

ATKIS® DATA BASE REVISION AND GENERATION OF DIGITAL TOPOGRAPHIC BASE MAPS

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Working Group IV/3

KEY WORDS: Spatial databases, Data acquisition, Revision, Buildings, Mapping, Semi-automation, Production

ABSTRACT

The federal states in Germany are currently building-up the basic geo-information system ATKIS® (Official Topographic-Cartographic Information System). ATKIS will provide a digital data base of the landscape and the terrain relief. These data can be used in all space-related information systems as geo-topographic data-basis. This paper describes the establishment of the Base-DLM (Digital Landscape Model) and the subsequent generation of Digital Topographic Maps (DTK10, DTK25) at the State Survey Administration of Brandenburg (LVermA BB).

ZUSAMMENFASSUNG

Der nachfolgende Beitrag beschreibt die Vorgehensweise des Landesvermessungsamtes Brandenburg beim Aufbau des Basis-DLMs von ATKIS und die anschließende Ableitung Digitaler Topographischer Karten.

1 INTRODUCTION

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). Objects of the 'Real World' like roads, rivers or woodland are stored in Digital Landscape Models (DLMs). These objects are described by coordinates for position and shape and by attributes for additional characteristics.

The Automated Real Estate Map (ALK), the German Topographic Base Map 1:5,000 (DGK5), topographic maps 1:10,000, aerial photographs and (digital) orthophotos are used as primary data sources for the establishment of the DLMs. The ATKIS data model has been derived from the ALK and extended by complex objects, object items and topological references. For data exchange the system-independent 'Uniform Data Base Interface' (EDBS) has been defined and realized for many popular GIS-packages (e.g. ARC/INFO®, ArcView®).

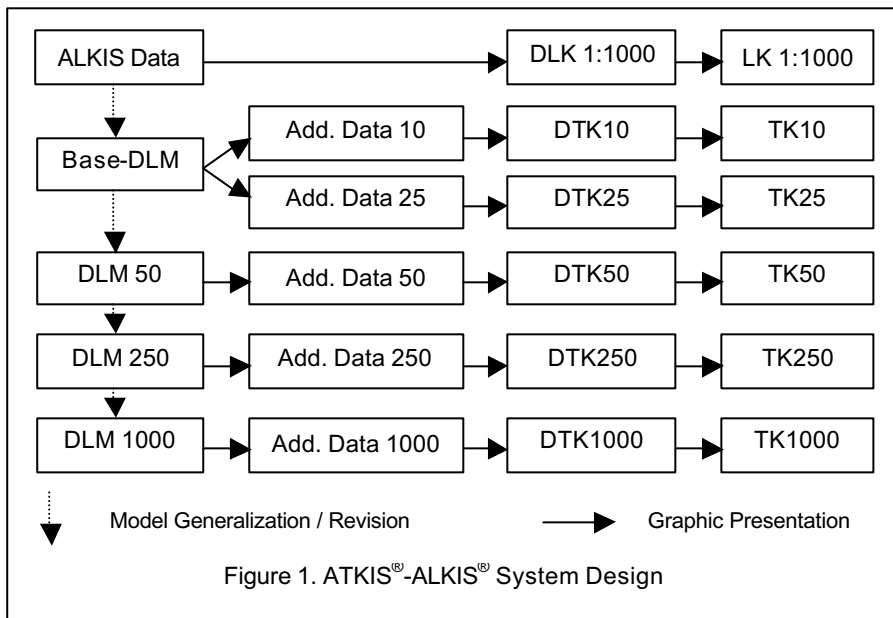


Figure 1. ATKIS®-ALKIS® System Design

The DLMs are vector-formatted and object-structured. The content of the DLMs and rules for data capturing are fixed in Feature Class (Object) Catalogues (OK). The content of the Base-DLM corresponds to topographic maps 1 : 10,000 ... 1 : 25,000. However the positional accuracy shall be improved to +/- 3 m for major linear objects. DTKs are generated from the DLMs by transferring the data into cartographic presentations according to specified scales and specific drawing rules which are outlined in Symbol Catalogues (SK). The raster-formatted DTKs can finally be used to derive the printing plates for producing analogue Topographic Maps (TKs). In future the ALK will be replaced by the

Official Cadastre Information System (ALKIS[®]). The data models and feature class catalogues of ATKIS and ALKIS will be harmonized. The ATKIS conception is documented in (AdV, 1989). Applications are described in the proceedings of several ATKIS workshops (e.g. Harbeck, 1994; Kophstahl & Sellge, 1995).

