Photogrammetrische Woche 1987
Institut für Photogrammetrie
Schriftenreihe, Heft 12, 1987

EXPERIENCES WITH DIGITAL MAPPING AT SCANKORT IN DENMARK

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1. INTRODUCTION

Denmark is one of the countries in which digital mapping was introduced at an early stage. The private mapping sector changed its map production method from the analog form to the digital form as early as 1981.

This was primarily a result of the natural gas companies requiring digital maps to use as the basis for their planning and administration of a new nationwide natural gas distribution network. At the same time many municipalities and utility authorities started using digital maps as the basis for their planning, design and administration.

There has been a tremendous development within the last 4 to 5 years, and a large number of interactive graphical systems have been implemented in both the public and private sectors.

We should like in this paper to give a short description of the technical development which our firm - and also the whole private and public mapping sector in Denmark has undergone in recent years, as well as giving an account of the technical and organizational changes that have resulted from this.

2. MAPPING IN DENMARK - IN GENERAL

There are two large public map producers under state auspices in Denmark the Geodetic Institute, (Geodætisk Institut or GI) and the Danish National Cadastre, (Matrikeldirektoratet or MD).

2.1 The Geodetic Institute is concerned with:

- primary geodetic stations across the country (c. 3o,ooo)
- general topographical maps at scales of 1:25,ooo, 1:5o,ooo, 1:1oo,ooo, etc.
- ortho-photo map production of parts of Greenland

Most of the topographical maps are photogrammetrically produced and undergo periodic revision. Most of the height information originates from plane table surveying carried out during the 19th century.

In 1986 the GI started the establishment of a newly surveyed nationwide height data base and a topographical data base of the Faeroe Islands.

2.2 The Danish National Cadastre is concerned with:

- the lower order fixed point network (c. 3oo,ooo)
- maintenance of a nationwide cadastral map at a scale of 1:4,ooo, with associated cadastral register and basic survey information.

The MD's register and maps (in analog form), originate from the 19th century, and is maintained in co-operation with approximately 15o private chartered surveyor firms.
The MD has carried out a number of pilot studies concerned with the conversion of the existing cadastral map into digital form as well as with ortho-photo map production at a scale of 1:4,ooo.

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In the period 1986-1998 the MD has planned to spend more than US $ loo million on the preparation of new co-ordination of the fixed point network, a digital cadastral map, and ortho-photo maps at scale of 1:4,ooo covering the whole country.

2.3 Private photogrammetric firms undertake all large mapping projects for municipalities and public companies at a scale of 1:5oo, 1:1,ooo and 1:4,ooo.

These firms also undertake projects for the GI and the MD, including aerial photography, fixed point co-ordination and ortho-photo map production.

8o-9o% of the country's urban areas have been mapped photogrammetrically at a scale of 1:1,ooo with o,5 m contour lines during the period 196o-198o. These analog maps were only partially revised, and consequently their value gradually declined.

From 1981-1987 the private sector has carried out new mapping in digital form of approximately 5o% of all urban areas and a large number of locations in rural areas. This digital mapping deals mainly with the topographical planimetry.

3. DIGITAL LARGE SCALE MAPPING AT SCANKORT

3.1 Background:

In 1981 five newly-established Danish natural gas companies were facing the task of supplying most of the country with natural gas. This natural gas had to be piped from town to town, in order to supply each individual house. The gas companies were to complete this task within 5-lo years.

In order to get hold of the maps they needed, as a basis for their planning, the gas companies examined existing maps at scales of 1:1,ooo and 1:5oo.
These maps as we have already mentioned, were out of date. If the gas companies wished to use them, then the task of having them revised was going to be both large and expensive.

At this time the Interactive Graphical System (IGS) was coming onto the market, and everyone felt that this was going to be the tool of the future, for the mapping sector as well as elsewhere.

Since all the regional gas companies were newly established, and had not already incorporated analog surveying and registration methods, it was decided that the gas companies needed:

- to establish a fixed point system for surveying and setting out in the field.

- to establish new photogrammetrically prepared base maps containing a limited amount of topographical information with no height information, but including street names and house numbers (fig. 1). These maps should be produced in a digital form and the data base, was to be kept by the producing firms until the gas companies obtained their own IGS system.

- a supply of maps at the scales of 1:1,ooo, 1:2,5oo and 1:4,ooo as well as street plans at a scale of 1:5oo, all automatically drawn from the data base.

- to measure the pipes while in open trenches with their subsequent registration including location and component information data.

