DEVELOPMENT OF DIGITAL CADASTRAL AND TOPOGRAPHIC MAPS - REQUIREMENTS, GOALS AND BASIC CONCEPT -

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ABSTRACT

In North Rhine-Westfalia basic social facilities gain a special importance because of the impact of the densely populated and industrialized state on our environment. For their installment surveying and mapping offers current, detailed and exact maps in different scales. The possibilities of map production by analoguous means are exhausted. Further developments can only be expected by the use of digital production methods. The technical prerequisites for the installation of these methods are guaranteed. In the future the map user expects a more flexible availability of topographic-cartographic informations. To the conventional map series further editions should be added with other user-friendly graphic symbols and contents. But additionally the surveying and mapping agencies have to be prepared for the rapidly growing demand for digital informations of the earth's surface. Therefore, we have to strive for the realization of a Land Information System (LIS), which can support the acquisition, storage and provision of cadastral, topographic and user-oriented data. In the nation-wide project, the preparations for a digital cadastral map, the so called ALK, are nearly completed. For topographic maps in scales 1 : 5 000 and 1 : 25 000 first experiences were gained in data acquisition and data output. Suited storage models are being tested.

SURVEYING AND MAPPING IN NORTH RHINE-WESTFALIA

Prerequisites

North Rhine-Westfalia is the most densely populated state of the Federal Republic of Germany. During the industrialization periods many people were employed in the Rhine and Ruhr district; meanwhile large conurbations were developed in these districts. According to the growing population the demand for housing areas, areas for transportation, private and public institutions for education, culture etc. increased. Especially in North Rhine-Westfalia the demand for industrial areas is considerable, because of softcoal mining, mineral coal mining, steal production and chemical industry. In order to supply the areas required and to secure certain living conditions as well, the development of basic social facilities were considered very important.

Means of planning were developed and applied successfully in a wide range. Since society became more and more aware of

the close relation between conurbations and natural resources, the provision of these social facilities also gained a new dimension since we do not want to endanger our own future.

Official map series

In these circumstances updated, exact maps in various scales become the important basis of all environment-related measures starting with the inventory and planning up to the realization. The constantly growing demand for maps for administrational or industrial purposes could be met up to now by the different official topographic maps offered by the surveying and mapping administrations.

Official maps of North Rhine-Westfalia

map series	number of sheets	revision cycle	application examples
cadastral map		permanent	- property register - town planning - utility base maps
1 : 5 000	8629	5 years	- "German Basic Map" - town planning - road planning
1 : 25 000	270	5 years	- regional policy - environment protection
1 : 50 000	72	5 years	- trail maps - military maps
1 : 100 000	19	5 years	- regional maps - traffic maps
photo map 1 : 5 000	8629	6 years	- environment protection - archaeology
photo map 1 : 25 000	270	5 years	(program started)

In contrary to the cadastral maps which are continuously updated, the maps in scales 1 : 5 000 to 1 : 100 000 have a revision cycle of 5 years. The photomap, scale 1 : 5 000, is renewed every 6 years, the photomap, scale 1 : 25 000, every 5 years.

Present production and distribution of maps

The development of a map, beginning with a mainly military function in the beginning of last century up to its present status as environment-related basis for the prevision of social facilities, was accompanied with a fundamental change of the production method of maps. Only by means of this

change the growing demand for maps could be satisfied. Thus, the use of transparent foil since the middle of this century enabled an even stronger differentiation of cartographic objects according to their colours, and depending on various foil-combinations different map editions were possible. Even the production of thematic maps on the basis of topographic maps became very simple by adding a thematic foil, variations in scale, colours and sheet lines were possible as well. Still today the use of transparent foil influences the cartographic production method. According to present map production, map editions basically different of the ones we know today, can only be realized by a high expenditure of personnel, time and money.

Future requirements

In spite of the high standard of our official map series, they are more and more criticized:

1) The map symbols should correspond to the knowledge of modern semiology. The basic graphic elements: area, colour and raster should be used more frequently.

2) Different groups of users need different types of maps.

