UPDATING OF THE ATKIS DIGITAL LANDSCAPE MODEL 25 AT THE STATE SURVEY ADMINISTRATION OF BRANDENBURG

Wilfried Müller
Landesvermessungsamt Brandenburg
Schwedter Str. 63, D-17291 Prenzlau

Eckhardt Seyfert
Landesvermessungsamt Brandenburg
Heinrich-Mann-Allee 103, D-14473 Potsdam

Commission IV, Working Group 3

KEY WORDS: GIS, Database, Revision, Acquisition, Exchange, Accuracy, Orthoimage, Stereoscopic

ABSTRACT

The survey administrations of the federal states in Germany are currently building up the basic geoinformation system ATKIS. Data collection for the first realization stage of the Digital Landscape Model 25 (DLM 25) will be completed in Brandenburg and some other states by the end of 1996. This paper describes the concepts of the State Survey Administration of Brandenburg (LVermA BB) for updating the DLM 25/1 and extension to the second realization stage DLM 25/2. The procedures will be based on the use of digital orthophotos and stereo-compilation. As a preprocessing step the planimetric accuracy of most DLM 25/1 data sets has to be improved in order to meet the corresponding ATKIS requirement. Since buildings are very important for many users they will be captured already for the DLM 25/2.

KURZFASSUNG

Die Landesvermessungsbehörden der Länder der Bundesrepublik Deutschland bauen zur Zeit das Basis-Geoinformationssystem ATKIS auf. Die Datenerfassung für die erste Ausbaustufe des Digitalen Landschaftsmodells 25 (DLM 25) wird in Brandenburg und in einigen anderen Bundesländern Ende 1996 abgeschlossen werden können. Dieser Beitrag behandelt Konzepte des Landesvermessungsamtes Brandenburg (LVermA BB) für die Aktualisierung des DLM 25/1 und die Erweiterung zur zweiten Ausbaustufe DLM 25/2. Die Verfahren basieren auf der Nutzung von Digitalen Orthophotos und der Stereoauswertung von Luftbildmodellen. Als Vorverarbeitungsschritt muß die Lagegenauigkeit eines Großteils der DLM 25/1-Daten verbessert werden, um die entsprechende ATKIS Anforderung zu erfüllen. Da viele Nutzer ein besonderes Interesse an Gebäudedaten haben, sollen Gebäude bereits in der Ausbaustufe 25/2 integriert werden.

1. INTRODUCTION

The Authoritative Topographic-Cartographic Information System (ATKIS) has been developed as a common project of the Working Committees of the Survey Administrations of the States of the Federal Republic of Germany (AdV). The ATKIS databases will consist of different models :

- Digital Landscape Models (DLM) contain topographic objects and relief data in digital form with high geometric accuracy. Objects like highways, roads or woodland are described in position and shape by Gauß-Krüger coordinates and their characteristics by additional attributes. The content of the DLM is fixed in Object Catalogues (OK).
- Digital Cartographic Models (DKM) are generated from DLM by transferring them into its cartographic presentation according to scale and specific drawing rules. The content of the DKM is outlined in Symbol Catalogues (SK).

These data can be used in all space-related information systems as geotopographic data-basis.

The ATKIS data model has been derived from the data model of the Automated Real Estate Map (ALK) and extended by complex objects, object items and topological references. For data exchange the system-independend Uniform Database Interface (EDBS) has been defined. The ATKIS conception is documented in (AdV, 1989).

The establishment of ATKIS is a time-consuming and costly process. Therefore the DLM will be created in several stages, according to user's requirements. The Digital Landscape Model 25 (DLM 25) will be realized by the state survey authorities with highest priority.

The content of the DLM 25 corresponds to topographic maps 1 : 25,000. However the positional accuracy shall be improved to ± 3 m for major linear objects like e.g. roads.

Applications of the DLM 25 are described in (Harbeck, 1994) and (Kophstahl & Sellge, 1995).

2. CREATION OF THE DLM 25/1

The LVermA BB has started in 1992 to built-up the DLM 25/1. The first realization stage will be completed by the end of 1996. Map sheets of the topographic maps 1 : 10,000 (TK 10 N) are choosen as capturing units. Since each of the federal states has to create the DLM 25 upto the state boundary, Brandenburg is covered by 827 full and 249 partial capturing units (each approx. 5.5 km x 5.5 km).

