A PHOTOGRAMMETRIC DATA CAPTURING SYSTEM FOR THE GERMAN ALK DATA MODEL

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Abstract:

This paper describes the development and testing of a data capturing environment for the „Automated Cadastral Map" - 'Automatisierte Liegenschaftskarte (ALK)' in Germany. The ALK combines cadastral data with topographic information at scale 1 : 1000. The conceptual data model was designed in the 1970s, independent from hard- and software constrains and was updated in recent years according to new developments in the field of GIS- technology. The main features of the data model are to be free of redundancies, to be a seamless data base, (thematic) layer orientation and the possibility to create of objects and object names in order to allow connection to other data bases. These definitions are flexible enough to accommodate the individual set-up of the independent German cadastral authorities. Details have to be defined by the cadastral authorities of the individual federal states of Germany.
The definitions of the state of North - Rhine Westfalia (NRW) are taken as basis for the development of the user interface, which is based on the Intergraph software MicroStation 5.0. Within the data structure designed, solutions for the special user requirements concerning non-redundancy and object definition are given. Most of the cartographic requirements are met by MicroStation 5.0 standard functions, however some restrictions were found.
On one hand, cadastral maps were used as data source for digitizing, on the other hand, stereo restitution and field completion was done using aerial photography.
In cooperation with the City of Wuppertal, Department of Surveying and Cadastre, and Hansa Luftbild, German Air Surveys, Münster, the user interface was tested.

Kurzfassung:

In diesem Vortrage wird die Entwicklung und der Test einer Erfassungsoberfläche für Daten der „Automatisierten Liegenschaftskarte" (ALK) beschrieben. Die ALK umfaßt sowohl Katasterdaten als auch topographische Informationen bezogen auf den Basismaßstab 1:1000. Das Konzept des ALK-Datenmodels wurde in den siebziger Jahre unabhängig von Hard- und Softwarezwängen entwickelt. Seither fließen ständig die neuen Entwicklungen auf dem Gebiet der GIS-Anwendungen ein. Wesentliche Punkte des Datenmodels sind Redundanzfreiheit, Objektbildung und Objektnamen als Schlüssel zu artverwandten Datenbeständen, Blattschnittfreiheit und thematisch Trennung der Daten auf verschiedene Ebenen. Diese Definitionen sind flexibel genug, um dem föderativen Aufbau des deutschen Katasterwesens zu genügen. Die detaillierte Ausgestaltung obliegt den Katasterverwaltungen der einzelnen Bundesländer.
Die Festlegungen des Bundeslandes Nordrhein-Westfalen waren Grundlagen für die Erfassungsoberfläche, die auf der Intergraph-Software MicroStation 5.0 basiert. Innerhalb der entworfenen Datenstruktur wurden Lösungsansätze für die speziellen Anforderungen bezüglich Redundanzfreiheit und Objektdefinition gegeben. Die kartographischen Anforderungen wurden zum großen Teil mit MicroStation 5.0 Standardmöglichkeiten realisiert, wobei aber auch Einschränkungen auftraten.
Als Datenquellen dienten zum einen Katasterkarten als Digitalisiervorlagen, zum anderen Luftbilder für die photogrammetrische Auswertung mit anschließendem Feldvergleich.
In Zusammenarbeit mit der Stadt Wuppertal, Vermessungs- und Katasteramt, und der Hansa Luftbild GmbH, Münster, wurde die Oberfläche einem Praxistest unterzogen.

1. Introduction

1.1 General

The growing demand of geographic information for urban and rural development, environmental monitoring, land use analysis and other purposes cannot any more be satisfied with conventional maps only.
As a consequence, geographic data bases - either for specific or - preferably - for general purposes are more and more implemented.
Users have defined their requirements in certain standards, sometimes independent from existing software. In Germany the Survey Authorities developed a set of different systems, where the 'Automatisierte Liegenschaftskarte (ALK)' - „Automated Cadastral Map" was designed as cadastral application for large scale mapping.
Data capturing for the ALK-standards requires topological structured data and the integration of non-graphical information. Photogrammetry is an appropriate tool to capture this data, particularly for large scale mapping, both in terms of accuracy and economy.
Within this paper, a procedure will be described to achieve this task in a consistent and economic way using Intergraph MicroStation 5.0 software.