2 ESTABLISHMENT OF THE BASE-DLM IN BRANDENBURG

2.1 Realization of the Base-DLM/1

Since the establishment of ATKIS is a time-consuming and costly process, the Base-DLM will be created in several stages, according to user's requirements. The Base-DLM will be realized by the state survey authorities with highest priority. The first stage comprises 65 of the most important and most frequently required topographic objects. This basic data includes line objects like all roads, paths, railways, waterways and district boundaries as well as area objects like residential areas, industrial and trade areas, woodland, arable land and others.

The LVermA BB started in 1992 to build-up the Base-DLM/1. Data collection for the first stage was completed by the end of 1996. Map sheets of the Topographic Map 1 : 10,000 (TK10N) were chosen as capturing units. Since each of the federal states has to create the Base-DLM up to the state boundary, Brandenburg is covered by 828 full and 249 partial capturing units (approx. 5.5 km x 5.5 km).

The following primary data sources were used :

- TK10AS (edition state, along border to other states)	3 %
- TK10N (after updating the former TK10AS and assembling to the new TK10N format)	38 %
- Orthophoto maps TK10L (generated by perspective rectification, e.g. with SEG VI)	41 %
- Orthophoto maps TK10DL (digitally generated with the PHODIS [®] -system from Zeiss)	15 %
- 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 were employed. Most of the data capturing work by table digitizing has been done in contract by private companies. For data capturing the software package ALK-GIAP[®] (Graphics Interactive Workplace) was used.

ALK-GIAP was developed by the state survey administration of Northrhine Westfalia for interactive 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 18 GIAP-systems with Raster-Module and connection to a table digitizer are available at the LVermA BB for correction, updating and extension of the Base-DLM. For each data set up to 8 digital orthophoto can be loaded into the GIAP, displayed and overlaid with the vector data in different transparent modes for on-screen digitizing.

2.2 Revision of the Base-DLM and Extension to Stage 2

The content of the second realization stage has been defined by the AdV in 1995 and comprises 111 different objects. Almost all relevant objects of the class 'settlement' with the sub-classes 'built up areas', 'open residential areas' and 'buildings and facilities' became part of the Base-DLM/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-Base-DLM but not part of the OK-Base-DLM/2 shall be captured or incorporated. These are e.g. water-gauges, pumping works, variable banks of rivers, boundaries of different types of protective areas, aisles within forests, walls, cranes, depots and buildings.

All users of the Base-DLM agree that a periodical revision of the data within an at least 5-year-cycle is absolutely necessary. In March 1997 after a few month of testing and adaptation of the ALK-GIAP working environment the procedures for updating the Base-DLM and extension to stage 2 were operational. Until March 1999 mainly digital orthophotos with 65 cm x 65 cm ground resolution generated from b&w photo flights 1 : 34,000 and revised analogue map sheets 1 : 10,000 were used. Since then digital orthophotos with improved ground resolution of 25 cm x 25 cm are used which are produced from b&w aerial photographs 1 : 12,500. The film rolls are scanned with 14 microns on a Zeiss SCAI-scanner with autowinder. Automated aerial triangulation (AAT) of the images is performed with MATCH-AT. By the end of March 2000 Base-DLM/2 data were available for 66 map sheets TK10N.

Some users also demanded a continuous updating or a priority treatment for densely populated areas or certain object classes (e.g. built-up areas and roads) with a shortened revision cycle. In order to fulfil these demands the AdV has set-up a list of objects and attributes with 'top priority' (e.g. roads, administrative boundaries). Changes belonging to this list

must be incorporated into the ATKIS data base within three months. The 'topographical information service' (TopMD), a subdivision of the LVerMA BB, maintains close contacts to administrations, other institutions and private industry in order to acquire information about those changes and other non-geometric descriptive information which can not be captured from orthophotos or existing maps. Unfortunately most of these organizations still refuse or are not able to supply digital data at all or in shortened periods. For the present the TopMD looks for hints about new or changed roads and streets in official gazettes and extracts the geometries from digital orthophotos with 1 m x 1 m ground resolution, which are produced every year for 1/3 of the state territory in areas which are not assigned for the periodical revision.