3) The reliability and updating of maps does not meet the demands of the user.

4) The possible combinations of situation and a special theme are limited by the number of foils used.

This means that map users do not only want updated and exact maps but a more flexible presentation of the available topographic-cartographic information. The conventional map editions should be complemented by further editions with user-oriented graphic symbols and themes. Recently new editon possibilities have been introduced in the Federal Republic of Germany. The surveying and mapping agency of North Rhine-Westfalia also took part and introduced two edition possibilities for maps in scale 1 : 25 000. These editions each with a different graphic representation and theme are meant for two different purposes. The first purpose, the map as planning material and scientific research basis, shows a geometric documentation of the earth's surface as complete as possible. In contrast to the conventional edition another graphic means - the area - was used in addition to new and more map colours. The second purpose, the map as a means of orientation, stresses all elements necessary for the orientation outside and does without any information useless for orientation. This can be seen by the different representation of housing areas and the addition of streetnames. In this edition the graphic elements: area, colour and raster are used more often than in the conventional one.

In addition the surveying and mapping administrations have to face an increasing demand for digital information of the earth's surface. New information systems are being developed for different purposes related to the earth's surface. The

surveying and mapping administrations developed the program system "Digital Cadastral Map", a parcel-oriented information system of high accuracy, which is meant to be the basis of user-oriented information for large scale maps. The development of topographic-cartographic data-banks has only just begun. We want to realize a Land Information System (LIS) for the acquisition, storage and processing of topographic data as well as user-oriented data.

DIGITAL MAP CONCEPT

I have already mentioned that the use of transparent foil for cartographic production meant a new step of cartographic evolution and thus enabled surveying and mapping administration to meet higher demands of former times. The next step of cartographic evolution has begun with the development of computerized information systems, which we also want to use for the production of official maps. Only thus we shall be able to meet the increasing demands of the future. Below, I want to describe the development of a Land Information System which we have begun in North Rhine-Westfalia.

Structure of the Land Information System

A Land Information System comprises all information on our environment for a defined region - a township, a county or a state. It is different from other information systems because of a geometrical, a 3-dimensional component of each information. This enables direct access to information of a certain region but also demands special geometrically oriented storage-structures which are difficult to handle by conventional data-management-systems.

All objects stored in a Land Information System need geometrical description based on coordinates. Therefore, special importance has to be given to a homogeneous, highly accurate horizontal and vertical control point net which serves as basis of the Land Information System. The surveying and mapping agency of North Rhine-Westfalia successfully uses methods of satellite geodesy, the Global Positioning System (GPS), in order to achieve this aim.

The horizontal accuracy neccessary for practical purposes also influences the choice of scale usefull for cartographic representation. An information system for 3-dimensional data will, therefore, be devided in scale sections as long as automatic generalization is still impossible. For official mapping the following scale sections are planned: scales 1 : 1, 1 : 5 000, 1 : 50 000, 1 : 250 000 and 1 : 1 million. These so called "Digital Land Models (DLM)" are based on each other and are meant to be the basis for all user-oriented information in the fields of planning, statistics, environment protection etc.

The surveying and mapping agency of North Rhine-Westfalia has to develop the "Digital Cadastral Map" (DCM), and together with the different cadastral administrations, to realize this project and install the Digital Land Models,

scales 1 : 5 000 and 1 : 50 000. The other scales belong to the responsibility of the Institute for Applied Geodesy.

The Digital Land Model is object-oriented, and comprises the original information of the earth's surface, not the already deducted information of the map. The Digital Land Model can be divided in two components: a "Digital Situation Model" (DSM) consisting of all informations about the horizontal position of the objects and a "Digital Terrain Model" (DTM) consisting of all informations of the terrain modulation of a region. The DLM can be used to develop "Digital Cartographic Models (DCM)" which are the digital equivalent to our analogous maps.

