not be ready in time to build up ATKIS databases. Data storage for ATKIS, which was initially planned to be handled by the database part of ALK, accessed through EDBS, is going its own route. ALK is now offering the possibility to enter ATKIS data only as an option.

The surveying and mapping agencies will hardly be able to realize the full contents of DLM 25 by themselves. Even data imported from external suppliers generally require substantial preprocessing efforts (e.g., reclassification) before they can be integrated into ATKIS. The currency of data sources is a problem, particularly where the DGK is used.

Implementing the ATKIS data model with TIGRIS administrator in Hesse's test project was straightforward and took a crew with no prior training one week. In addition to the similarity of the ATKIS and TIGRIS data models, the simplicity of data definition in TIGRIS proved to be a major advantage. The support for data consistency in TIGRIS is seen as an even more important point for building the kind of long-term, complex spatial information system which ATKIS represents.

The operators were also quite impressed with the TIGRIS user interface. They pointed out that the iconic screen menus were much easier to learn than digitizer table menus. Interestingly, the primary reason for this seems not to lie with icons as such but with spatial (gestural) memory working better for upright menus on screen than for those lying on a table.

With data acquisition getting seriously under way, the issue of suitable databases for ATKIS becomes pressing. Rapid display generation and particularly the merging of separately digitized map sheets is creating problems due to the large data quantities. The concept of centralized databases separated from data production and maintenance is becoming obsolete and local database systems with spatial access methods are needed.

The data model of ATKIS has some limitations which are recognized and continually discussed in a working group. The following examples are mostly drawn from discussions at a meeting of this group which the author could attend.

One problem with the data model is the lack of explicit relationships. It is particularly hindering for generalization, where information is transformed depending on complex relationships between objects (e.g., groups of houses). Also, attribute types are too low-level, being essentially the base types of standard programming languages. They are unsuitable to capture high-level semantics (such as road width classes) as long as they cannot be extended by implementors.

The limitation that objects cannot have parts of different topology such as linear and areal parts makes it difficult to model features like lakes with uncertain shorelines. Some cartographic generalization problems might be eased by more flexible DLM's. An example is the difficulty of turning road data which have been captured from 1:5000 maps or photographs into displays at 1:25,000. The shoreline example is a case which would be served by the possibility to have multiple representations for objects (both in DLM and DKM). The same applies to features like roads whose widths are currently treated as an attribute rather than as geometry, and rivers which are modeled either as linear objects (at small scales) or as areal objects (at larger scales).

Another difficulty lies in dealing with the third dimension in an essentially two (or 2.5-) dimensional model. The classical example are roads, rivers, and buildings overlapping in a two-dimensional projection ("Überführungsreferenzen"). These cases can become quite complex in urban areas. They call for careful extensions to the data model, as they are not properties or relations of the objects themselves, but rather of ways of looking at them, similar to obstructed views. A possible approach could be to record vertical orderings for selected points.

Finally, the data model needs to be augmented by meta data. There is a lack of quality information on acquired data, where ALK actually provides more means than ATKIS. Also missing is the possibility to formalize and monitor integrity constraints.

How to get from DLM to DKM, i.e., how to solve part of the generalization problem, is yet a largely unsolved question. It is easier to say how not to do it: not in a fully automated manner and not in one step. North Rhine-Westphalia is working on the generalization problem in collaboration with the University of Bonn and a local software company. Apparently, the Technical University of Dresden has also advanced quite far in generalization research over the past few years.

Maintaining the data collections calls for new approaches in ATKIS just as it does in ALK. It seems that effective and timely maintenance procedures will require a collaboration with other agencies and private enterprises that has not been institutionalized in times of analogue mapping. Such a development could significantly influence the market for information technology which is used in ATKIS.

First experiences with data dissemination in North Rhine-Westphalia give a taste of the problems to come in this area. Since ATKIS is only supposed to provide topographic base data, customers will generally need to combine these with their own or with additional external thematic data sources. The distinction of base vs. thematic data, however, is not straightforward. Some themes, like road data, are also considered part of base data by the surveying and mapping agencies. At the same time, there are external specialized road databases like the road information database (Strassen Informations Bank, SIB). A customer like the automobile and electronic industry producing the European Digital Road Map (EDRM) may not want to have to integrate multiple data sources for the same region. An agency's interest as a custodian of basic road data, thus, pushes it into additional activities to integrate its own data with those of others, in order to satisfy customers. With the growing multiplicity of land data collections, such activities could become very complex and costly.