In the first three years the progress for establishing the Base-DLM/2 was limited because

- new technologies (roll film scanning, AAT) had to be introduced and
- additional operators had to be trained (since the work can not be done by contract).

The delay was also caused by several special projects with higher priority :

- The reduced geometric accuracy of most of the available data sources for the Base-DLM/1 prevented to meet the planimetric accuracy requirement of +/-3 m. This disadvantage was accepted since a fast completion seemed to be of greater importance. Starting in March 1998 the planimetric accuracy has been improved to meet the ATKIS standard. Digital orthophotos, on-screen digitizing of control points (e.g. road intersections) and the data homogenization program FLASH were applied. This work was finished by the end of 1999.
- The original data base system has proved to be too limited and inflexible for future requirements. Therefore it will be replaced by a new one (AED/IDB connected with Informix). Currently the new data base system is passing the final tests and it is expected that in April 2000 all data can be fed in. This enables the LVerMA BB to use a special mechanism for supplying update data sets (including only new and updated data) to customers.
- The police district departments showed great interest to use the Base-DLM for their operation management systems. A program was set-up to capture all street names and incorporate them into the Base-DLM. As a side-effect this work also caused lots of changes in the topology of the streets itself. The incorporation of street names was completed in March 1999.
- The ministry of environmental protection requested to get water, landscape and other protection areas included into the Base-DLM. This work is also time-consuming since the boundaries of these areas are not always clear and sometimes have to be adapted to other existing geometries. It is planned to finish the program for capturing these areas until mid of 2000.

2.3 Incorporation of Buildings

In contrast to other state survey administrations the LVerMA BB intends to include all buildings already within or at the end of realization stage 2. The following arguments have influenced this decision :

- Some utility companies have started to establish information systems with buildings included by photogrammetric stereo-compilation.
- Many private companies and administrations show great interest in using ATKIS as geo-base for their GIS but only if buildings are included. Most of the private companies need 2.5-D building data.
- In Brandenburg the cadastral survey offices have started in 1992 to establish the ALK. The completion is progressing very slowly. Therefore it is not possible to get a complete coverage from this source very soon.
- Building data from the ALK will be 2-D and do not contain attributes like 'roof type' and 'mean height'. Since 2.5-D or even 3D-GIS are or will be available users will demand appropriate data.
- For 52 map sheets TK10AS no topographic base information is available. These map sheets cover former military training areas. If buildings are included cartographic presentations derived from the Base-DLM could serve as substitutes.
- Apart from contour lines buildings are the most frequent feature in a topographic base map. Only with buildings included it makes sense to change the method of cartographic updating from manual methods (drawing, scribing) to digital methods (automatic generation of a map presentation and interactive refinement).

In 1995 a pilot project covering 16 map sheets south-west of Berlin has been launched. The data (approx. 100,000 buildings) were delivered in April 1996. The costs were below 2,- DM per building. Since this pilot project was very successful (Müller & Seyfert, 1996), the LVerMA BB has set-up a program for the incorporation of buildings into the Base-DLM/2. B&w aerial photographs 1 : 10,000 were flown in spring 1996, 1997 and 1998 covering the whole area of Brandenburg. These photographs were processed in the following steps (Müller & Seyfert, 1998) :

- International tendering
- Aerial triangulation
- Stereo-compilation
- Field checking and capturing of attributes
- Post-processing for ATKIS compatibility

The most important specifications for stereo-compilation can be summarized as follows :

- Buildings have to be captured if they are larger than 15 sqm. The points to be measured are the roof corners. Hidden corners (e.g. by trees) must be constructed by line intersection. The use of 'building squaring' functions is not allowed.
- The roof type (attribute BDA, 13 values) must be captured using different feature codes or as an attribute string.
- Adjoining houses (annexes), serial houses and blocks of houses must be splitted into different objects if they have different heights, roof types or visible parcel boundaries. A planimetric snap function which preserves the true Z-coordinate must be used.
- The highest point of the building has to be measured in a special position depending on the roof type (see fig. 2).
- A point on the ground (mean terrain height) close to the building must be measured. With the Z-coordinates of the highest point and the ground point the attribute HHO (mean object height) will be calculated later on. This will also allow a user to create 3-D presentations and 3-D models with adequate approximation for simulations and predictions.
- In addition to buildings also different types of towers, chimneys (smoke-stacks), cranes and wind rotors must be captured since for these features the attribute HHO is required too.