The following primary data sources were used :

a)	TK 10 N (after updating)	44 %
b)	Orthophoto maps TK 10 L (generated by perspective rectification , e.g. with SEG VI)	39 %
c)	Orthophoto maps TK 10 DL (digitally generated with the PHODIS system from Zeiss	14 %
d)	Stereo models of aerial photographs 1 : 18,000	3 %

In addition maps and descriptive information from other administrations (road, railway, waterways) and private utility companies are employed.

The workflow for a) - c) is as follows :

1. Collection and preparation of source data.
2. Transferring of all geometries and attributes needed for the DLM 25/1 from the different sources into a single "information sheet" which also shows how the data has to be structured.
3. Checking of the information sheet by a supervisor.
4. Data capturing by table digitizing using ALK-GIAP workstations.
5. Running a final checking procedure.
6. Running a procedure to check along the frame to adjacent capturing units.
7. Cooperation with other state survey administrations for exchange and adaption of state boundary data.
8. Conversion to the EDBS format for
9. Input into the official ATKIS data base installed on an IBM mainframe computer.

Most of the capturing work (steps 2 and 4) has been done in contract by private companies. In some cases the DLM 25/1 was captured with the Zeiss/PHOCUS-system from stereo models using analytical plotters Planicomp P1/P3 with Videomap superimposition or a converted analog stereo-plotter TOPOCART.

3. DLM 25 REVISION AND EXTENSION

Starting in 1997 the LVermA BB is faced with the following tasks :
- improvement of planimetric accuracy,
- updating of the DLM 25/1 and
- extension to the content of the DLM 25/2.

The primary data sources used for establishing the DLM 25/1 in Brandenburg did not always fulfill the planimetric accuracy requirement of ± 3 m.

In some cases the TK 10 N used for capturing the DLM 25/1 was based on a revision from 1990. In some other cases the photo flight for producing orthophoto maps TK 10 L took place in 1991. For the time period up to 1997 a lot of changes can be expected which are partly influenced by the reunification of the two German states.

The content of the second realization stage DLM 25/2 has already been defined by the AdV as OK-DLM 25/2. Almost all relevant objects of the class "settlement" with the sub-classes "built up areas", "open residental areas" and "buildings and facilities" became part of the DLM 25/2. However buildings were left for a further stage. For objects of other classes it was defined that additional attributes have to be captured.

The LVermA BB has decided that further objects and attributes which are part of the complete edition of the OK-DLM 25 but not part of the OK-DLM 25/2 shall be captured or incorporated. These are e.g. trigonometric and levelling points, water-gauges, boundaries of different types of protective areas, walls, depots and buildings.

3. 1 Alternatives

Updating of topographical data involves the following processing steps :
- detection of (or getting knowledge about) relevant topographical changes,
- acquisition and examination of information about these changes,
- data capturing including geometry and attributive informations,
- incorporation into the data base and deletion of pre-existing data.

The following alternatives had to be examined :
a) periodical or continuous updating,
b) homogeneous or priority treatment of certain areas or object classes,
c) updating by contracts or by own staff,
d) various methods for change detection and data collection.

All users of the DLM 25 agree that a periodical revision of all data within a at least 5-year-cycle is absolutely necessary. Some users also demand a continuous updating. If changes can be detected or will be reported, they have to be captured and incorporated into the database immediately. Other users demand a priority treatment for densely populated areas or certain object classes (e.g. built-up areas and roads) with a shortened revision cylce of one year.

These additional demands can not be fulfilled with photogrammetric methods since too many photo flights would be necessary and the capacity for orthophoto production is limited. A close contact and data exchange between the LVermA BB and administrations, other institutions and private industry which can report changes and supply digital data could solve the problem in the long-term. At the moment almost all of them are still in a stage of building-up their information systems.

An active terrestrial reconnaissance service, as proposed by the state survey administration of Northrhine-Westfalia, would require personnel capacities which are not available at the LVermA BB. By various reasons the cadastral survey offices can not contribute to this work. Furthermore a continuous updating and/or a priority treatment would cause an increased effort for data management.

