CONCEPT AND PREPARATION OF A SPATIAL INFORMATION SYSTEM FOR DENMARK.

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Introduction.

In a move by the Danish Goverment to increase efficiency and cut spending, the Geodætisk Institut (Geodetic Institute), Matrikeldirektoratet (the Directorate of Land Registry) and Søkortarkivet (the Nautical Chart Division) were merged into one new institution at the beginning of 1989. This new institution was named Kort- og Matrikelstyrelsen (The National Survey and Cadastral, Denmark) or KMS. The authors of this paper are members of the Topographic Division of the former Geodetic Institute, where they have been working for the last 10 to 15 years introducing digital methods into the production of small-scale topographic map.

The problem of transforming an old and well-known manual procedure (the production of topographic maps on a scale of 1:25.000), into a digital one, is very complicated, and the authors are not claiming to have found the solution yet! There are many problems still to be solved. But it is also the opinion of the authors that the development of digital methods has advanced enough to allow local take-over and further adjustment. The grounds for this statement are as follows:
The price of hardware is decreasing and at the same time the capacity of the hardware, both in terms of calculation capacity and data storage, is still increasing. That is, the cost/benefit ratio of computer hardware is rapidly improving. In the software field the commercial systems, such as data acquisition systems and data base systems, are available at reasonable prices. Furthermore digital methods have been in use for more than 10 years at the KMS, so gradually a new generation of operators has been trained in the use of such methods.

In 1978 a digital ortho-photo project over Northern Greenland began. The intention was to produce approx. 100 ortho-photo maps on a scale of 1:100.000 based on aero-triangulation, digital controlled ortho-photos and computer calculated contour-lines within five years. While this five year period will be exceeded by at least 300%, the production rate has recently been restricted more for political reasons than as a result of technical difficulties. At the moment 25 maps have been published and the present production rate is approx. 10 - 12 map-sheets per year.

In 1982 a digital mapping project on the Faroe Islands was started. This time the aim was to produce a topographic map on a scale of 1:20.000. It was decided to produce the map-series on a Zeiss Planicomp C100 equipped with a DZ7 drawing table. All recordings were to be feature-coded. The contour-lines were to be plotted directly and not calculated, as a result of problems and delays in the development of programs in the Northern Greenland Project. At present about 40 % of the Faroe Island maps has been plotted, and progress on the project is satisfactory. The data are collected and stored through an in-house developed data base system, and the only major problem left is the editing of the data. So far only a prototype of the editing system has been developed.

In the mid sixties the Denmark's production of topographic maps at 1:25.000 shifted from table measurement to photogrammetric production. Now manuscripts on a scale of 1:10.000 are plotted on analog instruments and these manuscripts are brought into the field for completion. The plotting is slightly generalized to meet the demands of the map standard. At the moment more than 90 % of Denmark is covered by photogrammetric manuscripts, and the plotting is sceduled to be completed about 1991.

In 1981 natural gas was introduced in Denmark as an energy source. Construction, distribution and administration of this new energy source was assigned to newly-founded companies which had a comprehensive need to map all new facilities. These companies were not depending on existing old, analog archives. The competition among the private photogrammetric companies was tough, and within one year all the companies had shifted from analog to digital plotting. At present about 70 - 80 % of all urban areas are covered by digital maps based upon many different standards. A national standard has been developed for the exchange of digital data, and the five private companies cooperate with each other in many constellations. Problems in connection with revising digital maps are now surfacing.

In the meantime, the community demands on the national topographic map-series have changed, and one year ago the Topographic Division formed a task force to set up standards and production schedules for a remeasurement of Denmark. The new measurement will utilize digital methods and finally comprise a "Topographic Data Base" with a content and an accuracy according to a map scale of 1:10.000. This data base will form the basis for the production of analog maps at 1:25.000 as well as comprise an independent digital product.

An Information System for Denmark.

Experience over the last 10 years has shown us, that the number of people working on digital mapping at the KMS is not sufficient to develop, maintain and run a topographic data base. It is the authors' experience that development and maintainance of a system by the user has the advantage of allowing for greater possibilities of change or modification. By knowing what is actually going on inside the system one has the possibility of direct access to the problem if anything goes wrong. On the other hand, such full responsibility for the system leaves the user in a vulnerable position, as one is dependent on a small number of people who know the system well enough to correct errors which might (and certainly will!) occur. In the KMS's Topographic Division the computer system is of Danish manufacture. This fact has forced us to develop all software systems ourselves. At the moment, from 300 to 400 man-years worth of software is running on this computer. In 1988 the computer manufacturer announced a new "fault-tolerant" computer, especially designed for on-line data base manipulations. This computer is based on international standards working under UNIX and utilizing the programming language C as its primary programming language. This has opened up the possibility of both maintaining our software, while simultaneously developing and introducing new systems.