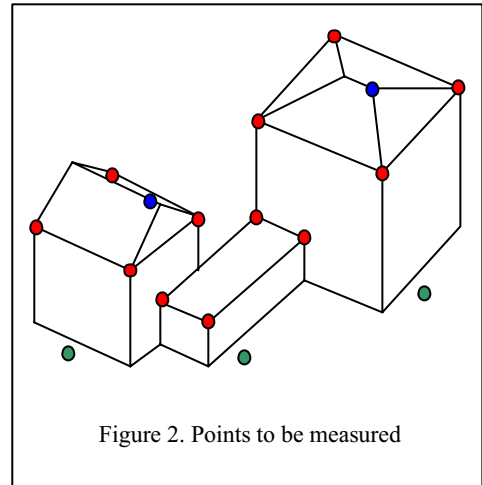


Figure 2. Points to be measured

In March 2000 the following state was achieved :

- digital building data from stereo-compilation available for 97 % of the area of Brandenburg (complete coverage until May 2000),
- cadastral survey offices have started to take over these buildings into the ALK as topographic objects,
- photogrammetric revision done for approx. 8 % of the available data (25 % up to the end of 2000),
- field check and capturing of attributes done for approx. 6 % of the available data.

The revision of building data in a 5-year-cycle can be done by own staff. The digital building data have already been intensively used, e.g. for

- state-wide creation of special presentations from Base-DLM/1 data + buildings for the ministry of environmental protection (LUA),
- calculation of noise spreading simulations and generation of noise protection maps for several towns by LUA,
- generation of qualified development plans and zoning/land use plans.

3 PRODUCTION OF DIGITAL TOPOGRAPHIC BASE MAPS

3.1 First Examples

Starting in 1994 first attempts (Kusch, 1995) were made to generate map substitutes from Base-DLM/1 data. After the reunification of the two German states the LVermA BB had set-up a program to convert the former map series TKxxAS ('edition state') into the new format TKxxN ('normal edition') by manual methods (cutting and assembling of films). In areas where the new TK25N was not yet available, a cartographic presentation automatically generated from Base-DLM/1 data and interactively supplemented with some-place names and other labels should be made available on demand. The resulting images were stored as PostScript-files for output on a precision raster plotter (Barco BG 3800) in order produce the print copy originals. The black-film was finally combined with the raster plotter output for the map frame. In this way 15 map sheet TK25F ('land use') were produced and printed.

The major drawback for these map substitutes was the lack of buildings. Built-up areas were only separated into the objects 'residential area', 'industrial and trade area', 'area of mixed use' and 'area with public buildings'. In a further attempt a cartographic presentation of Base-DLM/1 data at scale 1 : 10,000 was combined with a digitally generated orthophoto map TK10DL. The print copy originals were produced in the same way as for the TK25F. A presentation of the built-up areas only is used to produce a negative mask for the combination with the TK10DL. Again it was planned to produce this substitute for the TK10N only on demand.

The program for building capturing by stereo-compilation, changes in the ATKIS system design and a considerable progress in generating cartographic presentations led to the conclusion that these early solutions should not be further

developed. Instead the efforts for generating Digital Topographic Base Maps 1:10,000 and 1 : 25,000 from Base-DLM/2 data with buildings and contour lines included were intensified.

3.2 Motivation

The updating and extension of the Base-DLM and the revision of the analogue map sheet series 1 : 10,000 is a double work. Identical information is transferred into different storage media (ATKIS data base and plates of analogue map sheets) using different methods and equipment. Since nowadays also administrations are faced with reduced budgets and staff this type of double work could no longer be accepted. As a consequence the LVerMA BB has stopped the work for the topographic revision of the analogue base map series 1 : 10,000 in October 1999. Accordingly the cartographic revision of the topographically revised map sheets TK10N will come to an end until April 2000. Instead the LVerMA BB will concentrate the efforts on updating and extension of the Base-DLM for generating DTKs and printed maps from this source.

Some new decisions concerning the ATKIS system design (additional 'presentation objects' and 'cartographically generalized objects' within the ATKIS data base) make sure that manual editing can be reduced to a minimum and the results can be retained for future revision cycles. Successful tests for generating acceptable cartographic presentations at least for the scales 1 : 10,000 and 1 : 25,000 lead to the assumption that the timing for this change is right.