3.2 General Concept

Possible updating methods and workflows have been investigate and weighted. For the finally choosen procedures/ solutions the specific conditions in Brandenburg had to be taken into consideration. At the present stage of evaluation the following strategy seems to be most efficient at minimum costs :
- Improvement of planimetric accuracy should be done as a first independent step.
- Updating of the DLM 25/1 and extension to DLM 25/2 should be done as a common step in parallel to the 5-year-cycles for
  a) revision of the TK 10 N and
  b) digital generation of new orthophoto maps (TK 10 DL).

The hang on to these two cycles offers the following benefits :
- The work flow for updating the TK 10 N and the DLM 25/1 has some steps which are very similar. By combining both tasks double work can be avoided.
- The cycle for digital generation of the TK 10 DL follows the cycle for updating the TK 10 N with a delay of 2 to 3 years. A hang on to both cycles guarantees an up-to-dateness of 3 years for the DLM 25. This would be a good compromise between periodical homogenious updating and continuous updating or priority treatment of areas or object classes.

A subdevision of the LVermA BB called "Topographischer Meldedienst" (TopMD, topographical information service) will get a key-function for updating and extension of the DLM 25. Up to now the main task of the TopMD was to acquire and prepare non-geometric descriptive information for the revision of the TK 10 and derived maps (e.g. city maps).

In contrast to the OK-DLM 25/1 the object catalogue OK-DLM 25/2 contains a lot of objects and attributes which can not be captured from orthophotos or existing maps. The new task of the TopMD is to get into contact with suppliers of these informations and prepare them for updating and revision of the DLM 25. In a first stage up to the end of 1997 these information will be transferred into film plots of existing DLM 25/1 data in a colour coded form. An information system based on ARC/Info has been installed in 1995 for taking over and storing of the informations in digital form.

3.3 Improvement of Planimetric Accuracy

In the western part of Germany the German Basic Map 1 : 5,000 (DGK 5) is used as primary data source for establishing the DLM 25/1. Per definition the planimetric accuracy of the DGK 5 should be ± 3 m or better. This meets exactly the ATKIS requirement for the DLM 25. In the new federal states of the eastern part of Germany only topographaphic maps 1 : 10,000 (TK 10 AS) were available. For the area of Brandenburg these maps were generated from 1956 to 1973 mainly on the basis of rectified aerial photographs. Meanwhile - after 5 revision cycles - the planimetric accuracy is about ± 5 - 10 m (Krakau, 1994). In 1992 the LVermA BB has started a program to convert the TK 10 AS (Krassowski, $\Delta\lambda$= 3.75' x $\Delta\varphi$= 2.5') into the new TK 10 N map series (Bessel, $\Delta\lambda$= 5' x $\Delta\varphi$= 3'). While doing this, the planimetric accuracy will not be improved. The conversion program will be completed in 1998.

When the conception for creating the DLM 25/1 in Brandenburg was worked out, it has been decided, that a fast completition is of greater importance than meeting the accuracy requirement.

In areas where the TK 10 N was not yet available orthophoto maps 1 : 10,000 (TK 10 L) were used as primary data source. These orthophoto maps were generated in contract by private companies mainly by simple rectification without using a digital elevation model (DEM). In general Brandenburg is a rather flat area, but for some map sheets the effect of neglecting the relief generated local positional errors of up to 15 m.

Since November 1994 the LVermA BB is able to produce orthophoto maps 1 : 10,000 (TK 10 DL) by digital image processing with the Zeiss/PHODIS-system. Tests have shown that DLM 25/1 data captured from this source will meet the accuracy requirement of ± 3 m. The same is true for DLM 25/1- data acquired by stereo compilation.

The limited planimetric accuracy of most of the DLM 25/1 data becomes a problem if these data shall be merged with data from other (more accurate) sources, e.g. geodetic measurements. This could be the case if

- the LVermA BB wants to incorporate data into the DLM 25, e.g. buildings extracted from the ALK (the axis of a road may pass through buildings),
- users want to add their own thematic data, e.g. utility companies want to add their network of power lines (a road may cross a power line several times instead of running in parallel).