It has been decided to base further development of the topographic data base on this computer and, if possible, to use a commercial data

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base system. After a market research, the Informix relational data base system was chosen to hold the alphanumeric topographic information. The graphic interface modules will be developed in-house. A large host computer carries the main data base. This computer will be connected to other computers via a data-network, and all data-manipulation will take place on "minor" computers, handling extracts of the main data base.

After visiting exhibitions, reading papers and visiting factories, it seemed quite clear to us, that photogrammetric data aquisition systems meeting our demands are available on the market. In connection with this it also appeared that a graphic manipulation system might be available. Further, these systems could be connected via an ethernet, leaving only the decisions in connection with local configuration of the data base, training of operators and of course building the data base itself.

Contents of a Spatial Information System.

Since the data base shall serve the purpose of both being an independent digital product as well as forming the basis of the analog mapseries at 1:25.000 the required geometric accuracy of the points and lines in the base will be easy to determine. As almost all urban areas are already covered by large scale digital maps, there will be no need for a very great accuracy, therefore an overall accuracy of greater than one meter seems to be sufficient for the x and y coordinates. As photogrammetry is used to collect the coordinates, the accuracy of the z coordinate is introduced during collection. During the last eight years, i.e. the period during which the large-scale digital mapping of urban areas in Denmark has taken place, specifications for digital-mapping have naturally begun to develop. Three levels of maps have appeared depending on the degree of detail and the displaying scale. The number of feature-levels in these standards varies from 19 in the most coarse version to 58 in the most detailed. However, as the standards are not consistently hierarchically constructed and since they are the result of an evolutionary process, only a minor portion of the digital urban maps actually follow the standards exactly. Initially it seems reasonable to base the content of the data base upon a geometrical standard which is used for technical maps of a scale of 1:10.000 and then later on to extend the number of feature codes, until a sufficient level is reached. Analysis of the analog map-series at 1:25.000 indicates that more than 90 different features are in fact recorded, kept up to date and displayed on the map. Working out a data base will be much more advantageous if the data base can additionally be used to update the basic analog maps. This means that the needed information for the analog map-series must be extracted from the data base. The analog maps at 1:25.000 are up-dated every 8-9 years by the use of ortho-photos in order to maintain geometry, and completed in the field in order to verify information regarding possible alterations. One basic quality of the data base is that it must be able to accept the information collected through the updating process of the analog maps.

Another quality is related to the decision of not storing "plotting" orders. That is, the content of the data base must always remain primarily terrain-relational (as opposed to plot-relational),

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allowing the data to be displayed in many combinations and in connection with other data of many different origins.

A further important characteristic must be the possibility of archiving the origin of all data, both the geometrical origins and the feature origins, since the data base after a very short time will contain data from many different sources. A time stamp will also be connected to all data, since this will make the process of updating the analog maps much more easier.

During the last 10 to 12 years a data base containing all place-names on all map-series has been established at the KMS. A feature-code is connected to all names and a set of coordinates defines the (very) rough location of the feature described by the name. When the name describes an area, a polygon is connected.

Another very important aspect of a data-base like this is its connection to other non-topographic data bases. There exist several of this kind in Denmark, some of them even inside the KMS.

In the Cadastral Department there exists an alphanumeric data base containing information about parcel-numbers, the owners of the parcels and other data. The key information in this data base is the parcel-number. The Cadastral Department is also running a pilot project to establish a digital cadastral map. Within the next year almost 10% of Denmark will be covered by such a digital map.

Outside the KMS several data bases are of interest. In Denmark every person, every house, every building and every street have unique numbers of identification. Of course administrative data bases have long been established containing information about persons, parcel-houses and so forth in Denmark. However, to combine data bases with different keys, there has been established a new data base, called the Cross-Reference Data Base. The idea behind this data base is to provide the possibility of having information connected to one key and via the cross-reference referencing other keys, thereby opening the possibility of going into other data bases to obtain vital, related information. The Cross-Reference Data Base combines three basic keys: the person-number, the parcel number and the address of the person/parcel. The cross-reference data base is prepared for coordinates connected to the address, so graphical output can be obtained and/or a geographical search can be made, from each of the separate data bases.

Who are the Users of the System?

In the early eighties the former Geodetic Institute made a survey of the need for digital products in order to be able to supply the user with the appropriate products when asked for them. Using hindsight, it is obvious that this market survey was carried out at the wrong time (i.e. to early), since it did not predict the change in production methods that was to take place only one or two years later. Some of todays leading users of digital maps did not even answer the questionaire that was sent to them!

