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QUALITY ASSURANCE FOR 2.5-D BUILDING DATA OF THE ATKIS DLM 25/2

Wilfried Müller & Eckhardt Seyfert
Landesvermessungsamt Brandenburg
Heinrich-Mann-Allee 103
D-14473 Potsdam

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 DLM 25 (Digital Landscape Model) has already been completed. Currently the DLM 25/1 is beeing updated and extended to the second stage DLM 25/2. The State Survey Administration of Brandenburg (LVermA BB) has decided to incorporate building data already within this stage while other states will leave this task for the final stage. This paper describes the motivation and the workflow for capturing 2.5-D building data. Different provisions are made in each step of the production process for ensuring a high quality of the building data. These measures will be discussed in detail. Finally an example for a topographic map sheet 1 : 10,000 generated from this data is presented.

1 INTRODUCTION

The Authoritative Topographic-Cartographic Information System (ATKIS) is a common project of the survey administrations of the Federal Republic of Germany. 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 geotopographic data-basis.

Based on applications and experiences gained with the available DLM 25/1 data the original ATKIS conception from 1989 has been further developed into a new system design shown in fig. 1. Objects of the ‘Real World’ like roads, rivers or woodland are stored in Digital Landscape Models (DLMs). These objects are described in position and shape by coordinates and their characteristics by additional attributes. The Automated Real Estate Map (ALK), the German Topographic Base Map 1 : 5,000 (DGK5), topographic maps 1 : 10,000, aerial photo-graphs and (digital) orthophotos are used as primary data sources for the establishment of the DLMs.

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 25 corresponds to the Topographic Map 1 : 25,000. However the positional accuracy shall be improved to ± 3 m for major linear objects.

Digital Topographic Maps (DTKs) are generated from the DLMs by transferring the data into a cartographic presentation according to scale 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 (ATKs). The ATKIS conception is described in *(AdV, 1989).* Applications are described in the proceedings of several ATKIS workshops *(Harbeck, 1994; Kopstahl & Sellge, 1995; LVermA RP, 1996).*

2 ESTABLISHMENT OF THE DLM 25 IN BRANDENBURG

The LVermA BB started in 1992 to build-up the DLM 25/1. Data collection for the first stage was completed by the end of 1996. Topographic maps 1 : 10,000 (TK 10 N/AS , 41%), orthophoto maps (TK 10 L, 41 %), digitally generated orthophoto maps (TK 10 DL, 13 %) and stereo models (3 %) were used as main data sources. Most of the data capturing work by table digitizing using ALK-GIAP (Graphics Interactive Workplace) workstations has been done in contract by private companies.

In March 1997 after a few month of testing and adaption of the ALK-GIAP working environment the procedures for updating the DLM 25/1 and extension to 25/2 were operational. As data sources mainly digital orthophotos and revised analogue map sheets 1 : 10,000 are used. By the end of May 1998 DLM 25/2 data were available for approx. 30 map sheets TK 10 N.

In the first year the progress for the DLM 25/2 was limited because of several special projects with higher priority :

- The reduced geometric accuracy of most of the available data sources for the DLM 25/1 prevented to meet the planimetric accuracy requirement of ± 3 m. This disadvantage was accepted since a fast completition seemd to be of greater importance. The planimetric accuracy ist now beeing improved. For this purpose the data homogenization program FLASH is used. Digital orthophotos and on-screen digitizing of control points (e.g. road intersections) are applied.

- The original data base system has proved to be too limited and unflexibel for future requirements. Therefore it will be replaced by a new one.

- The police district departments showed great interest to use the DLM 25 as a base for their operation management systems. A program was set-up to capture all

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street names and incorporate them into the DLM 25. As a side-effect this work also leeds to lots of changes in the topology of the streets itself. The incorporation of street names will be finished by the end of 1998.

- The ministry of environmental protection requested to get water, landscape and other protections areas included into the DLM 25. 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 1999.