Since the number of DLM 25 users ist constantly growing, the planimetric accuracy should be improved as soon as possible. The correction of geometry can be done independently from updating and extension to the DLM 25/2 using digital orthophotos or by stereo-compilation.

Tests have shown that the geometric displacements are more or less random. Therefore the problem can not be solved with a semi-automatic procedure, e.g. a batch program. However the GIAP software supports manual editing such that points can be picked and moved to the right position without destroying the topology of the data. Tests have also shown that only about 1/3 of the points have to be shifted (e.g. points of the boundaries of built-up areas don't need to be shifted because these boundaries can not be sharply defined).The work for improving the planimetric accuracy will be started in April 1996.

3.4 Use of Digital Orthophotos

In 1993 a PHODIS-system (Photogrammetric Digital System) from Zeiss was installed at the LVermA BB for digital production of orthophoto maps. The system consists of a PS1 photogrammetric scanner, three workstations running the PHODIS-software and the SCOP/DEM-software, an IRIS 3047 colour proofer and a BARCO BG3800 raster scanner/ plotter. In November 1994 the system became operational. The production rate is up to 8 orthophoto maps 1 : 10,000 per day (8 h). In October 1995 a PHODIS ST 30 digital stereoworkstation was integrated into the system. It is mainly used for DEM measurement and DEM control.

The digital orthophotos are produced from b&w aerial photographs 1 : 34,000. As a preprocessing step a DEM 25 is generated from digitized contours of topographic maps 1 : 25,000 and additional stereo-scopic measurements in areas with non-uniform relief. The grid width is 25 m x 25 m. The accuracy of the DEM is about ± 2 m. The output format for the orhophotos is TIFF. The ground resolution of an orthophoto pixel is 65 cm x 65 cm.

Tests have shown that the resolution and accuracy of the orthophotos are suitable for updating and extension of the DLM 25.

The digital orthophotos can be used with the "Raster-Module" of the ALK-GIAP workstations. The ALK-GIAP (Graphics Interactive Workplace) was developed by the state survey administration of Northrhine-Westfalia for interactiv and graphic aided work with data of the ALK. Later on the software system was extended to handle the ATKIS data structure. On the basis of this software AED Graphics has created an all-purpose geo-information system. Currently seven GIAP workstations with Raster-Module and connection to a table digitizer are available at the LVermA BB for correction, updating and extension of the DLM 25.

A digital orthophoto can be loaded into the GIAP, displayed and overlayed with DLM 25 vector data. The display of raster or vector data can be switched off. Different transparent and opaque modes are also available. At the moment the display of orthophotos is limited to 64 gray values. This figure has to be increased for reliable interpretation.

For detection of changes and new DLM 25/2-objects the following alternatives will be tested concerning reliability and production speed :

a) Overlaying a raster plotter output of the digital orthophoto and a plot of the DLM 25/1 vector data on a light table

and marking of objects which have to be captured.
b) Overlaying both types of digital data on the graphics screen and comparing the data patch-wise.

In both cases changes and new objects will be digitized directly from the screen using the zoom-function.

3.5 Use of Stero-Compilation

Stereo-compilation has already been successfully applied to create the DLM/1 for a limited number of capturing untits in areas where no others data sources were available.

Analytical plotters Planicomp P1/P3 with Videomap superimposition and a converted analog stereoplotter TOPOCART were used for data capturing with the PHOCUS-system from Zeiss running on VAX/VMS workstations. In comparison with table digitizing the time consumption was about 1.5-times higher. However this will be compensated since it is not necessary to improve the planimetric accruracy of these data.

PHOCUS was supplemented by an ATKIS-module consisting of a working environment (object- and graphics-tables) and data conversion programs EDBPHO/PHOEDB (from/to the EDBS-format). The data captured with PHOCUS were loaded via the EDBS-format into the GIAP-workstations for final treatment (e.g. adding administration boundaries and topological references for traffic objects crossing by bridges). For a fully ATKIS-compatible data capturing with PHOCUS a relational data base (RDB) would have to be attatched to PHOCUS.