DLM, DCM and official map series

Digital Cadastral Map (DCM)	-	Cadastral Maps 1 : 5 000 - 1 : 2 000
DLM 5	DCM 5	German Basic Map 1 : 5 000
DLM 50	DCM 25	Topographic Map 1 : 25 000
	DCM 50	Topographic Map 1 : 50 000
	DCM 100	Topographic Map 1 : 100 000
DLM 250	DCM 200	Topographic Map 1 : 200 000
	DCM 500	General Map 1 : 500 000
DLM 1000	DCM 1000	International Map of the World 1 : 1 000 000

The development of a DCM is necessary since a map cannot be produced automatically from the original DLM because of its complex map symbols. Manual corrections of the DCM at an interactive workstation are necessary in order to guarantee a correct graphic representation. In special cases these corrections might be relatively extensive, therefore, it seems adviceable to store the corrected DCM also to reduce the time expenditure for the next map revision.

In order to handle such a Land Information System all surveying and mapping administrations agreed on certain standards. The first step was the edition of a uniform object-catalogue for all objects represented in official maps. The catalogue for cadastral maps is already completed, for medium and small-scale maps it is being revised.

In the second step to standardization a data-model was developed. According to their shape the objects were classified in point-shaped, line-shaped and area-shaped objects, and additionally for each object the details relevant for representation were given. E.g. for the object 'parcel' the details relevant for representation are parcel boundary and parcel identifier.

In a third step this data model was considered the basis of

a standard-interface necessary for data exchange, the so called "Uniform Data Bank Interface" (UDBI).

Further standards define the graphic representation of map objects and individual names of map objects (e.g. parcel identification, building identification). These elements can be used to link informations of the data file with files which do not contain any geometrical information.

Because of practical reasons for the organization of the DLM maps will be the primary source of information. Only for revision purposes it seems useful to use the countryside itself as main source but it also depends on the scale of the model revised. The DCM (equivalent to maps in scales 1 : 500 - 1 : 2 000) is based solely on original surveying informations, the DLM 5 (equivalent to the map scale 1 : 5 000) is partly based on original surveying informations and partly on aerial photos; the models of smaller scales are based on aerial photos only but are controlled by field checks if necessary.

The special advantage of a Land Information System is the variety of its products. Besides conventional official maps a whole range of different map editions will be available. Maps of each scale, of any map section, of any contents desired, and of any graphic representation demanded can then be offered to the user. Because of the linkage between all geometrical data files and those of other thematic information thematic maps can easily be produced.

Digital production methods

The organization of the Land Information System consists of two seperate parts: the storage of data on the one hand and the processing of data on the other. Not only the producer of this program-system (the surveying and mapping agency of NRW) shall be able to use all data stored but also the other users, (e.g. all cadastral administration i.e. townships in NRW). Therefore, a standardized, central large-capacity computer is used. But we do not plan to store all possible DLM in the storage of this central computer. Especially the models for the cadastral maps, will be stored decentralized in computers of each township concerned since in NRW the cadastral functions are carried out decentralized by the administration of each township county or community.

Similar to the storage of the DLM data processing is also carried out decentralized e.g. in the cadastral administrations of each township or the departments of the surveying and mapping agency in charge of a certain map scale. Because of these complex programs and the integration of the different operations an interactive graphic workstation should be used. The data flow between the central computer and these interactive graphic workstations is guaranteed by the standardized interface mentioned above, the so called "Uniform Data Bank Interface".

In this development stage of the LIS the surveying and mapping agency of NRW uses the special hardware configuration - figure 1 -, without scanner/ rasterplotter.

This configuration is based on the special necessities of the program-system for the Digital Cadastral Map. The central unit is a SIEMENS-computer; the data bank for the Digital Cadastral Map is tested with a multipurpose data bank program-system and will soon be available for general use. In the departments of the surveying and mapping agency of NRW in charge of the production of different map scales vector based graphic computer systems are used for decentralized data processing.

The interactive graphic workstation will be the most important tool of the user. This workstation was developed especially for the requirements of the DCM-project. It is, as already mentioned above, a vector-based system equipped with additional functions, e.g. for data acquisition, data revision and for data application (automated drafting or computing). These functions can easily be modified according to the wishes of each individual user.