- purchase of their own IGS system within 1-2 years.

FIG. 1

Private photogrammetric firms were given 6 months to commence the establishment of a complete digital mapping procedure.

The private sector had no experience of digital mapping and hardly any equipment developed for this form of production. There were no specifications on how to deliver the digital data. Furthermore, a demand was that the price should not exceed that of analog mapping.

3.2 In the beginning:

By 1981 Scankort had already established itself as a photogrammetric company, with its own aircraft (PN-68), aerial survey camera (Zeiss), fully-equipped photographic laboratory, Planicomp (C-100), DZ-7 drawing table, HP-1000 computer and several graphical data terminals.
Although this equipment had been purchased for other purposes, it turned out that we were able to adapt it for digital mapping. This entailed a considerable amount of work, because we were forced to develop the following ourselves:

- coding conventions for the topographical elements

- a program for the registration and simultaneous control of topographical detail

- a program for editing the data base

- a program for the digital connection of the topographical elements between the models and between the flight lines.

- provisional data exchange program for the first clients

All programs and working procedures were prepared within 6-12 months. These programs were first generation programs that had only been developed for our own use, many of the working processes were cumbersome and difficult.
For example, in digitizing alphanumeric information one of the Planicomp's plate carriers was used as a "digitizing table".

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3.3 The next step:

Customer demands for greater amounts of information in the data base grew - and our own demands as to speed and volume of production were also increasing. At the same time we felt that more advanced programs would have to be introduced, to enable us to handle the growing size and complexity of the data base.

Due to this, in late 1983, the firm purchased another Planicomp (C13o) and a Danish Interactive Graphical System (DanGraf) with 2 workstations for editing, insertion of alphanumeric information, utilities registration and extraction of information from the data base in different exchange formats. During this period we installed 2 more plotters (TA 1o & HP 7585 B) and purchased 3 AGA total stations for our surveyors.

In 1984/85 we introduced a further Planicomp (C13o) with Videomap and a Danish developed drawing program which was installed into our Prime computer.

This development and re-adjustment process called for considerable efforts on the parts of the employees (4o) including engineers, technicians and surveyors who already had experience with computers and mapping.

Recent years have taught us that digital mapping is considerably more complicated than analog mapping, and it has been necessary to introduce a tight technical procedure in the organisation, with quality control at every stage of production.

4. DEVELOPMENTS AMONG MAP USERS

The most important map users are the Danish municipalities, other public authorities, utility authorities, engineers, surveyors and other advisors.

Technical maps and plans are used among other things for:

- planning
- design work
- landscaping
- maintenance
- administration

The increasing use of maps for all these purposes has made users aware of a number of important factors in mapping, for example:

- the quality and permanence of the reference points
- the development of norms and standards for mapping
- co-operation between different public authorities in order to establish a base map that meets common requirements, and thus reducing the cost in connection to its establishment, revision and maintenance.
- the establishment of an organisation that is able to manage the database and to develope procedures and strategies for the maintenance of this.
- the splitting up of costs amongst the maps users.

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All this has in recent years led to the formation of a series of practical co-operation efforts under municipal auspices, and in some parts of the country, on a larger scale between a number of municipalities and utility authorities. The same organizational models are not always used, but the aim of these joint efforts has always been to produce a common map and to find joint answers to the above.

As a result of the development in high technology, it has in recent years become natural for all mapping to be carried out using digital methods. This does not necessarily mean that all users today use maps digitally, but the majority of all mapping takes place digitally, so that users may at a later date switch to a digital use of maps in their own organisations.

Despite the positive development in terms of the establishment of co-operative map efforts, which in the slightly longer term will lead to more systematic conditions in mapping, including the establishment of norms and standards and a better utilization of financial resources, we must be prepared for the fact that the total process of adjustment to this new enviroment will take a long time.

In practice we can expect the development beginning with the municipalities acquiring a workstation that will be connected to a regional service centre established by or in co-operation with other municipalities. The next phase will be the purchase of their own computer and development of the necessary data-processing organisation.

We have also seen an example in which a mapping authority chose to order a mapping system, delivered as a total package including data processing equipment, programs, data base and training, i.e. a turn key system.

5. DEVELOPMENTS AMONG PUBLIC MAP PRODUCERS

The Council for Denmark's Geographical Reference Grid has been established in recognition of the enormous importance the basic reference grid has for mapping and surveying in the field. This council functions as a co-operative organisation for all map users and producers working with the reference grid.