Meanwhile the PHOCUS-system has been upgrated to Unix workstations and supplemented by a further Planicomp P33. Due to problems with the EDBPHO conversion program and a decision from Zeiss to stop the support for RDB's a new solution had to be developed for updating the DLM 25. It is intended to use the Planicomp P3 and P33 as input devices for the GIAP-software running on the same workstations as PHOCUS. A corresponding driver will be developed at the University of Neubrandenburg in cooperation with Zeiss and AED Graphics.

Stereo-compilation for updating and extending the DLM will be coupled with the revision of the TK 10 N. This will avoid some double work. The workflow is as follows :

- B&w aerial photographs 1 : 18,000 will be used for both purposes.
- The TopMD has to prepare non-geometric descriptive information for both purposes only once.
- Detection of changes will be done only once with KARTOFLEX map revision instruments for TK 10 N updating.
- The results from the KARTOFLEX evaluation will be examined whether objects of the DLM 25 are affected.
- If so, these objects can be captured
  a) in case of minor changes directly from the topographic revision sheet by table digitizing or
  b) in case of major changes by stereo-compilation with analytical plotters.
- For absolute orientation of the aerial photographs control points can be extracted from existing long-term usable point fields :
  a) LuPa - about 25 point groups (6 points, mainly roof corners) per TK 50 N, with coordinates determined by geodetic measurements.
  b) PaTop - about 36 points per TK 10 N, with coordinates determined by aerial triangulation.
- If necessary, the topographic field survey, who has to inspect the area of the map sheet anyway, will be instructed to check the correct classification of some features or collect missing attributes. For this purpose a GIAP-workstation will be installed in their cars.

3.6 Treatment of Buildings

Within the working group responsible for the content of the DLM 25/2 there was a long discussion which types of buildings should be included in stage 25/2. Finally the AdV-Plenum has decided that integration of all types of buildings can be left to a later stage. The most easiest way is to extract building from the ALK. In contrast to other state survey administrations the LVermA BB intends to include all buildings already within realization stage 25/2.

The following arguments have influenced this decision :

- One utility company which supplies 1/4 of the state of Brandenburg with electricity has established an information system with buildings included by photo-grammetric stereo-compilation. Other companies are planning to do the same. They will change to ATKIS only if the DLM will contain buildings.
- In Brandenburg the cadastral survey offices have started in 1992 to establish the ALK. The completition is progressing very slowly and will be finished in 2010 or later. Some local cadastre renewal projects have be lauchend but none of them is finished. Therefore it is not possible to get a complete coverage of building data from this source very soon.
- For 52 map sheets 1 : 10,000 no topgraphic base information is available. These map sheets cover former military training areas. If buildings are included cartographic presentations derived from the DLM 25 could serve as temporary substitutes.
- In the long-term it is planned to replace the revision of the TK 10 N completely by derivation from the DLM 25. This intention is becomming realistic because in the revised object catalog for the DLM 25/2 some of the data collection criterias (e.g. minimum length, minimum area) were changed towards the TK 10.

For incorporation of buildings into the DLM 25/2 the following procedures will be applied :

- In areas with local cadastre renewal projects the buildings will be extracted from the ALK.
- Existing building data can be bought from utility companies if their quality and up-to-dateness is sufficient and the price is reasonable.
- Based on an agreement between different administrations b&w aerial photographs 1 : 10,000 will be flown in 1996 and 1997 for the whole area of Brandenburg.
- It is planned to make arrangements with potential users to share the costs for stereo-compilation. The compilation will be done in contract through private photogrammetry companies. A pilot project for 16 map sheets TK 10 N south of Berlin has been sucessfully carried out. The costs were below 2,- DM per building.
- In contrast to other objects of the DLM 25 also the heights of all building corners shall be stored in the ATKIS database. The z-coordinates will be delivered by stereo-compilation anyway. Aditional attributes like roof type, mean height of the building and highest point above sea level will also be captured. This will enable a user to create 3D-presentations and 3D-models with adequate approximation for simulations and predictions. The additional effort for capturing these attributes is not useless since future GIS will be able to handle these data and demands for 3D-building data will arise.