This interactive graphic workstation is based on the international graphic standard, the so calles "Graphical Kernel System" GKS, which also implies a special organization of software - figure 2 -.
This software is specially oriented according to cartographic requirements consisting of different sections for a graphic data bank, which enable the use of digitizers, menu-functions and complicated graphic representations. Thus, this workstation can be applied for many fields:

- cadastre
- soil evaluation
- mapping of land use
- regional planning
- development planning
- mapping of cables and pipelines

This program-system proves the capacity of the GKS also for complicated graphic applications and shows in every day programming and application the advantages of such a graphic system.

It is based on the highest level of the GKS, therefore, its portability is limited to computers, where GKS of the highest level can be implemented. The programs are written in FORTRAN 77. According to principles of software engineering a special programming structure was developed to enable the programming of the components of the basic system and the application components.

This vector-based graphic interactive workstation for the digital cadastral map meets all our requirements. But using this workstation for smaller scales soon shows its bounds. We estimated that data acquisition for a DLM 50 (equivalent to the maps scales 1 : 25 000 to 1 : 100 000) of North Rhine-Westfalia with conventional digitizing methods based on the maps, scale 1 : 25 000 and the momentary staff-capacity would take about 10 - 15 years. A second problem arises

by the automated drafting of one sheet of the map, scale 1 : 25 000. According to our experiences this takes about 50 hrs (without contour lines) on a CONTRAVES-plotter with light-head.

A solution of these problems could be the use of scanners for automated digitizing and of raster-based plotters for automated drafting. But we are not yet sure about how much acquisition expenditure scanners would actually save. The development of special software designed for the recognition of patterns and structures has only just begun. These programs still leave many details to manual correction and addition especially considering the relatively complex symbols of topographic maps.

The use of a raster-based plotter shows immediate efficiency, instead. The problem of converting raster-data to vector-data is already solved, thus, the raster-based plotter could directly replace our vector-based one. An additional advantage of the raster-based plotter is, that it easily drafts areas of solid colour and screened areas.

Because of the advantages of raster-based graphic data processing the surveying and mapping agency of NRW considers to supplement the configuration with an efficient raster-based high precision plotter. We expect great advantages for the reproduction of maps, especially for colour seperates and map printing. By means of this new high-precision plotter we hope to introduce data processing techniques in the production process of topographic maps and orthophoto maps. We also expect that the raster-based techniques expedite the conversion process of the analoguous cadastral map to the digital cadastral map and in general also the development of a LIS in NRW.

FIRST EXPERIENCES

Since 15 years the surveying and mapping agency of NRW is using methods of graphic data processing. Not all developments which we started were successfully, and we also thought to manage the problem of automated generalization, meanwhile, we are sober to think that we are farer away of the solution of this problem than ever. We turned to closer problems: the processing and computing of mass-data of a LIS, the acquisition of topographic and other environment related data for cartographic data-banks, and their output in an either digital or analoguous way. Therefore, we finally developed an interactive graphic workstation as modern tool for all applications concerning a Land Information System by applying many experiences we gathered with other previous systems. We used it e.g. to assist the revision of 100 maps, scale 1 : 25 000 by digitizing, controlling and correcting interactively 1,1 Million points in 4000 hrs. The workstation was used successfully for the production of thematic maps, for digitizing of cadastral maps and for the development of a digital terrain model. Today we can offer a mature, multi-functional interactive graphic workstation, which is compatible to all computers designed for high-standard graphic data-processing because of the GKS and its pure modular structure.