The LVerMA BB has been charged by the AdV to develop examples for a new Digital Topographic Map 1:10,000 (DTK10). The following map sheets were chosen for the test :

- 3644-NO Potsdam SO (densely built-up city and suburban area, 15400 buildings),
- 3644-SO Saarmund (agriculture area with 1/3 forest and 5 villages, 3100 buildings).

3.3 Generation of the Digital Topographic Base Map 1 : 10,000 (DTK10)

For data collection and updating the graphic presentation of the data could be kept simple for faster screen display. A presentation which is appealing to cartographers and map users required to develop new symbol libraries and special drawing procedures. Also new menu libraries had to be developed (e.g. to select fonts or to handle the additional 'presentation objects'). The 4-GL programming language of the GIAP was used to write the new procedures for the cartographic presentation of the Base-DLM/2 data. In the following the state of development achieved in November 1998 is described.

In a first step the Base-DLM/2 data are automatically displayed using the new symbol libraries and drawing procedures. Streets are generated with two or more parallel lines depending on the attribute FSZ (number of roadways) and filled with ochre or yellow colour depending on the attribute WDM (administrative classification). Within crossing areas intersecting lines are cut off. Special symbols are automatically created to show street classifications down to the county-level. For this purpose the attribute KN (short name) is evaluated. All street names are displayed but must be manually positioned.

The different types of built-up areas are presented in different colours :

- industrial areas in grey, trade areas in white,
- areas of mixed use, areas with public buildings and densely built-up residential areas in pink,
- open residential areas in different shades of green with additional symbols depending on the type of vegetation.

In order to differentiate the type of vegetation additional 'presentation objects' are created and overlaid onto the existing objects for residential areas. As an alternative the use of an additional attribute VEG (type of vegetation) was discussed within the AdV.

In a pre-processing step isolated small buildings are filtered out. Afterwards the buildings are loaded and presented in red (public) and dark-grey (others) colour. For tall buildings (attribute HHO building height > 50 m) a black surrounding contour line is generated. Depending on the attribute GFK also additional symbols (e.g. for hospitals, police-, fire-stations) or texts (e.g. school, train station, revenue-office) are automatically created. For building complexes these must be reduced to one occurrence and afterwards manually positioned.

Administrative boundaries must be completely replaced by 'presentation objects' in order to solve the displacement problem for generalization. All place-names and other names must be newly captured from existing map sheets TK10N as 'presentation objects'. Depending on the size or importance of an object different PostScript fonts, styles and sizes can be chosen via screen or table menus.

Objects of the class 'relief' are already defined in the ATKIS-OK (e.g. DEM-grid, contour, break line, slope, dike) but the integration into the Base-DLM is left to further stage. The LVerma BB has already established a digital elevation model (DEM25, grid width 25 m, height accuracy +/- 2 m) for the digital generation of orthophoto maps TK10DL. The DEM25 was interpolated from

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

Unfortunately the DEM accuracy is not sufficient to interpolate 1-m- or 2.5-m-contour lines for the DTK10.

It is planned to generate a new DEM (grid width 10 m, accuracy +/- 0.5 m) by laser scanning. This would enable to interpolate contour lines for different map scales. A large area along the river Oder has already been processed in this way. But since laser scanning is still costly a complete coverage can not be achieved in the near future. Therefore raster data of the scanned (200L/cm) relief layers of the TK10N, which are available for all map sheets, are automatically vectorized using the program VECTORY from Graphicon GmbH. VECTORY is able to separate contour lines, contour labels, dams/dikes and scarps. The output is a DXF-file with different layers. The contour labels are converted into real numbers. The DXF-file is transferred to the GIAP and displayed together with the other data. Corrections are then made interactively :

- gaps must be filled,
- vectorization errors (crossing or touching contours) must be corrected,
- dam or scarp lines must be repositioned along streets, railways or rivers.

After all interactive additions and corrections are made the resulting image is saved as TIFF- and PostScript-file. The PostScript-file is used to control a colour inkjet plotter NovaJet II for check purposes or a Barco BG 3800 precision raster plotter for the production of print copy originals in the colours of the European scale comprising cyan, magenta, yellow and black.