The council has set up two working groups. One is working on a classification of fixed points and the accuracy of their measurements. The other is working on the establishment of a computer-based information system which in time will include all fixed points. This system is to be easily accessible by all map users and producers in the country.

At the Geodetic Institute, preparations are under way for the use of digital techniques for topographical mapping at scales of 1:1o,ooo and larger.

In the field of topographical mapping, maps of the Faeroe Islands have been made using digital methods. Furthermore, the build-up of a digital height data base using photogrammetric measurements (obtained by a Planicomp) has commenced at the GI.

In recent years attempts have been made to set up co-operation between the municipalities and the GI concerning the utilization of municipal large scale maps as basic data for topographical small scale mapping. This co-operation, if it bears fruit, would mean a reduction in the overall cost of mapping in Denmark.

The Danish National Cadastre has decided, on the basis of pilot studies carried out on Bornholm in 1983/84, to commence an even larger project which will cover 1o% of Denmark - to be more specific, the island of Funen.

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This project comprises 3 constituent activities:

- an improvement of the fixed point network

- the establishment of ortho-photos at a scale of 1:4,ooo

- the production of digital cadastral maps.

Since the cadastral register is a vital key to a great amount of information that is relevant for planning purposes, it is essential that the cadastral maps and register is produced in digital form, so that it can be intergrated with the information systems of the future.

The present cadastral map is approximately 2oo years old and comprises 18,ooo sheets at a scale of 1:4,ooo or larger. The majority of these maps are so-called "island" maps (maps on independant local grids), which bear no relation to the common reference system.

It will require a lengthy task of conversion to transfer these non-system-related maps into system-related framework maps, on which information is in digital form.

Conversion is based on survey information from over 1 million ordnance maps. In areas where these measurements are insufficient or inconsistent ortho-photo maps are used as a basis for conversion.

The Danish National Cadastre has recently agreed on a contract concerning the purchase of an IGS system (Intergraph). In the future it will presumable also be possible for local chartered surveyors to do a good deal of their work by altering the cadastral register via the telephone network, just as other users of cadastral information will be able to extract data from their own computer terminals.

6. EXCHANGE FORMAT

A data exchange format is a necessary basis for transfer, use and maintenance of data bases, utility registers and more extensive land information systems.

The exchange format should include a description of data structure, code tables and possibly graphical symbol standards (but not necessarily a symbology of ones own choice). Furthermore it is important to be able to include more than geographical information. All kinds of descriptive data should be included, and for utility authorities it is important that the following:

- location data

- component data

- network information

and the relationships between these types of data may all be defined unequivocally and transferred into digital form by using the exchange format.

The Danish Society for Photogrammetry and Remote Sensing (DSFL) took the initiative in building up an exchange format as early as 1982, and in the spring of 1983 the first standard for the exchange of digital maps was produced. The DSFL continues to maintain and expand this standard. Acceptable international standards in this area are still lacking, but there are a number of national standards which are more or less widespread.

We believe that one of the reasons for the rapid introduction of digital maps in Denmark is that this exchange format was defined at an early

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stage, becoming thereby a "de facto" standard which purchasers of digital maps include in their conditions of delivery when entering into a contract.

The DSFL exchange format includes at the moment:

- topographical/technical detail and associated descriptive data
- cadastral information
- utility information (being completed)

7. WHAT REMAINS TO BE TACKLED ?

Until now digital mapping in Denmark has been concentrated on topography. As a result of this, and apart from the collection of height information at the GI, contours have only been taken into account to a very limited extent.

This means that contours, whenever needed in connection with design and landscaping, must be obtained in a traditional way by newly drawn analog maps.

The amount of information that is produced when working with contours digitally is high even for todays computers. Technically there is no difficulty in handling contours, since there are many systems to deal with Digital Terrain Models. Highest priority has been given to topographical data as height information covering whole areas has up to now not been needed for daily use.

There is one particular problem connected with contours. Houses and certain other features are to be kept free of contour lines, which means that routines for the automatic removal of these lines has to be worked out, and should preferably take place at the moment of drawing.

Another major question in connection with digital maps is revision. We have to admit that the process of revision is both technically and administratively more complicated than we had expected, one of the reasons being the relationship between geographical and alphanumerical data in the users data base.