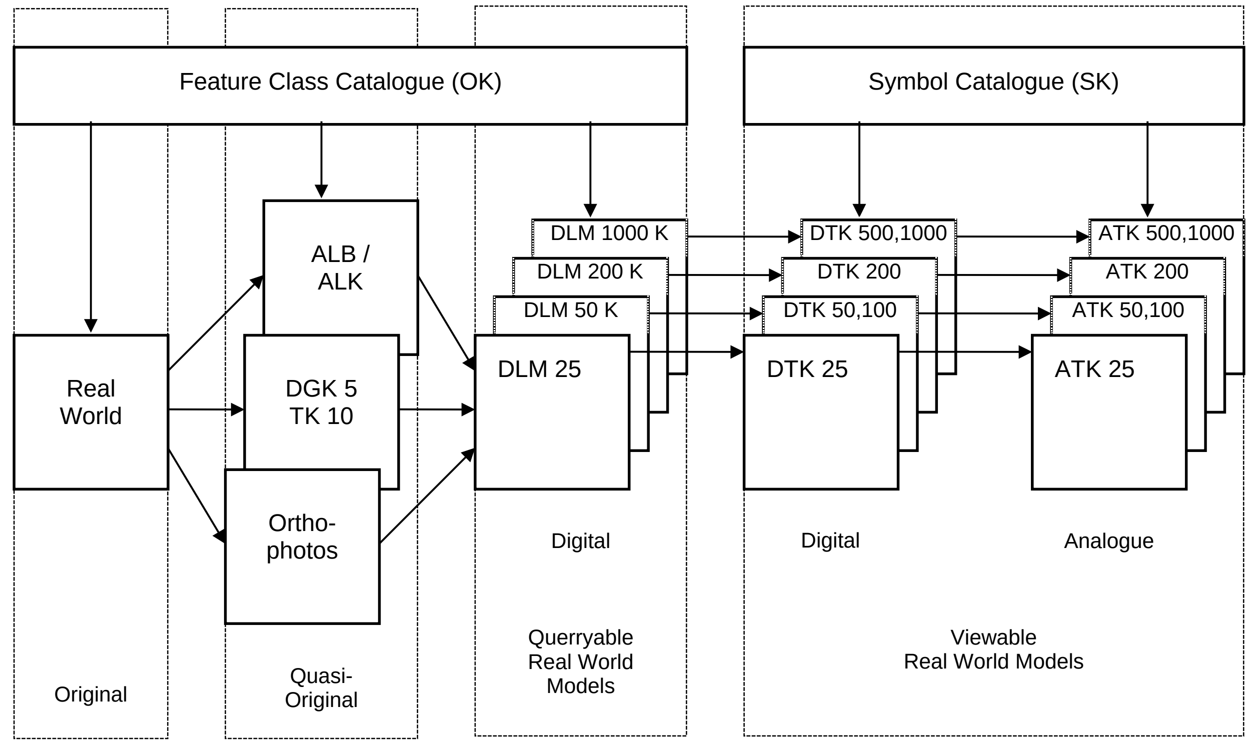

Fig. 1 : ATKIS System Design

3 MOTIVATION FOR THE INCORPORATION OF BUILDINGS INTO THE DLM 25/2

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 it was decided that integration of all types of buildings can be left to a later stage. The most easiest way is to extract buildings 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 :

- Some utility comapanies have started to establish information systems with buildings included by photo-grammetric 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 completition is progressing very slowly and will be finished in 2010 or even later. Some local cadastre renewal projects have been launched but almost none of them is finished. 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 3-D-GIS are or will be availabe users will demand appropriate data.

- For 52 map sheets 1 : 10,000 no topographic 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 substitutes.

- The updating and extension of the DLM 25 and the revision of the analogue map sheet series 1 : 10,000 is a double work. Identical information is transferred into different storage media (DLM 25 data base and plates of analogue map sheets) using different metheods and equipment. Since nowadays also administrations are faced with reduced budgets and staff this type of double work can no longer be accepted. As a consequence the LVermA BB has decided to stop the revision of the analoque base map series 1 : 10,000 by the end of 1998 and concentrate the efforts on the updating and extension of the DLM 25. DTKs and ananlogue maps

will then completely be generated from the DLM 25.
Some new decisions concerning the ATKIS system design (additional 'presentation objects' and 'cartographically gerneralized objects' within the DLM data base) make sure that manual editing can be reduced to a minimum. Successful tests for generating acceptable cartographic presentations at least for the scales 1 : 10,000 and 1 : 25,000 lead to the assumption that this time-table is realistic.