6 Data Exchange Standards

EDBS

The definition of the uniform database interface (Einheitliche Datenbank-Schnittstelle, EDBS) dates from the late 70's. EDBS is the fundamental link between the centralized data storage and the local processing of ALK. Currently, EDBS is also the data exchange standard for ATKIS. Hesse uses its own predecessor to EDBS, developed for the exchange of data with HEAG.

EDBS can not only describe land data as such, but updates as well. This capability is essential in view of the enormous data quantities and the low bandwidth connections in the current architecture of ALK. The design of EDBS would allow for its interactive use, but neither the complexity of the language nor the difficulties of data transfers make this seem realistic. Higher level languages which can be translated to and from the highly cryptic EDBS code are needed if this standard is to have a future.

The signals about the future role of EDBS in ATKIS are mixed. The fact that ALK's data structure has been extended to handle ATKIS data would seem to speak for at least some role. It is not clear how much investment into EDBS support is reasonable nowadays from a technical point of view, even if a vendor's commitment to land information, particularly at larger scales, is sometimes measured by its willingness to deal with this standard. It seems likely that the real concern is to have an exchange standard which is capable of preserving the information in ALK and/or ATKIS realizations. If EDBS can do this - fine (though the reported implementation problems and a lacking support for topology raise some doubts). If a modernized, ISO approved standard does the job and can possibly be translated into EDBS - all the better.

Whatever the fate of EDBS as such will be, the land information profession asks for domain-specific standards and will not be satisfied by general-purpose standards alone, neither for data exchange nor for other purposes, like query languages. One of the reasons is the need to integrate geometric and thematic data, whereas "general-purpose" standards typically separate data into "graphics" and "attributes".

European Standards

Coordinated European efforts for exchange standards have been focusing on small-scale data so far, where pressures for data integration have been considerably higher than at larger scales. Furthermore, coordination in the cadastral domain faces stronger and more diverse national traditions.

National standardization efforts which are considered as a basis for European coordination are most advanced in Britain, France, and Germany. Currently, the U.S. Spatial Data Transfer Standard (SDTS) is hardly being discussed. The main roots for a European exchange standard to be defined by CERCO are NATO's DIGEST or Britain's NTF. NTF is currently getting increased attention, due to the publication of a significantly extended version with a quite flexible geometric data model.

7 Conclusions

The German efforts to coordinate the acquisition, management, and dissemination of land data have to be seen in the larger context of an *evolving land information market*. It is becoming evident that not just the surveying and mapping agencies, i.e. the "administrative market", are at stake here, but the whole community of private, semi-private, and governmental enterprises involved in the business of handling land information.

The surveying and mapping agencies have been very active - individually and collaboratively through AdV - to ensure their future role in this land information market. There is a commitment to avoid unnecessary duplication of efforts in data collection and maintenance and to assure data integration to the highest possible degree in the decentralized organization of Germany's public surveying and mapping. The agencies see themselves as providers of *base data* (Grunddaten) about the land, its ownership, and its use. ALK, ALB, and ATKIS are the technical realizations of this philosophy.

Since no agency can be the source of complete land information at any scale in a digital environment, the customers of an agency will combine such base data with their *thematic data* (Sachdaten). The difficult question is, of course, what should count as base data, particularly beyond the cadastral and the purely topographical domain. The distinction between geometric and non-geometric data which is sometimes suggested does not satisfy, because geometry is not really separable from object semantics. In some cases (e.g., for certain road data) it may even be preferable to let private enterprise supply geometry as well. The ATKIS object catalogue contains a detailed and extensive definition for base data at scales of 1:5000 and smaller. Progress and success in implementing this catalogue on the one hand and external market forces on the other hand will determine to what extent established custodian roles for land information will remain unchanged.

Experience shows that coping with initial *data acquisition*, even for subsets of base data, is a tremendous task for any agency and may simply take too long. Customers like the transportation industry may attempt producing the data themselves if the agencies cannot deliver in time. On the other hand, efforts of utility companies in the early 80's to create their own cadastral databases by digitizing maps have generally failed due to subsequent maintenance problems. Thus, while data acquisition is the major time and cost factor at the moment, having acquired the data does not yet guarantee its usefulness. *Maintenance* needs to be planned right from the beginning of a project. Collaborating with future customers already in the data acquisition phase and thereby speeding up the acquisition process as well as freeing capacity to look ahead to maintenance seems a promising approach to this dilemma and is being seriously considered.