Different strategies for map revision must be considered:

- Should totally new mapping be carried out every 2, 3 or 5 years, with a replacement of the whole data base or is it possible at an appropiate point in the administrative process to collect alterations in an acceptable standard and suitable for revision ?
- Can the photogrammetric branch supply competitive solutions for revision to the customer's data base ?
- Can we develop suitable routines to carry out this revision without losing either information or connections to other data in the data base ?

We must also face the fact that in the future there will be more copies of the data base for example, within municipalities and utility authorities. Great discipline will be needed to ensure that all updates are carried out in all versions simultaneously. We are still waiting for the day when all map users will be linked to the same computer so we only need one version of the map.

Practical and economical answers to all these questions are needed. We are in the process of answering these questions - especially the important one of map revision.

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8. THE EXPERIENCES OF 6 YEARS OF DIGITAL MAPPING

This section comprises a brief list of the experiences of map producers and users respectively in connection with large-scale digital mapping.

8.1 Experiences of the producer:

A mapping task has to be planned all the way through the process of production so that the coding system, data transformations and drawing standard all have to be determined prior to the commencement of the project. A set of mapping standards, including a definition of the extent of topographical detail and symbols is extremely important.

Great demands must be made on the analytical stereo instruments as far as routines for the collection of data and the preliminary editing and updating of data bases (e.g. Videomap) are concerned.

The analytical instruments have to be directly linked to, or have high priority access to transfer digital data to the Interactive Graphical System, where the final editing and additions of supplementery data can be carried out.

Demands on the cartographic quality of the final map will decrease as a result of the fact that the most important product in connection with this type of mapping is digital data. This means that demands to the producers precision drawing tables will in the long run decrease. A great number of plans will be produced on inexpensive paper by drumplotters instead of being scribed by precision plotters.

Advanced exchange formats including topographical data, descriptive and structured data are of crucial importance for developments in this area. The exchange format must be generally accepted in the branch and it must be constantly maintained and expanded by competent bodies.

In connection with the delivery of a project to a customer in digital form, the producer must store a copy of the data which has been exchanged. This is necessary on account of the following:

- the producers and the customers data bases are structured differently and will develop differently after delivery
- the exchange format code tables are the most unequivocal documentation of the information supplied, so this data contains a minimum of interpretation problems
- the control of data, the customer may inadvertently carry out alterations which could have judicial consequences for the producer during the period of guarantee. It is therefore necessary to be able to document precisely the nature of the data that has been supplied.

Demands on organisation are made as far as the following factors are concerned:

- production planning
- quality control of data following the phases of aerotriangulation, digitizing, editing, drawing and digital exchange
- updating of knowledge concerning technological developments in this area.

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Is is an advantage to obtain ready-made IGS-systems with a strong organisation to back up and maintain this system. At the same time it must be a "sine qua non" that access to the complete contents of the data base is available, and that the necessary tools are available to develop supplementary programs and routines for the manipulation of the data according to the customer's particular requirements. This is a crucial factor in terms of competitiveness.

8.2 Experiences of the users:

A number of the experiences of the users are identical with those of the producers as far as the build-up of a computer system, computer organisation and training of staff are concerned. But there are also a number of additional points that should be mentioned:

Map users in a particular area must of necessity co-operate so that they use the same map information. This is a pre-requisite for the collation of map information and other utility register information. Financial considerations also make this co-operation necessary.

Maps are mainly used as a basis for other thematic information. Much of this information has to be gathered from other public data bases. This applies to cadastral, land register, building, housing and property information. It is necessary to store keys to these registers in the shape of title numbers and addresses (street names, house numbers etc.) in connection with the digital map. Making it possible to derive a large amount of data from these data bases which is needed for planning purposes and combining it with map and utility data. This is the prelude to the land information systems (LIS) of the future.

When building-up the map data base it is important that large areas should quickly be covered both geographically and thematically. Changing the administration from the old manual system to the new digital one will only be of benefit when an area and a theme has been completely established.

9. THE FUTURE

The information society of the future is on its way. People are recognising the fact that geographical related information plays a crucial role in the planning and administration of our society.

This is why we need to establish land information systems. In the beginning these systems will be spread out among different organisations and data may be exchanged via exchange formats.

Later on the information will perhaps be concentrated in one computer, this will mean only one version of the data base will be needed. Until that time the actual location of data is not particularly important, as access is via a data terminal and a cable of unknown length.

The user who has the primary interest in any given piece of information also has the responsibility for the maintenance of this data, recording its current status, accuracy and origin. These parameters are necessary for all other users in order to assess the value of the information, so that its proper use can be assured.

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