4 WORKFLOW FOR THE INCORPORATION OF BUILDINGS

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. For a small area inside the project area also ALK data were already available. A comparison showed that the correspondence is sufficient for topographic purposes. Since this pilot project was very successful, the LVermA BB has set-up a program for the incorporation of buildings into the DLM 25/2.

B&w aerial photographs 1 : 10,000 were flown in spring 1996, 1997 and 1998 covering the whole area of Brandenburg. These photographs were/will then be processed in the following steps :

1. International tendering
2. Aerial triangulation
3. Stereo-compilation
4. Field checking and capturing of attributes
5. Post-processing for ATKIS compatibility

In each of these steps provisions are made that a high data quality is ensured. The aspired quality is described by characteristics for completeness, correctness, consistency, accuracy and up-to-dateness. These characteristics have been defined as a compromise between different user requirements and posibilities for realization. They are partially fixed in technical decriptions which are part of the tendering documents.

5 MEASURES FOR QUALITY ENSURANCE

5.1 Tendering

Announcements of the project are published in several advertizers (e.g. of the European Community). Quality assurance accreditations are not demanded because
- this would handicap the smaller photogrammetric companies and
- aerial triangulation and capturing of buildings are standard photogrammetric tasks.

From our experience we can state that no significant difference concerning the quality of the work could be found between companies with and without quality assurance accreditations.

The companies have to prove their ability to do the work by supplying a list of references of similar projects. Also a list of the photogrammetric equipment and software packages is required but no restrictions are made ('knock out criteria') as long as the needed accuracy can be achieved. Companies which get their first contract must perform a stereo-compilation of a small test area in order to show that all specifications can be met.

The project area is splitted into lots with sizes ranging from 2 (242 km², densely populated areas) to 6 (726 km², low populated areas) map sheets 1 : 25,000. Contracts were made with quite a lot of companies because of
- the tight time-table (caused by budgeting),
- the limited production capacities of the smaller companies and
- in order to minimize the risk of getting unacceptable results.

In 1996 and 1997 29 resp. 19 lots were given to 14/19 companies (3/5 of them from other european countries).

5.2 Aerial triangulation

For aerial triangulation the LVermA BB supplies contrast-adjusted diapositive, paper prints and control points from an existing long-term usable photogrammetric control point field. The control points (mainly roof corners and gable points of new buildings) are arranged in groups of 6 points/group with a density of 1 group per 20 km² and have a planimetric/height accuracy of ± 0.10 m / ± 0.15 m. For vertical control improvement the companies have to select and measure at lest 5 additional height control points (spot elevations) from each map sheet 1 : 10,000.

Before starting with aerial triangulation the companies have to check and accept the delivered diapositves and other material. Tie points must be marked in the paper prints and documented by sketches or pugged in the diapositives.

The block adjustment can be done with any program which is able to handle the whole block. The standard deviation of adjusted coordinates should be better than ± 0.20 m (planimetry) resp. ± 0.35 m (height). In case of independent model adjustment the companies also have to supply a file of photo coordinates. The LVermA BB repeats all block adjustments with PATB because of the following reasons :

- The company results can be checked without knowing all the details about the used block adjustment program (e.g. PATM, BLUH, BINGO, CAP, CLIC, ORIENT, ISSBA, MHH850) by comparing the adjusted coordinates. The results are accepted if the mean (and maximum) differences are less than 0.15 m (0.45 m) in planimetry and 0.20 m (0.60 m) in height.

- The PATB results can be visualized (e.g. residuals, detection of lacking model or strip ties, accuracy of adjusted points).

- The results can be transferred into model set-up parameters for the analytical plotters Planicomp P1, P3, P33 for fast model orientation. This also works if not all tie points are well documented. It enables the LVermA BB also to use the orientation parameters in other projects (e.g. generation of digital orthophotos) and to sell photographs with the appropriate orientation data.

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5.3 Stereo-compilation

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

- Buildings have to be captured if they are larger than 2.5 m x 5.0 m resp. 15 m².
- The points to be measured are the roof corners. Hidden corners (e.g. by trees) must be constructed by line intersection. A function 'building squaring' is not allowed.
- The attribute BDA (roof type) must be captured as an attribute. The operator has to select one of 13 pre-defined roof types.
- 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 pre-serves 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 (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 heigth) will be calculated later on. The above-mentioned specifications will also allow a user to create 3-D presentations and 3-D models with adequate approximation for simulations and pre-dictions.
- In addition to buildings also different types of towers, chimneys (smoke-stacks), cranes and wind rotors must be captured since for these festures also the attribute HHO is required.
- The data can be delivered in several formats (Zeiss/ Phodat, DXF, PTF = simple Ascii).

