TOP10DK, THE NATIONAL TOPOGRAPHIC DATABASE OF DENMARK

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ABSTRACT:
In 1994 The National Survey and Cadastre - Denmark began the establishment of a digital topographic database. The name of the database is TOP10DK indication that the database is intended for TOPographical mapping in the scale of 1:10.000 (and smaller) in DenmarK. The purpose of the database is to serve as a background for intelligent GIS where the users install their own keys and for production of plain, cartographic products without any human Interference. On the first hand, effort is concentrated to establish the database nationwide. This is due to user wishes, stating, that coverage was more important than content. Therefore the first version of the database is reduced in number of object types, but not in geometry. On a long term basis, the database will form the basis of map production for medium and small scale topographic maps in Denmark. The database will be established using EU tendering leaving less than 10% of the work for in-house production. Except for test areas no areas have been completed but production is taking place in approximately 30% of the contry and total coveridge is expected to be reached in year 2001.

1. BACKGROUND

The National Survey and Cadastre - Denmark is responsible for the geodetic networks of Denmark, Greenland and the Faroe Islands, the topographic mapping of these areas, the nautical charts covering the waters surrounding these areas, and the cadastral service in Denmark.
The National Survey considers it as one of its prime tasks to provide modern and up to date maps and map data to the Danish society. Therefore, the National Survey has decided to rearrange the production of topographical maps in Denmark. The production methods are now almost reorganized to digital manners and it has been decided to produce a modern topographical database. This database will be suitable for modern GIS and on long terms form the basis of holding the updating of all scales of topographical map series in Denmark.
This database, named TOP10DK should reach an accuracy of one metre for well-defined points and have an updating frequency of five years. On the long term updating data should be bought from the municipalities, which produces the digital technical maps in Denmark. The number of municipalities is 275 and it is doubtful wether they all can handle this task in near future. Therefore the National Survey will carry out the updating until the municipalities are cable of carrying out the updating of maps in Denmark.

2. PRECONDITIONS

In the beginning of the 1980 the utility companies forced the private photogrammetic companies to introduce digital methods in the production of technical maps in Denmark. During the eighties most of the urban areas in Denmark except big cities were digitally mapped. During this process standards for technical maps and for data exchange were developed. In the same period the National Survey went on plotting analog manuscripts for the production of the base map of Denmark scale 1:25.000. The production of this map was the third mapping of Denmark and was planned to end in the beginning of the nineties. In 1988 the major utility companies asked the National Survey to participate in a digital small scale mapping of all rural areas of Denmark, because they needed an overview map to put behind the registration of their utility networks. A major problem was disagreement concerning copyright. Another problem was that utility companies owned much digital map data covering small areas, and these areas were to be included in the mapping. Since the urban area maps were large scale maps produced using different standards, problems arose concerning homogeneity. The National Survey had no money for such a project and the utility companies continued, without the participation of the National Survey, to define and produce the map. The map was to be produced from aerial photographs scale 1:25.000-1:30.000, and no areas were defined except buildings, and topology was not considered. The consequence was, that in four years starting in 1989 all rural areas of Denmark were digitally mapped using standards, which were not designed for future use. The National Survey succeeded to cooperate with some utility owners and participated in one project covering app. as third of the area of Denmark.

3. STANDARDS

During the eighties several standards for technical maps developed in Denmark. The development took place rather uncoordinated but after a while some standard were developed. In 1988 this standard for technical maps was redesigned describing three levels of maps, from the most detailed maps to overview maps in scale 1:10.000. The mapping of the rural areas caused a new standard in 1989, which did not fit into the hierarchy of the other types of maps. A working group was created to write a new standard and solve the problem of hierarchy. The intention was that the National Survey would end its own collection of data for updating databases and analog map production. Instead updating should be based on data collected for updating large scale technical maps. Unfortunately we did not succeed in incorporating all the wishes of the National Survey in the new standard, but many problems were solved. Besides the hierarchic extensions, which were incorporated to make it easier to build up topology, it was stated that all map data should be 3D data.
In the same period the standard for data exchange was also revised and updated to meet new defined context in data.