1.2 Data Structure of the German Cadastral Services

The user requirements, a modern multi-purpose cadastre has to serve, can only be achieved by the use of modern technologies.
Since 1976, some research was undertaken in Germany by the Surveying and Mapping Agencies of the Federal States and some other Surveying and Cadastral agencies to establish the 'Automatisierte Liegenschaftskarte (ALK)' - „Automated Cadastral Map" [Richter (Edt.) 1993].
The result of these efforts is a seamless database containing graphical and alpha-numerical data as well as a user interface, a software called ALK-GIAP ('ALK-graphisch interaktiver Arbeitsplatz' - „graphic interactive workstation") and a data exchange format called 'Einheitliche Datenbankschnittstelle (EDBS)' - „unique database exchange format".
The data structure is described to some extend in the 'Objektabbildungskatalog (OBAK)' - „object description catalogue", and the 'Objektschlüsselkatalog (OSKA)' - „object key catalogue". The layout and symbolization of the maps is given in the 'Zeichenvorschrift Aut (ZV-Aut)' - „the specification" [OBAK 1994, OSKA 1994, ZV-AUT 1994].
In general, the data are organized on a layer/object type description, where features are divided in areas, lines and points with no redundancy. This leads to the multiple-theme approach.

2. Logical data structure of the ALK

The logical data structure of the geometric data is designed as system independent structure. The layer oriented set-up allows grouping of features, where for every type of feature a code number (OSKA-code) is assigned. This organization guarantees flexible handling and easy-to establish extension, if new features have to be accommodated. Also, the task of 'open LIS' can be achieved in this way. For this code lists have to be designed for every application. Groups of layers are already reserved for special applications.
The basic geometric elements are point, line and area. For line, a set of geometric defined features is allowed:

line	straight connection between two points
polygon	chain of lines
curve	interpolated polygon (spline)
arc	part of a circle
clotoide	special, mathematically defined curve

For specific features, an '**Objekt**' - „object" is formed. This combines geometric elements to one feature, based on a m:n relationship, for the sake of easier manipulation and attaching additional information.
However these are objects in the geometric sense; since the data model is not fully object-oriented. It does not support rules, inheritance, constrains and behavior of objects. This is planned as extension to the data base in the future.
An '**Objektname**' - „object name" is assigned to this objects, containing additional information (e.g. for parcels the cadastral division and sub-division, for houses the street name, house number, etc.).
For every object - disregarding the type of geometry - an **object coordinate** is stored for identification purposes and search algorithms.

Another principle of the data structure is **being free of redundancy** over the whole data set, which includes the use of the **multi-theme features.** Figure 1 shows a cadastral parcel 765 with house number 44 , fence and a cadastral sub-division boundary. The parcel boundary markers and relevant points are numbered for reference. The lines 6-8 covers two themes - parcel and cadastral sub-division boundary. The thick line parallel servers as cartographic layout only. The lines 1-6 and 1-4 have only partly multi-theme meaning. The part 6-7 of the line 1-6 is beside the parcel boundary also a fence. For 1-4 the double meaning healds for the part 2-3 (building and parcel). So multi-theme features can either be defined for complete geometric elements or parts of them.
The definition of a part of a line with additional meaning is done by introducing the **'unechte Punkte'** - „virtual points", which have no influence on the geometry of the line, just defining sub-divisions (points 2,3,7 in the example).
In order to adjust the logical data model of the ALK to the needs of the individual cadastral administrations, each Federal State has designed it's own OSKA-code list.

The seamless ALK database does not store a map or graphics, but only objects with their attributes and the spatial relationship between objects. The realization (e.g. display, plot) of the map (e.g. cartographic layout, hatching, etc.) is left completely to the graphics software used.
The complex data structure of the ALK data model should be supported by the graphics software used in a way, that the user is not affected more than necessary in any stage of the work. As much as possible, the software has to organize the required data structure.

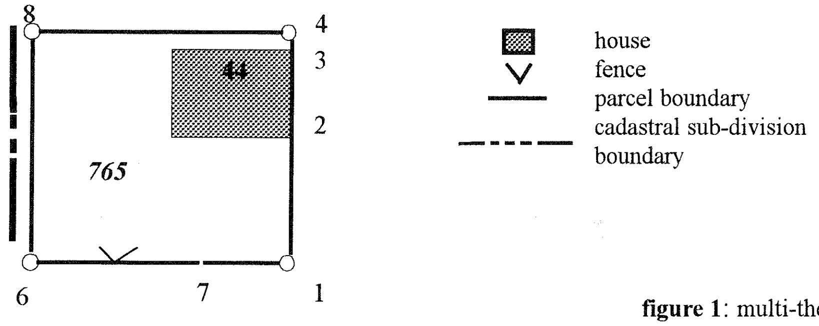

figure 1: multi-theme feature

For more detailed information, see [NOEV 1980, NOEV 1980, NOEV 1989, Stoeppler 1985a, Stoeppler 1985b]