As a first completeness check plots of scale 1 : 10,000 are compared with the existing topographic map or the orthophoto map. This allows to detect missing groups of buildings (e.g. very small villages). From each lot 4 - 6 models are choosen for a detailed check on an analytical plotter with superimposition. The models are visibly inspected to see if all specifications are met. About 50 buildings are remeasured in each model to compute a mean geometric accuracy which must be better than mx=my= 0.40 m, mz= 0.50 m.

Other checks are made with batch programs (e.g. plausibility of Z-coordinates, overlapping of building areas, correct use of snap functions). Buildings with detected errors will be marked by changing the feature code and creating a point-type object in the center of the building. The companies then have the choice to correct these errors or to accept that these buildings will not be paid.

If data capturing is complete for one or more map sheets the companies have the possibility to supply the data for checking. This option is frequently used and avoids problems caused by misinterpretation of the specifi-cations. The results of all the checks are documented in a detailed protocol.

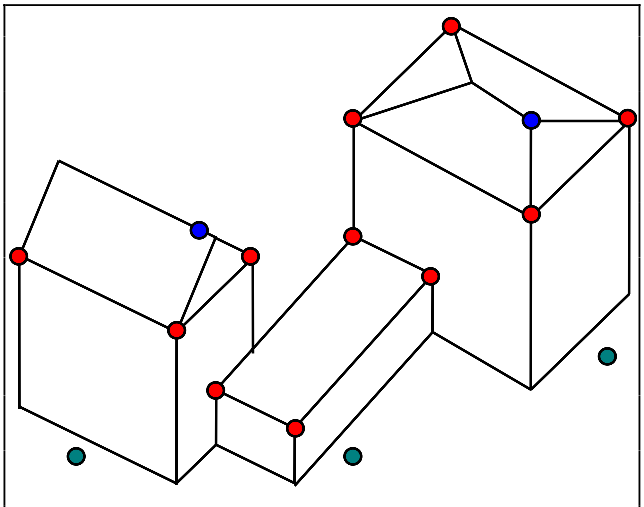

Fig. 2 : Points to be measured

5.4 Field checking

By using aerial photographs it is unavoidable that the data sets contain some objects which are not really buildings (e.g. tents, caravans, piles of wood). On the other hand some iosolated buildings will be overlooked especially if the analytical plotter is not equipped with superimposition. In other cases it is not possible to recognize buildings due to coniferous trees around them. The time-period between the date of the photo flight and the date of data delivery is usually one year and meanwhile some of the buildings may already be pulled down or reconstructed.

The only way to remove this kinds of errors is to do a field check. In preparation of the field check the new building data are compared with raster data of the scanned existing topographic map. For this purpose the PHOCUS monoplotting software is used and the situation layer of the digital topographic map is treated as an orthophoto. Missing buildings are digitized from the screen using a different feature code. New buildings (in comparison to the old map) are also marked by changing the feature code. Roads, streets, railways, rivers and lakes will be extracted from the DLM 25/1 and added to the data set. Finally A2-size paper plots 1 : 2,000 are generated showing the identical buildings and the differences in different colors.

The differences are then clarified by a field check. In addition also the attributes

- GFK (function of the building, 88 different attribute values, e.g. 1121 = school) and
- ZUS (status, 5 values, e.g. 1200 = out of operation, closed down)

are captured for these buildings. The quality of the field check is controlled for at least 4 plots of each lot by a repetition through a second topographer.

The results of the field check and additional attributes GFK from the TK 10 N (e.g. annotations for some types of public buildings and industrial plants) are taken over into the digital data using a PHOCUS editing workstation. Really existing new buildings get the original feature code. Roofs on pillars without walls get a seperate feature code and pulled down buildings are eliminated. This editing

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work is also controlled by checking at least 4 plots of each lot.