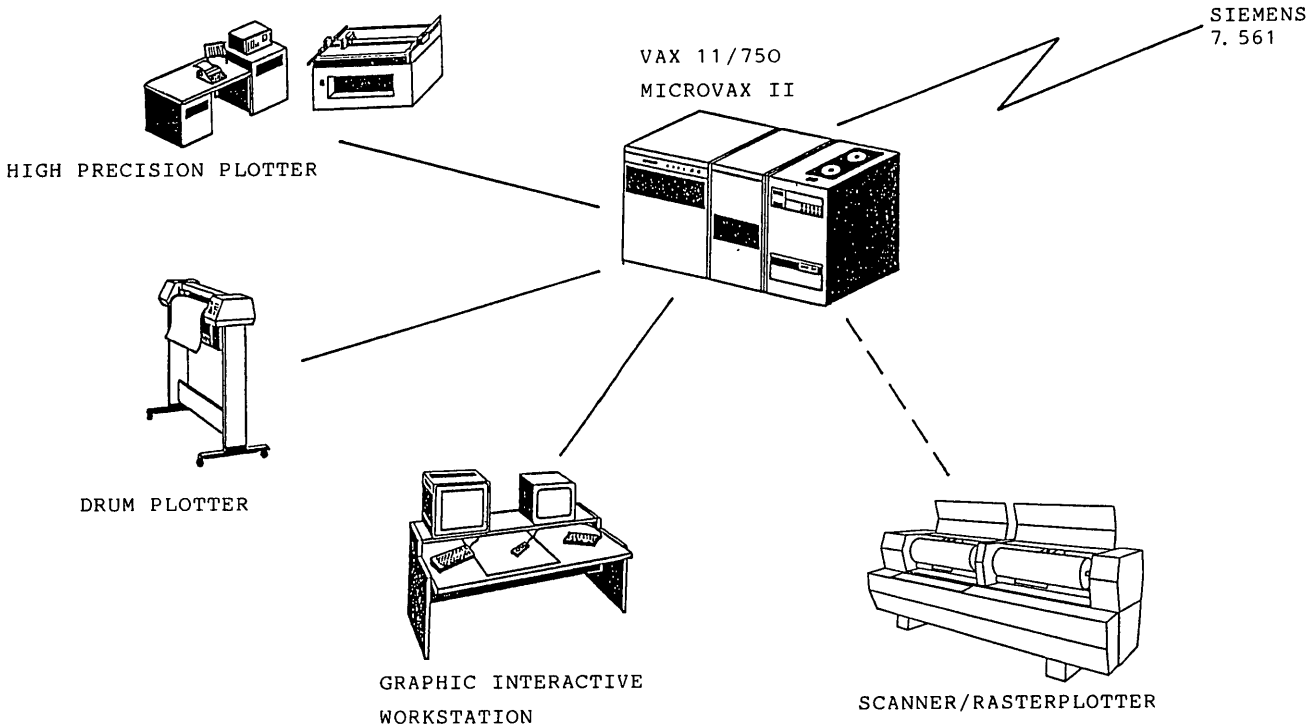

Figure 1: Hardware Configuration

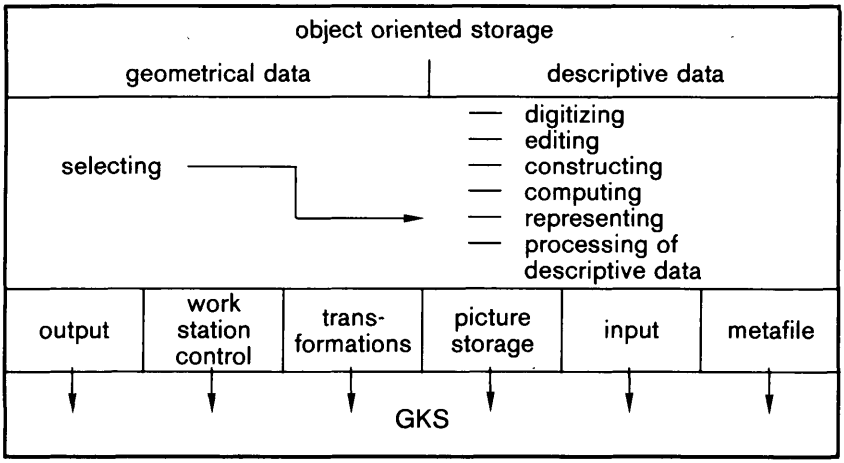

Figure 2: concept of the interactive graphic workstation for the digital cadastral map