The test for generating the two map examples was finished in September 1998. The amount of interactive was 200 hours (3644-NO) resp. 165 hours (3644-SO). Meanwhile some of the procedures have been further developed. It is estimated that now the work could be done in 137 resp. 119 hours. Both map examples have considerably influenced the definitions and rules in the symbol catalogue ATKIS-SK-10 which is now ready for confirmation by the AdV. Figure 3 shows a section of the new DTK10 3644-SO Saarmund. For comparison a corresponding part of the former TK10N (see Fig. 4) is also presented. Figure 5 shows a section of a digital orthophoto with the central part from fig. 4.

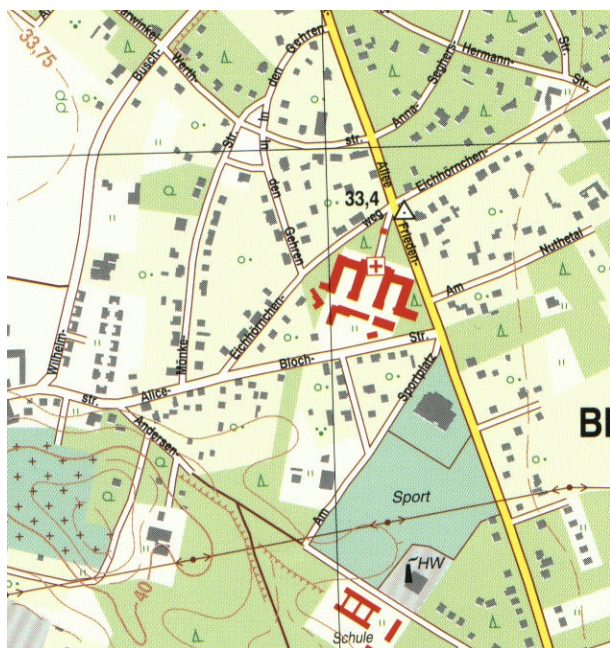


Figure 3. Section of the new TK10 3644-SO Saarmund (gen. from Base-DLM/2 data, revision 1997, scanned with 200 dpi from the printed map)

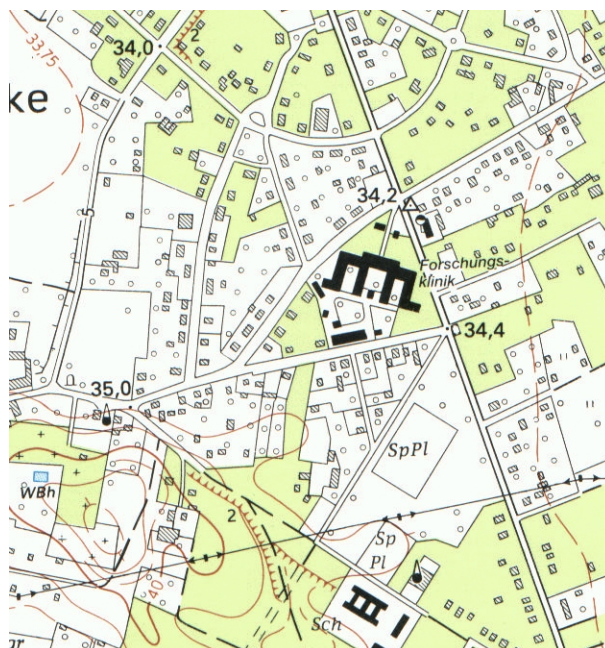


Figure 4. Section of the former TK10N (generated by conventional methods, revision 1993)



Figure 5.

Section of a digital orthophoto
(ground resolution 65 cm x 65 cm,
photo flight 1998)

3.4 Generation of the Digital Topographic Base Map 1 : 25,000 (DTK25)

The procedure is quite similar as for the DTK10. The major difference is that the amount of interactive work increases because of generalization problems. Also buildings are treated differently. In a pre-processing step buildings are separated into two different groups (public, others) according to the attribute GFK (function of the building, 98 different values). The geometry of each group of buildings is automatically generalized (coupled, simplified) using the program CHANGE_buildings from the University of Hannover.

In March and April 1999 the LVermA BB has generated a map example for sheet 3644 Potsdam. The time for creating this example was 270 hours (can be reduced to 200 hours). Figure 6 shows a section of the printed map.