Collaboration and coordination efforts extend beyond data acquisition, however. Agencies and enterprises which had not much to do with each other in the past (or were even unaware of each other) are becoming aware of *common interests* in land information or overlapping stocks in land data. North Rhine-Westphalia plans to establish a state wide coordinating agency for land information (Dezernat für Raumbezogene Information), charged with managing the flow of that information. Baden-Württemberg has plans for a state-wide integration of land information. Lower Saxony has even passed a parliamentary resolution to implement ALK and ATKIS and make them the basis for all activities involving land information. Thus, there is also a realization at the political level of the potential gains from exploring common interests in land information. This will certainly have a positive effect on the market for information as well as for tools.

Resulting from these integrative forces is the need for improved *data exchange* mechanisms. Today, serious problems with data exchange between the multiplicity of systems in use are reported by industrial as well as administrative users. One of the fundamental problems with exchange standards is the need to deal with data models of widely different quality and sophistication. If a standard's modeling requirements are too high, low-end systems will not be able to describe their data. If it is too low, high-end systems loose information in transfers. Future solutions for cadastral as well as topographic data will obviously have to support data models at multiple levels.

What do all these developments mean for the future role of standards like ATKIS or ALK and of the institutions behind them? The trump card of surveying and mapping institutions at all levels is that they have the expertise not only to collect and reproduce land information, but to maintain it as well. Since reproduction of data causes little problems in a digital environment, maintenance capabilities are likely to become the decisive economic factor. In the long run, authority over data collections as such may become less important than the service of maintaining and providing data in time, up-to-date, accurate and at a competitive cost.

Another consequence from a growing interconnectivity is that decisions on hardware and even on software *platforms* are not seen as dominating issues anymore. Some surveying and mapping agencies take a very open-minded attitude to this question, in the sense that platforms could be changed after a few years, if it became appropriate to do so. Thus, the major consideration for them is whether a system environment is able to preserve the tremendous investment in data. A vendor's responsiveness to the needs for solutions which take into account the particularities of cadastral and topographic information is seen as decisive. Considerations about vendor independence are thus likely to move from the software-hardware interface to the data-software interface. This could to some extent reduce reservations against the use of special-purpose, state-of-the-art hardware.

The strengths of new, object-oriented technology are precisely the characteristics needed for successful implementations of topographic standards like ATKIS. At the same time, however, the cadastral domain could benefit even more from these features, regardless of existing data models which date from times when the notions of object-orientation and topological data structures were almost unknown. The parcel is becoming the elementary unit of information, not only for the traditional cadastre, but for planning and environmental purposes as well. Planning, transportation and environmental protection, as today's primary areas in need of land information, are increasingly dependent on ownership information and therefore large-scale, parcel-oriented data collections. This trend has also been observed in pilot projects in the United States, such as the Dane county land records project [Niemann 1987].

Abbreviations

AdV Working Committee of the State Surveying and Mapping Administrations (Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland)

ALB Automated property register (Automatisiertes Liegenschaftsbuch)

ALK Automated property map (Automatisierte Liegenschaftskarte)

ATKIS Authoritative topographic-cartographic information system (Amtliches Topographisch-Kartographisches Informationssystem)

EDBS Uniform database interface (Einheitliche Datenbank-Schnittstelle)

ILI Institute for Land Information

ÖbVI Association of licensed surveying engineers (Verband der Öffentlich-bestellten Vermessungsingenieure)

References

AdV 1984. *Surveying and Mapping in the Federal Republic of Germany*. Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland (AdV). Verlag des Instituts für Angewandte Geodäsie, Frankfurt am Main.

Hesse, W., and F.J. Leahy. 1990. *Authoritative Topographic Cartographic Information System (ATKIS)*. Department of Surveying and Land Information, University of Melbourne. English description, based on AdV publications.

Niemann, B. J., and J. G. Sullivan. 1987. Results of the Dane county land records project: Implications for conservation planning. Proceedings, *Auto-Carto 8* : 445-455.

Widmark, J. 1986. Modern Techniques and Mapping Policy: Developments and Trends in Sweden. Proceedings, *FIG XVIII International Congress* 3 : 105-114.