ESTABLISHMENT OF A SYSTEM OF NATIONAL TOPOGRAPHIC DATABASES AND MAPS AT 1 : 50 000 AND 1 : 25 000 SCALES

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Abstract

A national topographic map at 1 : 50 000 scale (DTK 50) will be the next systemic topographic map in Slovenia following the national topographic map at 1 : 25 000 scale (DTK 25). The Surveying and Mapping Authority of the Republic of Slovenia is preparing a project for production of this map especially for the needs of the Slovenian Army, in co-operation with the Institute of Geodesy and Photogrammetry FCEG. New methodological solutions, recent computer-aided technology and certain changes in content and design will represent major changes in comparison with DTK 25. Together with the DTK 50 project and two test sheets, the foundations for the second issue of DTK 25 and progressive re-establishment of the TOPO 25 topographic database will also be prepared. The project will be completed in the first half of 1999, when production of the new map will begin.
Keywords: *editing plan, national topographic-cartographic system, technological and methodological solutions, topographic database, topographic maps at 1 : 25 000 and 1 : 50 000 scales*

1 PURPOSE AND COURSE OF WORK TO DATE

In the year in which the production of the first issue of the National Topographic Map at 1 : 25 000 scale (DTK 25) was approaching completion, the Surveying and Mapping Authority of the Republic of Slovenia published a public official invitation to tender for a project for the outline concept of the next map from the national topographic map system, the National Topographic Map at 1 : 50 000 scale (DTK 50). The available national topographic maps are not sufficient for all the needs of current users. The main shortcomings are:

- maps of certain scales are missing from the cartographic system (1 : 100 000, 1 : 200 000)
- certain maps in the system are inappropriate (unknown accuracy, presentation of the contents not uniform among the system maps)
- obsolete content in certain maps in the system (the European norm for obsolescence is five years)
- inappropriate (obsolete) technology of map production in the system
- maps are not adapted to users' current needs (different data form, speed of access)
- maps are not harmonized with the systems of international associations of nations and organizations (NATO, EU).

In addition to the need for a map suitable for planning at a regional level, the Slovenian Army is another important client interested in the DTK 50 map. Maps at a 1 : 50 000 scale are basic for NATO's troops; therefore, without such a map the Slovenian Army would experience difficulties in fulfilling the requirement of interoperability within the framework of the Partnership for Peace. Therefore, the Surveying and Mapping Authority of the Republic of Slovenia and the Ministry of Defence of the Republic of Slovenia have begun a joint project for production of a topographic map at 1 : 50 000 scale. Due to essential needs of the Slovenian Army and a somewhat different orientation (the speed of map production is of primary importance), the Ministry of Defence of the Republic of Slovenia commissioned a parallel project which is based on the experience of foreign geographic services (NATO international standards) and DTK 50 as a basis for the production of VTK 50. The contractor for this project was the Institute of Geodesy and Photogrammetry FCEG.

1.1 Outline concept for DTK 50

The outline concept for the DTK 50 project was prepared by cartographic professionals at the Institute of Geodesy and Photogrammetry FCEG . It includes many experiences and findings from our own developmental projects as well as developmental and implementation tasks in the cartographic field. The Surveying and Mapping Authority of the Republic of Slovenia was the client for the majority of these projects. The result of the outline concept is text in five volumes that contain:

- certain analyses and statements essential for the project (the place of DTK 50 in Slovenia's cartographic system, the topographic database, the mathematical basis for DTK 50, sources for the production of DTK 50, description of certain important technological and methodological solutions, and NATO standards, i.e. a military topographic map at 1 : 50 000 scale)
- outline concept for organization of the production of DTK 50 (project structure, a network plan, personnel needs, hardware and software needs, and costs and time estimates)
- draft of editing plan with all elements
- draft of guidelines for the organization supervising national maps
- list of unsolved problems and proposal for further activities.

To continue preparing the groundwork for the production of DTK 50, the Surveying

and Mapping Authority of the Republic of Slovenia published an invitation to tender for a new project which envisages the production of two sheets of DTK 50 (Kranj and Novo Mesto) and, on the basis of experience, supplementing of the outline and preparation of the final project for the production of DTK 50. At the same time, one DTK 25 sheet, which will be harmonized with the production of DTK 50, will be produced within the framework of this project, and the method of simultaneous establishment of the TOPO 25 topographic database will be determined. This means that the project will result in a comprehensive solution for the establishment of topographic and cartographic products at 1 : 25 000 and 1 : 50 000 scales.

2 NEW METHODOLOGICAL AND TECHNOLOGICAL SOLUTIONS

The most important new features include original methodological and technological solutions on the international scale for the production of topographic maps. After winning its independence, Slovenia was found in a special position regarding topographic maps. This can only be compared with the situation in other new countries in the territory of the former Yugoslavia (Croatia, Bosnia and Herzegovina, Macedonia) and probably also in certain countries of the former Soviet Union. In these nations, the coverage of their territories with topographic maps at all scales is thorough and high-quality, but the materials for their production and originals are lacking.

2.1 Feasible solutions for the marketplace

We are limited by the present situation from borrowing the methodological solutions from the majority of cartographically developed countries in the modernization of our topographic-cartographic system, in transition from a classical to a computer-aided production and maintenance of a map system. Cartographically developed countries use two solutions. The first, of a transitional nature (within a long-term framework), anticipates the scanning of originals and further raster processing of the existing maps. The second, a more comprehensive one which does, however, demand much more money and time is to establish a complete vector topographic database, from which maps at appropriate scales are produced using generalization and cartographic modelling. Due to unsolved problems in the field of automatic generalization and the high cost of vector data capture, the second solution is currently limited to large-scale maps (1 : 5 000, etc.), certain smaller areas or areas for which appropriate maps did not exist. The described principles are within the capacities of software packages available in world markets, the best-known being Intergraph's and ESRI's systems.