As a final step all stereo models are set-up using the orientation parameters (PHOREX-Files) generated from the PATB results. Previously overlooked buildings are measured and buildings marked as faulty (e.g. missing ground point) are corrected.

Due to a reorganization of the structure of the LVermA BB in future the number of topographers for this work will be increased from 1 to 5.This will allow to capture the attributes GFK and ZUS for all buildings. In addition also the attributes

- NTZ (usage, 4 values, e.g. 1200 = public)
- WDM (dedication, 1 value, 1202 = monument, memorial)

shall be captured. Many users also have a strong interest in getting house numbers. Because no other reliable data sources for house numbers are available it is also planned to capture these numbers and combine them with the street id-number.

Since all these additional attributes can not be captured on paper plots it is intended to use pentop PC's. The GIAP-software has already been ported to a PC running under Windows-NT. Tests in cooperation with the Technical College of Neubrandenburg have shown that this solution is possible but still not flexible enough. Currently other (more simple) GIS-packages are investigated. The use of pentop PC's will make the generation of paper plots and the subsequent incorporation of the field check results superfluous. It will also make the quality control easier since two independent field check results can be compared with a program.

5.5 Post-processing

Building data can be transferred into the ATKIS DLM 25 as soon as the specifications in the Feature Class Catalogue OK 25 are revised and released *(Müller & Seyfert, 1996).* For buildings the final version is still in discussion.

The Working Committee of the Survey Administrations of the States of the Federal Republic of Germany (AdV) has charged a group of experts to elaborate a conception to harmonize the feature class catalogues of ATKIS and ALKIS (Automatted Real Estate Information System). A first proposal was released in May 1998. It generally confirms the DLM data structure as a common basis. The number of attributes and attribute values is slightly increased. The attribute GFK is renamed to FKT and must be capture. Different levels of detail are defined and can be choosen.

If the new OK 25 is released, the values of some attributes will be calculated (e.g. HHO = height of object) or set to standard values. The data will then be converted into the EDBS- (Uniform Database Interface) format and transferred to the GIAP workstations. The consistency with existing DLM 25 data will be checked (e.g. intersections with streets, buildings must overlay one of the basic classes of build-up areas).

6 UPDATING OF BUILDING DATA

After finishing all the special projects mentioned in chap. 2 (improvement of planimetric accuracy, capturing of street names and protection areas) the LVermA BB can fully concentrate on the establishment of the DLM 25/2. Digital orthophotos with 20 cm ground resolution produced from photo flights 1 : 12,500 will serve as main data source. It is assumed that stage 25/2 can be completed within 5 years. The same aerial photographs will be used to update the building data. For this purpose stereo-compilation can be carried out on

- two analytical plotters Planicomp P3/P33 which are linked with the GIAP-software via a special driver *(Kresse, 1996)* and
- one digital stereo workstation PHODIS-ST which is also linked with the GIAP-software.

A further alternative which will be used is data exchange with the cadastral survey offices. For buildings previously captured by stereo-compilation only the more accurate planimetric coordinates will be replaced in the DLM data base while all other information related to the 3rd dimension will be kept. For new buildings the 2-D information and attributes will be incorporated immediately. The corresponding height information (mean height, roof type) will be added later on by stereo-compilation when the area is sheduled for DLM 25/2-capturing.

7 CONCLUSION, OUTLOOK

The LVermA BB will have achiedved a statewide coverage of photogrammetrically captured building data by the end of 1999. Up to May 1998 data for approx. 1.120.000 buildings have been delivered. Field checking and incorporation in the DLM 25/2 will be completed until the end of 2001. This data set will be unique because of

- the complete coverage,
- its homogenity (aerial triangulation based on a dense control point field, common capturing rules, overall positional accuracy ± 0.50 m),
- the extension to 2.5-D (attributes mean height and roof type),
- additional attributes (e.g. GFK function of the building),
- its reliability (field check) and
- up-to-dateness (permanent data exchange with ALK, periodical revision at least within a 5-year-cycle).

In comparison building data from municipal information systems and private suppliers (e.g. captured for telecommunication companies) are heterogeneous, locally restricted and partially have lower accuracy requirements. Building data from the ALK are more accurate but only in 2-D and not completely available until 2010 or later.