4. PILOT PROJECTS

Parallel to the negotiations with the utility owners an in-house plan to begin a fourth measurement of Denmark was established. The plan was to create a digital basis for the production of the base map 1:25.000. The cooperation with utility owners establishing a digital map covering parts of Denmark forced this plan to be abandoned. Instead a pilot project was created. The plan was to use modern data acquisition techniques to develop and test a new standard for digital mapping based on medium scale photogrammetry.
In 1991 the Map and Chart Division was moved to a new address in Copenhagen and a new Zeiss Phocus system was purchased. The Phocus system consisted of one plotter P1, three modified and digitized Wild A8 plotters and two working stations.

The aim was on one hand to create a digital map, which could be useful to a broad range of users, from the inexperienced user to the professional, and could form the future basis for map production at the National Survey. It was a demand that the map data could be used on a personal computer to serve the local municipalities in Denmark without restricting the advanced use of data. The analog base map has more than 90 different codes (signatures, areas with colours, patterns and so on) for objects shown on the map. In the new standard for digital maps these were cut down to less than thirty, but in a way that ensured that geometry still was complete. As many object types as possible were defined as areas. Roads, rivers and railways were defined as networks with topology and nodes. The width of roads is linked to all centerline's and there are defined nodes at all crossings. The buildup areas were classified according to usage and type of buildings. These rules make the map data well suited for GIS, allow easy plotting of simple cartographic products, and form a map which is easy to combine with other geographic related data.

Bornholm Project

FK-standard. In spring 1991 the Danish island of Bornholm was covered by aerial photography scale 1:25.000 for updating the analog map 1:25.000. This photography was used to develop the new standard and testing the Phocus system. The test area is approximately 600 km^s and are covered by approximately 75 models. While plotting the standard developed according to in-house wishes. The standard was called "FK-standard" because the acronym for the plotting unit was FK. The standard was published 1993. The most sophisticated part of the standard was that more than half the object types were defined as areas, and that build-up areas were devided in four classes. To test how this classification would work out in practice it was decided to plot, what was considered the most difficult area in Denmark: the central part of Copenhagen. This test worked out very well. To reduce plotting time, because this time is expensive, data acquisition has to follow the rules of the software used in the data acquisition phase. Another point is that data created by photogrammetry are not perfect and need revision. This is normally done in an after processing that follows the plotting. The main scope is to correct the data using other sources than aerial photographs and to ensure that structure in data is correct according to the defined rules of plotting.

TOP10DK. Having a standard for photogrammetric plotting does not mean that a database also is defined. The specification of the database is based on a data model which is separated in three parts: geometric topology, semantic topology, and an object catalogue. The geometric topology describes the rules for the interrelation of the different types of geometry: point, line, and area. All object types are connected to one of these types. The semantic topology establishes rules for the interrelation of the different types of objects. The object catalogue is a description of the different types of objects of TOP10DK. This part of the specification is very similar to the plotting standard. Besides this the specification contains rules for how the administrative division of Denmark has to be worked out. Rules about place names and elevation conditions are also included in TOP10DK.

Aarhus Project

Having the standard and being quite satisfied with it the next step was to make the standard known throughout the country. The National Survey contracted private companies to work out test plots. The final step was to announce a public test inviting possible future users to participate. An area of approximately 100 km^2 in the northern part of Aarhus the second largest city of Denmark was chosen. Production of data was handed out to a private company and afterwards checked and upgraded by the National Survey.
Governmental agencies, counties, local communities, and private companies participated in the project. All participants had the data and used it in their everyday life. After the test period they were interviewed about experiences good or bad. Special interest was payed to wishes concerning content of the database, time of establishing and number of features, and the degree of details of objects. A result of the Aarhus pilot test was that it was strongly stated to the National Survey, that a complete coverage of Denmark was the most important matter, even more important than the number of individual codes or themes. Consequently the standards were changed.

Additional Data. All participants expressed wishes concerning height information. Using photogrammetry as a basic data acquisition method all points are three dimensional from the beginning. If the producer has to edit data height information might be lost, but in principle all points have three coordinates. If the basis was chosen to be older technical map data heights are not always present. It was decided to add height information to the data. At the National Survey there exists a DHM covering the whole of Denmark. The grid is 50 x 50 m and the accuracy of the points is expected to be between one and two metres. Further contour lines with equidistance of 2.5 metres were scanned, vectorized and annotated.
Considering a topographical database geographical place names are important. A place name serves as a key in the database, since the users very seldom know the coordinates of a place, but instead they know the name. Place names have been in databases for quite a long time in Denmark. Approximately 150.000 placenames are stored in a relational database in 20 tables. Place names and appellatives will be connected to geometry to serve as keys in the data base.
Denmark is completely covered by cadastral maps. Now these maps are converted to digital form. The cadastral register has been on EDP for several years. Combining these databases in a GIS will form a very strong tool for administrating Denmark.
Outside the field of responsibility of the National Survey other databases exist. Most interesting are addresses, which during the last decade have been linked to the digital technical maps. The linking is established through a coordinated point situated inside the polygon of the house. Addresses are considered as a primary

key in the digital future administration of Denmark. The National Survey intends to incorporate the address theme in the data base, if a customer owns this theme.