- As a further attribute the function of the building (GFK, e.g. dwelling-house, school, church, administration, farm, etc.) has to be ascertained. In a first step this attribute will be set according to the representation in the TK 10 N. Corrections will then be made by local administrations.
- Discrepancies between the stereo-compilation and the TK 10 N concerning missing or additional buildings will be clarified by topographic field surveyors if the revision cycle for the TK 10 N reaches the corresponding area. At this stage also further corrections for the attribute GFK will be made. After this step the buildings can be stored into the ATKIS database.
- If at a later stage the ALK is complete for an area with buildings already captured by stereo- compilation only the planimetric coordinates and the attribute GFK will be replaced by a semi-automatic procedure. The heights and other attributes which are not stored in the ALK will not be changed.

3.7 Integration of Relief Information

Objects of the class "Relief" are already defined in ATKIS-OK (e.g. DEM-grid, contour, break line, slope, dike) but the the integration into the DLM 25 is left to further stage.

The LVermA BB has already established a digital elevation model (DEM 50, grid width of 50 m x 50 m, height accuracy ± 5 m) from digitized contour lines of topographic maps 1 : 50,000. A DEM 25 (grid width 25 m x 25 m, height accuracy ± 2 m) is currently beeing built-up for digital generation of orthophoto maps TK 10 DL. The DEM 25 is interpolated from

- contours digitized from maps 1 : 25,000 and
- photogrammetrically captured geomorphologically relevant information like ridge lines, surface edges, scarps, ramps and dikes.

The parameters of the DEM 25 correspond to the ATKIS requirements and would allow the integration into the DLM 25.

The LVermA BB is however currently testing different methods for generating a more accurate DEM 10 (grid width 10 m x 10 m, height accuracy ± 0.5 m) :

- Digitizing of contours from the TK 10 N,
- Image matching with TopoSURF,
- Photogrammetric measurements,
- Laser-scanning.

Based on the results of these tests the generation of the DEM 10 will be started as soon as the DEM 25 is complete.

4. FUTURE UPDATING METHODS

Some proposed semi-automatic updating methods were investigated and their potential and chances for realization were judged.

While methods based on remote sensing or auto-mated feature extraction do not promise reliable results within the near future, a data exchange with the ALK seems to be possible in areas where the ALK reaches a certain completeness.

Also a data exchange with users of the DLM 25 might be possible in a later stage if these users are capable to deliver EDBS-formatted updating data sets (e.g. update records about changes of road classifications from the road administration).

5. OUTLOOK

Concerning updating of the DLM 25 the German surveying and mapping agencies are still in a stage of evaluation or testing. The described solutions for the state of Brandenburg are based on well known and proven technologies and therefore there is no risk that they might fail. A change to more sophisticated automated procedures might be possible even within the realization phase of the DLM 25/2 (1997 - 2000) if they prove to be reliable and less costly.

REFERENCES

Journals:

Krakau, W., 1994. Die großmaßstäblichen topographischen Kartenwerke 1 : 10 000 und 1 : 25 000 des Landes Brandenburg. Kartographische Nachrichten (KN), 44(2), pp. 45-54.

Krause, U., 1995. Konzeption des Landesvermessungsamtes NRW zur Fortführung des DLM 25/1 und zur Realisierung des DLM 25/2. NaKaVerm Nr. 113, pp. 139-145.

Mischke, A., 1995. Fortführungsmöglichkeiten für das Digitale Landschaftsmodell 25 (DLM 25). NÖV NRW Heft 2, pp. 131-141

Books:

Harbeck, R. (Ed.), 1994. Das Geoinformationssystem ATKIS und seine Nutzung in Wirtschaft und Verwaltung. Proceedings of the AdV-Syposium ATKIS at Landesvermessungsamt Nordrhein-Westfalen, Bonn-Bad Godesberg.

Kophstahl, E. & Sellge, H. (Eds.), 1995. Das Geoinformationssystem ATKIS und seine Nutzung in Wirtschaft und Verwaltung. Proceedings of the 2nd AdV-Symposium ATKIS at Hannover.

Others:

AdV, 1989. Amtliches Topographisch-Kartographisches Informationssystem ATKIS - Gesamtdoukmentation. Printing & Distribution : Landesvermessungsamt Nordrhein-Westfalen, Bonn Bad Godesberg