The new 2.5-D building data has already been used for different planning purposes and for noise spreading simulations. Fig. A shows a section of the Digital Topographic Map 1 : 10,000 Potsdam, which was completely generated from DLM 25/2 data with buildings included. This example gives an impression of the new possibilities.

8 REFERENCES

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

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

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

Kresse, W., 1996. Visuelle Überlagerung von ALK-GIAP-Vektordaten zur Verbesserung der geometrischen Genauigkeit und Fortführung der GIS-Daten. Proceedings of Workshop 'Datenqualität und Metainformationen in Geo-Informationssystemen', Rostock, Okt. 1996.

LVermA RP, 1996. Das Geoinformationssystem ATKIS ... Proceedings of the 3rd AdV-Symposium ATKIS at Koblenz.

Müller, W. & Seyfert, E., 1996. Incorporation of buildings into the ATKIS DLM 25/2. Proceedings of Workshop '3D-City Models, Bonn 1996.

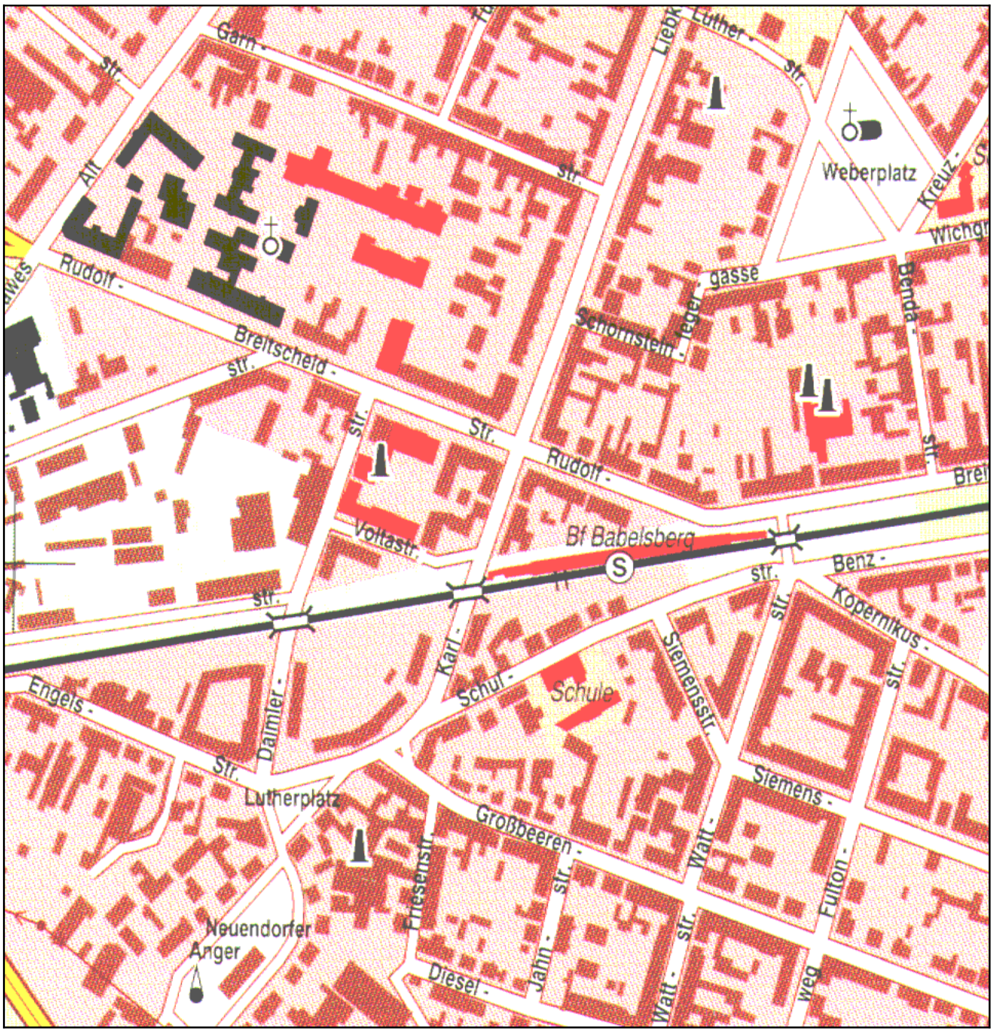

Fig. A : Section of Digital Topographic Map