5. PRODUCTION

In November 1992 the board of directors of the National Survey decided to establish the database, if as much as possible of the existing data was reused. This was partly a political descision and not an ideal solution, since tests had shown that updating old data was expensive and difficult, and most of the existing map data were old and not updated. New tests had shown that this bad condition of the existing map made it less expensive to produce new map data than to update and upgrade existing databases. Negations between the National Survey and the data owners for more than one year once again failed to set up a contract to define the conditions on which the National Survey could use the existing map data. One important issue on which the negotiations failed were copyright terms. The consequence of this missing deal is that more than two thirds of the rural areas are to be plotted again, although there exists digital map data covering these areas.

EU tendering

The objective of producing the total database within five years would demand external production and properly the use of production capacity outside Denmark. The total project is estimated to cost more than 100 million Dkr. Contracts of this magnitude has to be put out for tender. The EU has set up rules for this. When one has learned these rules, they are quite easy use. In January an advertisement in the Official Journal states the approximate total value of tenders the National Survey intends to advertise during the year. Referring to this time limits can be cut to a minimum. The kind of tendering chosen, is the one using prequalification, which means that companies asking for a pre-qualification has to prove to the National Survey that they can handle the job. Normaly the National Survey will prequalifie five companies. To our surprise many companies do not know the rules and referring to the prequalification note ask for tender material. They will get a short letter stating the rules. Having run six tenders we can say that companies all over Europe ask for a preficalification in despite of that all contract material, standards, and specification are written in Danish.
To handle production the total area is divided into seventeen areas. That means that the areas in average is approximately 2500 km^2 and normally makes one tender. Dependent on topography an area is futher divided into stages - normally four. If the National Survey has no access to the data covering the rural areas, the production is specified as mainly as photogrammetric production else as mainly upgrading existing map data. Before the advertisement the National Survey will contact the local municipalities and ask if they have data for sale. If they have they are asked to send the data to the National Survey for checking. Dependent of the state of the data the data owner will get an offer from the National Survey. The price will be strongly dependent of wether data are in the new and wanted standard, the time of plotting/up-dating, and the number of hectares for sale. The National Survey has set a limit of 500 hectares for the smallest area to buy.
The aerial photography needed for production of TOP10DK is not parts of the tender.For the updating of analog maps aerial photography covering about 20% of Denmark is taken every spring according to the areas to be updated. These areas will, if necessary be expanded to serve the production of TOP10DK. The National Survey will provide diapositives and contact prints of the aerial photography covering the area to the producer. The aerial photographs provided are scale 1:25.000 black and white wide-angle photographs. Besides these photographs a test area with full control is provided. This makes the producer able to put up a model and try plotting using the FK-standard. The test area is not representative for Denmark. It has been chosen to cover most of the types of areas and features to be plotted.

Production Flow

The flow in the production is as follows: aerotriangulation, test plotting, plotting according to FK-standard, and upgrading to TOP10DK standard. .Between deliveries a control is carried out. The producer is not allowed to carry on to the next part of the job, before he has got an acceptance of the delivery to The National Survey.

Control. To get a contract the producer must establish a system for quality control, not necessarily ISO9000, but some procedure, to convince the National Survey that quality control will be carried out. The demand is put up to ensure that quality control is not one-sided put on the National Survey.

Aerotriangulation: The type of areotriangulation asked for is bundle adjustment, but also anblock is accepted. If the producer uses a program that is not internationally recognized, he has to make a test calculation, prove to the National Survey that program does work. Regardless which program the producer uses, he must deliver picture coordinates (not model coordinates) to The National Survey. For control coordinated natural points such as church, towers, chimneys, and so on, are delivered. The demands are internationally recognized demands - one coordinated point for every 2-times basis on the edge of the block and one for every four-times basis inside the block. If the number of control points recognizable in the models does not fulfill the demands, the producer himself must establish more points. Height control is supplied with provisional x and y coordinates, in order to make it possible to put the measuring mark on the ground in an analytical plotter. The number asked for are tree points in every model on the border, and one per model inside the block. The number of height control points supplied is sufficient to meet the demands.