3. Software used

The software package MicroStation PC was introduced by Bentley Systems Inc. around 1987 as further development of IGDS (VAX-based), graphic software of Intergraph. Already the older version was used for mapping, especially in photogrammetry. With the development towards digital based production lines, the capabilities of MicroStation PC were fully utilized by the users, particular for those using photogrammetric workstations in their production line. Intergraph software was chosen by the vast majority of the German photogrammetric companies as their graphic software. Several advantages are the basis for this choice:

- ♦ easy to use
- ♦ economic since it has a good performance
- ♦ powerful application programs
- ♦ includes possibilities of own programming (from simple to sophisticated programs)
- ♦ does not need data conversions between MicroStation software running on different platforms
- ♦ can be used with commercial DBMS
- ♦ has interfaces for different other data formats (import/export)
- ♦ offers vector and raster capabilities
- ♦ is customized for semi-analytical, analytical and digital plotters of different manufactures

The latest software version 5.0 (MicroStation PC 5.0 available in Europe since autumn 1993) includes a number of remarkable extensions of functions. Some of them are going to be used for the user interface designed. It was found, that they are useful for the problems, which had to be solved. The most interesting new features for the field of mapping applications are :

- group settings
- custom line styles
- tags
- SELECTOR as part of MicroStation 5.0
- dynamic patterning and hatching
- extended text functions
- extended complex functions
- tool settings box

More details are given in *[Intergraph 1994]*.

4. Design of the data structure

Transferring a given conceptual data model in the data structure of a graphics software needs a lot of time-consuming work. Everything has to be tested rigorously until the results are satisfactory. Only after that a production line can start. Performing structural changes during data capturing or before data delivery is very costly and even more time-consuming.
But also number of other aspects have to be considered when designing a user interface, namely:

- the requirements of the customer
- economic aspects
- easy to handle for the operator
- the structure has to be clearly defined
- easy to check
- as much as possible supported by the system
- repetition of work should be avoided
- a good documentation for users
- new features of the software should be used, if well documented

Trying to consider all these points, a data structure for the ALK data model in Intergraph MicroStation 5.0 was designed by the authors of this paper

In addition to the more general points mentioned above, there are a number of ALK-specific topics to be reviewed.
The cartographic requirements defined in the ZV-Aut NRW have to be met, as well as the settings given by the OBAK-LiegKat NRW in terms of elements to be captured, layer orientation, object formation, object names and coordinate, area coverage, non-redundancy of the data set, etc..
Because MicroStation 5.0 is neither object-oriented nor able to handle a multi-theme vector data structure in its original design, special solutions for these topics had to be found. Virtual points (cf.: 2.) are not a default feature of the MicroStation either, therefore a specific procedure was needed. Finally, restrictions due to plotting and the planned data transfer via EDBS had to be examined, because in first instance the data set should serve data delivery purposes, but plotting requirements also have to be considered. The general questions are discussed in the next section, while the solutions of specific problems are given after, following the ALK structure.

5. Definitions of the OBAK-LiegKat NRW

Elements to be captured / OSKA-code as identifier

There are about 1100 different objects defined within the OBAK-LiegKat NRW, differentiated basically by their unique OSKA-codes. The cartographic layout is only used for display and plot respectively. This information is not to be transferred while data transfer via EDBS (e.g. hatching for buildings, embankments, default positions for annotations, etc.), except for special solutions (e.g. annotation on non-default position, etc.).

Working with graphic software such as MicroStation is based on visualization of different features. Distinction between elements is usually done by level, color, weight, line style, text and symbol size and layout. Assigning numbers such as OSKA-codes is not the preferred way, as most people can easier work with visual impressions than with number codes.

Following this, a data structure has been designed, where to each OSKA-code given in the OBAK-LiegKat NRW a unique MicroStation level-symbology was assigned.

Layer orientation

This problem was easy to be solved as ALK as well as MicroStation are layer oriented. So, for every ALK layer, one or more MicroStation level are exclusively assigned. As MicroStation is restricted to 63 levels, it is not always possible, to keep the layer number equal to the level; but this is done as far as possible. For various layer, more than one MicroStation level was assigned for the sake of easier differentiation of elements.

Geometric elements to be captured

For some of the objects, a restrictions in terms of the allowed geometric elements is given in the OBAK-LiegKat NRW, e.g. only lines for parcel boundaries. This restrictions have been considered within the data structure.