However the survey showed that a lot of users had plans to use digital maps and methods but that only very few of them really were

prepared to allocate the resources and time to make the changeover. It was clear that the most serious project at that time was the modernization of the cadastral maps. This project involved the improvement of the basic point network, the production of orthophoto-maps on a scale of 1:4000, as well as a digital cadastral map. It was therefore decided to establish a digital height model meeting the demands of the ortho-photo-maps, but with regard to any other topographic objects it seemed at that time wisest to just wait and watch the situation until a more specific project might turn up. This policy was based upon our goal to produce small-scale topographic maps and data, so there seemed to be no conflict of interest with respect to the development and implementation of large-scale technical digital maps by local municipalities and by the utility owners.

As a national map producer the KMS has been watching the users of the already existing digital maps. Our conclusion has been that with some execeptions, only the new gas companies have been able to utilize the digital maps reasonably. The fact that all orders for new technical maps in Denmark have included demands for digital methods for some time can be explained as a willingness to invest in the future. Most users utilize the digital data as background material for their analog data. The fact that the archives are analog is a very difficult limit to overcome. Of course users take advantage of the digital mappings' possibilities for scale, feature and color selection.

Many map-users have been thinking of transforming their archives into digital form, but not until the beginning of primo 1988 was serious contact made between the KMS and a number of large map users in order to establish a digital map covering more than just the urban areas of Denmark.

The situation today seems to be that some utility owners, certain Government authorities and municipalities, as well as selected other public authorities have realised that within the next decade a digital information system covering the whole of Denmark will be needed. Therefore it is nessesary to invest in such a system now if the benefits are to be realized within a reasonable time period.

The Reality.

During the last 12 months there have been negotiations between the KMS and utility owners. The negotiations have taken place in three separate groups: one for Jutland, one for Funen and the last for Zeeland.

In Jutland the utility owners have started a mapping project. From aerial photographs on a scale of 1:30.000 a very course map is recorded. The map is developed in rural areas excluding all towns larger than 30 hectars.
The feature-codes recorded are as follows:

Building	Greenhouse
Other structure	Pier
Road, centerline	Railway
Coast line	Lake

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Waterway(river/canal)
Boundary
Woods, coniferous
Single points
Electricity lines, pylon
Fence
Wettland
Woods, non-coniferous
Electricity transmissions line

An address theme is connected to the centerlines of the streets.

The KMS is not a partner in this project because of disagreement in opinion regarding copyright and the marketing of the project.

At this moment a sales offer exists for the KMS to purchase the map without the address theme.

On Zeeland agreement has been obtained between the KMS and the telephone company of Zeeland and the three electricity companies on Zeeland. The maps that are to be developed are very much like the ones that are under development in Jutland execept that the photo-scale on the Zeeland project has been chosen at 1:25.000.

On Funen the local municipalities want a greater accuracy and more features in the map. They have therefore chosen the normal standard for technical maps of 1:10.000 connected with a photo-scale of 1:20.000. The KMS has been offered participation in this project.

In conclusion, it seems that within the next two to three years all rural areas of Denmark will be coverd by a very simple digital map. Different regions will have different standards. And the maps will not be complete, since in Jutland all towns exceeding 30 hectars are omitted.

As a national coordinator of mapping in Denmark the KMS will be held responsible for all coordination. Therefore a complicated job is left for the KMS to attempt to work out a homogeneous digital map of Denmark.

Copyright Aspects.

Although legislation could be more specific, it can not be questioned that topographic maps, both analog and digital, as well as topographic data bases are protected by copyright law. This, in short, is the conclusion of a Nordic Working Group on the subject and also the firm opinion of the corresponding CERCO Working Group I.

When establishing an information system (GIS, LIS etc.) the data will be collected from various sources. In our particular case even the topographic geometric data will have different sources as well as different producers, as the basic digital map (the pure geometry of the topographic elements) is to be established within a number of collaborative constellations varying from one part of the country to the other and consisting of private companies, local municipalities and the National Survey. It is therefore not practical or possible to point out just one copyright holder for the entire information system, and not even for the topographic portion of the data base. There is, of course, the possibility of a shared copyright, meaning that two or more parties together could hold the copyright. However as they would have to act juridically as one legal body, and as the actual constellations vary, this would indeed make everyday life

unecessarily complicated. Fortunately, however, the parties involved have agreed to handle the problem in a much more practical way.

The concept of copyright legislation consists of two parts, one part dealing with the so-called ideal rights (i.e. the moral aspects) and one part about the economic rights. Basically the copyright laws are based on the principles of property protection, meaning that the creator should gain a proper reward for his effort, and meaning that no man should be free to unjustly enrich himself at the expense of another by unjustified utilization of his work.

With a system on the order of complexity of information systems the ideal part of the copyright is more or less illusory. The different collaborative parties have therefore focused on the much more interesting economic aspects and for each and every separate case carefully described in the formal collaboration agreement, i.e. all participants' actual rights: The right to utilize, the right to sell at which price and at what profit etc. Through this pragmatic approach the complex and often very emotional problem of the copyright, while not yet solved, has been handled thus far in a way that is both practical and satisfactory to all parties.

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