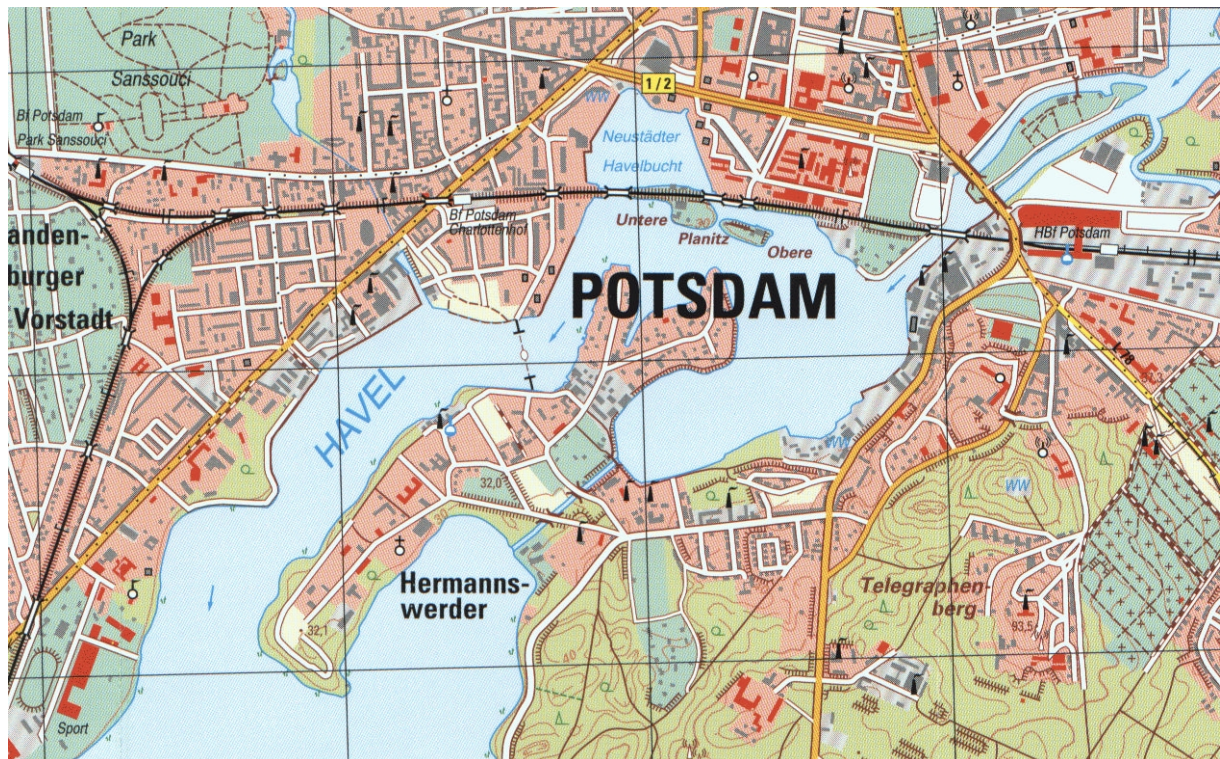


Figure 6. Section of the new TK25 3644 Potsdam (generated from Base-DLM/2 data, scanned with 200 dpi)

4 CONCLUSION, OUTLOOK

With the generated map examples an inquiry of users was carried out. The result was a great acceptance both for raster data (TIFF) which can be used in geo-information systems as background information and for the printed versions. One of the biggest advantages is that the intended change of the geodetic datum (Potsdam datum, Bessel-ellipsoid -> European Terrestrial Reference System) and map projection (Gauss-Krüger -> UTM) can be realized very easily.

The development of the production methods and procedures has reached a state which will allow an operational use. The amount of interactive work for generating and positioning of additional 'presentation objects' and 'cartographically generalized objects' is still high but can be reduced by improved procedures and the work can be retained for future revision cycles. It is planned to produce the DTK10 at first for those map sheets where the analogue TK10 N/AS does not exist (former military training areas) because of missing topographic base information. Currently the field check for buildings takes place in these areas. Afterwards the DTK10 will also be produced for areas where the Base-DLM has been extended to stage 2 and building data has been updated with new photo flights.

Further investigations will mainly be concentrated on improvements for the vectorization of the relief layers and the generalization of buildings. In co-operation with the Institute for Cartography of the University of Hannover the program CHANGE_buildings will be further developed to handle necessary displacements.

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