Color coding

Color coding is no requirement of the ALK data structure, but was used for different purposes. One is the definition of elements, which occur on more than one layer and will not be plotted (e.g. OSKA 0242 (line for object definition) and 0249 (virtual object line)). These are stored on MicroStation levels 61 and 62 respectively. The color number represents the ALK layer. Both levels can be excluded from plotting in the final output.

Another use of the color code is performed with the OSKA-code 0292 (arrow), which also occurs on different layers, but has to be plotted. Here, the color number zero was always assigned.

As mnemonics, certain colors were assigned to lines with symbols. For fences, hedges, walls, cadastral division borders, etc., the OBAK-LiegKat NRW differentiates between symbol to the right-hand side, to the left-hand side, on both side or no symbol (note: the direction indicates the ownership, where applicable). The direction left/right is defined by the orientation of the linear feature seen from the first point being the most western one and the azimuth for the second, i.e. for ALK data structure the last point, being within 200 grades. As this rule is rather involved for data capturing, as the exact azimuth would have to be measured before digitizing a line, the final check should be left to the data transfer software. For the data capturing, color coding disregarding the digitizing direction is more obvious specially for lines, where the symbolization has to be shown separately (e.g. cadastral divisions and sub-divisions).

For	**r**ight-hand side	**r**ot	red	(color code 3, 13, 23, etc.)
	left-hand side	**l**ila	purple	(color code 9, 19, 29, etc.)
	on both sides, '**w**echselnd'	**w**eiss	white	(color code 0, 10, 20, etc.)
for symbol as separate line			cyan	(color code 5, 15, 25, etc.)

note: this lines are for plotting only and the color codes are chosen from German color names.

The color table is arranged accordingly.

Creating objects

Forming 'Objekte' - „objects" is another necessity in order to fulfill the definitions of the ALK. For objects consisting of more than one geometric element, the function 'grouping' (also called orphan cell) as well as graphic groups are used, e.g. the geometric elements of buildings are combined to a group for data transfer. In this way, all required elements are easily found. The creation of groups should be supported by an ucm or mdl rather than only using the MicroStation standard functions in order to avoid forgetting the inclusion of geometric elements. Using the *object coordinate* as start point for the search algorithm, the program can perform an automatic or semi-automatic forming of a closed area around the centroid. The operator will attach the alpha-numerical information - *object names* - to these objects in several sub-information, using the MicroStation command 'tag'.

The graphic group function offers the advantage of being a toggle function (on/of), so that, single elements of a graphic group still can be manipulated. A disadvantage is the restricted number of graphic groups and difficulties with the numbering under certain conditions.

Object coordinate

In general the justifications of symbols and text can be used as described in the OBAK-LiegKat NRW. For symbols, this point of placement is by definition the object coordinate. In most cases, it is identical with the geometric center of the symbol (e.g. center point of circular symbols, etc.); for MicroStation, this results in the justification 'center center'.

When text feature are placed parallel to the ordinate (y-axis) of the coordinate system, only one point of origin is needed, as the direction is already defined implicitly. This point is usually the center point of the base line, which can be described in MicroStation as justification 'center bottom'. For text written in more the one line (e.g. parcel number as fraction), the MicroStation feature 'text node' with justification 'center center' is applied.

Some text features require two points of placement for alignment with the topography (e.g. street names along the road). The justification is set to 'bottom left' and the second point has to be calculated from the rotation angle and the length of the text during data transfer.

For the justification of text and symbols, the following positions are going to be used:

text, if parallel to the grid	center bottom	(cb)

text, if aligned with topography left bottom (lb)
(second point for data transfer to be calculated by length and rotation angle of the text)
symbol, if parallel to grid center center (cc)
symbol, if aligned with topography center center (cc)
(azimuth to be calculated form rotation angle)

For a number of features, there is the possibility of using OSKA 0292 - an arrow -, if the space is not sufficient for placing the feature in the required position, e.g. a parcel number inside a parcel, the head of the arrow serves then as object coordinate, while the ending has to coincide with the text origin of the text, (here: parcel number). For the head of the arrow, the MicroStation command 'line terminator' is going to be used, which requires a cell to be placed at the end of a line.
As the usual work-flow implies the other possible sequence of points (from the text to the area), an ucm was programmed, in order to exchange the sequence of points in the linear part of the arrow by calling the new MicroStation feature 'change direction of a line' already during placement.