Plotting of test area. While the aerotriangulation is prepared and measured, the producer has to make a test plot and send it to the National Survey for acceptance. The problem is to ensure that the different operators have reasonably uniform understanding of the plotting standard. Having seen the plotted test area the National Survey normally invites the producer to visit the National Survey and have an assessment of the test plotting.
Some producers need more than one delivery to achieve acceptance and permission to continue with the proper plotting.

Plotting of FK-data. The area is divided into stages, usually between three and five. The producer has to deliver data divided into two times two km^2 for approval. It makes data handling much more easy and calculations of completeness and topology much faster when data is delivered in such small areas. In the beginning of the whole project it was up the producer to choose the software tools to be used in the control phase before delivery to the National Survey. Experience has shown that this caused much work at the National Survey - many errors were found and had to be corrected. In fact there existed very little of this kind of

software, cable of checking and displaying these kinds of errors that oprators very often makes. Now such software has been developed by the National Survey and is delivered to the producers to be used in the internal quality control before delivery to the National Survey.

Upgrading to TOP10DK.

Upgrading TOP10DK is done according to the specifications. The topological rules are specified carefully, and the National Survey tests whether data fulfill the rules. No area is allowed to be partly part of another area. The distance between points is at minimum 1.00 metre. If two points are situated closer to each other than this minimum distance they have to be joined. This is valid in all three dimensions. All centre lines of roads have to form a network. No rounding error of just one centimetre is allowed. All points must have a code of origin. If the producer edits one point within an object the code of origin must shift because the production method has shifted from photogrammetry to editing. Last but not least data must be readable, i.e. the exchange format must be written correctly. Since there is no internationally accepted exchange format the producers very fast accept to use the software offered by the National Survey because it automatically writes files in a format accepted of the National Survey.

6. UP-DATING TOP10DK

One basic idea of TOP10DK is to transfer the work of collecting updating data from the National Survey to the local communities, were the technical maps are administrated and updated. The idea of making a hierarchical standard for technical maps is to make it possible to extract updating data from these large scale technical maps by using the same feature coding as used in the small scale maps.
If a change is found and stored it in TOP10DK, it can be used in all map series and there fore time and money is saved. A major problem is that TOP10DK and the series of analog maps at the National Survey are not hierarchical according to feature and content! The resources to collect updating data for the analog maps are very limited and tailored to this specific task. During the last four years efforts have been made to convert production methods of topographical maps and nautical charts to digital means, and now the base map scale 1:25.000 is updated digitally. In principle this should make it easier to combine these different data collections, but in practice little have been done to ensure exchange of data between the different production lines. The decision of establishing TOP10DK was combined with the clause that the establishing period should be short. But when TOP10DK does exist in an area what will happen when the base maps in the same area are to be updated? This situation occurs at Bornholm, where TOP10DK exists and the base map is to be updated this year. The updating method of the map 1:25.000 involves digital orthophotos and for obvious reasons it seems natural to involve digital photogrammetry and a method to record changes in the scanned foils of the base map. These changes should be classified in categories of kind of object deleted and kind of object added. Since the updating of the base map is done using digital photogrammetry one possible solution could be to involve digital photogrammetry while updating TOP10DK. A working group is formed to organize a full scale test on Bornholm this autumn.

7. TIME SCEDULE

Time schedule is normally defined in the tender material, but of course the National Survey is willing to change schedule when negotiating the contract. Having experiences from five contracts, it can be said, that none of the producers has been able to fulfill the contract according to time schedule. The consequences of this has been that the internal plans of work load at the National Survey have been shifted with great inexpedient consequences for the (very small) internal production. The contracts contain an inbuilt possibility to exceed the time schedule up to thirty days. If the schedule passes more than that the producer must pay a fine figured out by the time delay.

8. THE FUTURE

In the years to come the establishment of TOP10DK and updating the base map will coincide in major parts of Jutland. The way how analog map series and TOP10DK interact must come to some solution very soon. If a solution is not found the whole idea of establishing a basic database might be lost.

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