Object names
Alpha-numerical information, mostly object names, annotations, etc., requested as 'Objektname' - „object name" are stored using the MicroStation feature 'tag'.
'Tag' is a simple, non-hierarchical database with user-defined tables, called 'tag sets'. The single entries represent the data to be attached to geometric elements. These entries can either have default or individual values. Another possibility is the 'displayable tag', where the value can be placed as text in the MicroStation design file.

Examples for tags are:

object name of a parcel, here the information on cadastral division and sub-division is stored
annotation of man holes, here the usage (e.g. electricity, sewerage, telephone) is shown as a displayable tag.

Area coverage
Two layers of the ALK have to be captured with full area coverage (parcels and actual land use). The completeness of the procedure can be checked by area calculation. The sum of the single areas has to be equal to the total area size. MicroStation offers possibilities of creating shapes (closed areas) around centroids (e.g. text, cell, etc.) and area calculation of these shapes. Before an automatic creation of shapes can be performed, the geometry (over- and undershoots, etc.) has to be checked. This is also required as a quality check *[ZV-Aut 1994, p.7]*. Standard software for this is available (e.g. MGE, MircoGIS).
Also for other area objects such as buildings, roads and embankments, a centroid is going to be placed (e.g. parcel number, OSKA-code, embankment symbol, etc.). The shapes to be created for this features can consist of elements from several levels. A list of relevant levels has to be assigned to specific features.

Checking the complete area coverage can be done in two ways:
either by using a data base for the storage of parcel sizes and calculation of sums
or by annotating every complex shape with its size, extracting these in an ASCII-file (mdl TEXTX) and using this as entry to EXCEL (chart calculation program).

In both cases, the result has to be compared with the size of the complete area captured.
The method last described should be supported by a mdl, combining the single steps.
The error detection (e.g. missing areas, etc.) can be supported by using the area fill (display function) for shapes.

Symbols
Within the ZV-Aut NRW the layout of every feature to be captured is given. By listing line width, text size and style, symbol size and default offset (where applicable) for every item, combined with an example, a complete definition is given for the cartographic layout.
A large number of ALK objects are shown as point symbol, e.g. parcel boundary marker, man hole, symbols for actual land use, etc..
There are two possibilities within MicroStation to create point symbols: cells or symbol fonts. Although cell are the default way, symbol fonts offer a number of advantages in terms of less storage requirements, easier updating a data set after applying changes and protection against unwanted changes, therefore this possibility was chosen.

Line styles
Within the ZV-Aut NRW, also a large variety of linear symbolization is defined. From cadastral boundaries and ferry routes as dashed lines in different variations of line styles and gaps, to hedges, fences and metro lines as combinations of lines and symbols. There are about forty different line styles. Employing the new MicroStation command 'custom line style', a line style library was established, trying to fulfill the requirements of the ZV-Aut NRW.
Special attention was paid to the feature 'hedge', where the specification defines the opening of the circular symbol to be always heading south, disregarding the orientation of the base line. This could not be achieved with a satisfactory result.

non-redundancy of the data set
The most complex problem to be tackled is the non-redundancy. Out of several possibilities (color-coding, attaching a database, using tags, storing the OSKA-code as z-value, redundant capturing) the last possibility was chosen. As the data input is inhomogenous, the multi-theme lines are not easy to recognize during data capturing procedures already. For the work flow, this solution has only minor drawback.

For data transfer, redundant data can be delivered via EDBS using the parameter FEIN. The target system has to take care, if an element is new or already stored in the database. If the object already exists, only the new OSKA-code has to be assigned [Steinbach 1995].

6. Practical test

A practical test was performed in order to verify the possibilities of the data structure and user-interface designed.
For the sake of realistic conditions, a test side in Germany was chosen. Due to personal contacts, a cooperation with the cadastral office of Wuppertal could be arranged. Aerial photographs and cadastral maps were supplied. The test was

performed using the technical equipn
German Air Survey, Münster.
As first step, the digitizing of tl
performed using an ARISTO A0 form
attached to a PC. The data captu
superimposed during stereo rest
Planicomp P33, PC-based, equipped with MicroStation
and P-CAP, but the superimposition facility VIDEOMAP was not available. Therefore it was difficult, to recognize multi-theme lines based on the cadastral information during stereo restitution. The remaining information needed for the final date set was gathered during field completion and editing. After final editing and quality check, the data set was ready for hand over to the data transfer procedures, still to be developed.
For more details see [Steinbach 1995].

7. Conclusion

The experiment showed that all information for the German ALK data model can be accommodated in MicroStation 5.0, although the graphics software is neither object-oriented nor designed for a data set free of redundancy.

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