2.2 Attempts at vector solutions

Slovenia does not have the originals for the majority of its maps (except for DTK 25) and the possibility of obtaining them is uncertain. The first solution cannot therefore be used as a foundation for the entire system. The second solution was tested at the level of 1 : 25 000 scale within the framework of a project entitled Production of Prototypes for Digital Topographic Maps. The vector database for the entire DTK 25 sheet content was captured using three methods. In the first, all

available databases were used. The heterogeneity, incompleteness and, in certain cases, data forms inappropriate for cartographic presentation, caused the sheet to contain numerous cartographically inadmissible errors and it was useless without thorough modification. In the second method, the entire contents of a classically produced DTK 25 sheet were vectored and data was modelled cartographically. The final sheet appearance did not differ from the classical one; only the additional operation (vectorization) somewhat lowered the positional accuracy. This procedure was very time-consuming as well as expensive, and the end result corresponds with the situation upon last map revision. In last case, an entire topographic database with analytical evaluation of aerial photograms was captured for the entire sheet. This yielded an updated database with topographic positional accuracy. The price of data capture here was the highest; in addition, an extensive (predominantly manual) generalization will be necessary. The contents of the produced sheet differed from presentation on a classically produced DTK 25, especially for forested areas. This difference results from the fact that, during the production of topographic maps at the Military Geographic Institute (MGI), a field survey was performed in addition to an aerial photogrammetric survey. This field survey was the source of the majority of data on paths, streams and forested areas.

2.3 Attempts at raster solutions

Given these circumstances, we attempted to find an optimal solution for using the greatest possible degree of the accurate and high-quality contents of MGI's maps in the production of a new system of national topographic maps, merely modifying it with certain changes and supplements. A completely graphical solution of colour scanning, supplementing and printing in four basic colours (cyan blue, magenta red, yellow and black) did not work. Major changes in map content and appearance were not possible, and the graphic quality was unsatisfactory (primarily for contour lines, which were composed from rastered prints in three colours). We therefore attempted to find a solution that would divide a colour raster sheet image into raster images of individual colours, in which the map was originally printed, using a combination of appropriate filters and graphic operators. Taking into account the deformations of the base medium, i.e. paper, this would yield the same result as if the sheet's originals were scanned. After our own, only partially successful attempts, we sought software in the market which would achieve the desired solution. In spite of intense discussions and tests performed, an appropriate solution was not found.

Under these circumstances, DFG Consulting d.o.o. managed to produce an extremely effective software solution. This software enables scanograms of printed map sheets to be first appropriately transformed to theoretical dimensions and then divided into raster images of individual colours. If the printed sheets' input scanning resolution is appropriately high, the graphic quality of raster images for individual colours (separates) will be sufficient for further reproduction. The new method even has a certain advantage over the scanning of sheets' individual originals. Since deformations are eliminated prior to colour separation, full agreement of individual raster images is ensured, and their sizes are also completely identical (the number of image elements, or pixels). If individual originals are scanned, it is hard to fulfil this condition, and in the opposite case there would be major problems in

further processing. Naturally, there is no doubt that individual originals will be scanned and co-ordinated for the second issue of DTK 25.

2.4 Content supplementing

Successful separation of raster images is only the first step in map sheet production. Even though the Intergraph cartographic software system makes possible all further steps of processing and supplementing raster images and preparing files for reproduction, the offered solutions are not always the most rational ones. The cost and difficulty of using this system makes it difficult to establish a sufficient number of lines for sheet production that would make possible regular production and updating of topographic maps at acceptable time intervals. Therefore, a combination of various simpler software packages, a few of which we produced ourselves, was used to design a quicker and cheaper procedure for sheet production. These procedures also enable changes in sheet content and design. The production of new contents between and outside frames is inevitable, and presentation methods for individual content can also be varied (e.g. changes in cartographic symbols), certain object types can be eliminated or added, and the colour presentation of individual symbols or entire maps can be changed. The division of maps into sheets can be changed, and their content can be transformed into any projection. In addition to accurate capture of MGI map contents, high-quality and complete map revisions are also important for the production of high-quality topographic maps. Therefore, more than mere corrections and supplements from DTK 25 captured aerophotogrammetrically will be used in the production of DTK 50: its revision was incomplete, five years have passed from the production of the first DTK 25 sheets, and the recorded corrections are given only in graphic form.

2.5 Planned method of TOPO 25 and DTK establishment

The project anticipates the following solution (Figure). Photogrammetric evaluation of aerial photograms at 1 : 28 000 scale will be performed using digital procedures at the level of 1 : 25 000. This evaluation will provide corrections and supplements to map contents at 1 : 25 000 scale in vector form and verify the accuracy of original surveys. This data will represent the beginning of the establishment of the national topographic database TOPO 25. At the beginning this database will contain only captured supplements to topographic map contents, but it will gradually be supplemented with an ever growing number of objects. Since aerophotogrammetric data capture is limited by visibility, a group of topographers will supplement the captured contents through field surveys. This will include the interpretation and categorization of photogrammetrically captured objects, capture of objects not visible in photographs (especially in forested areas) and capture of objects which were constructed in the field after the date of aerial photography. The results of field surveys (which will, as a rule, be in their original digital form) will be included in the topographic database.

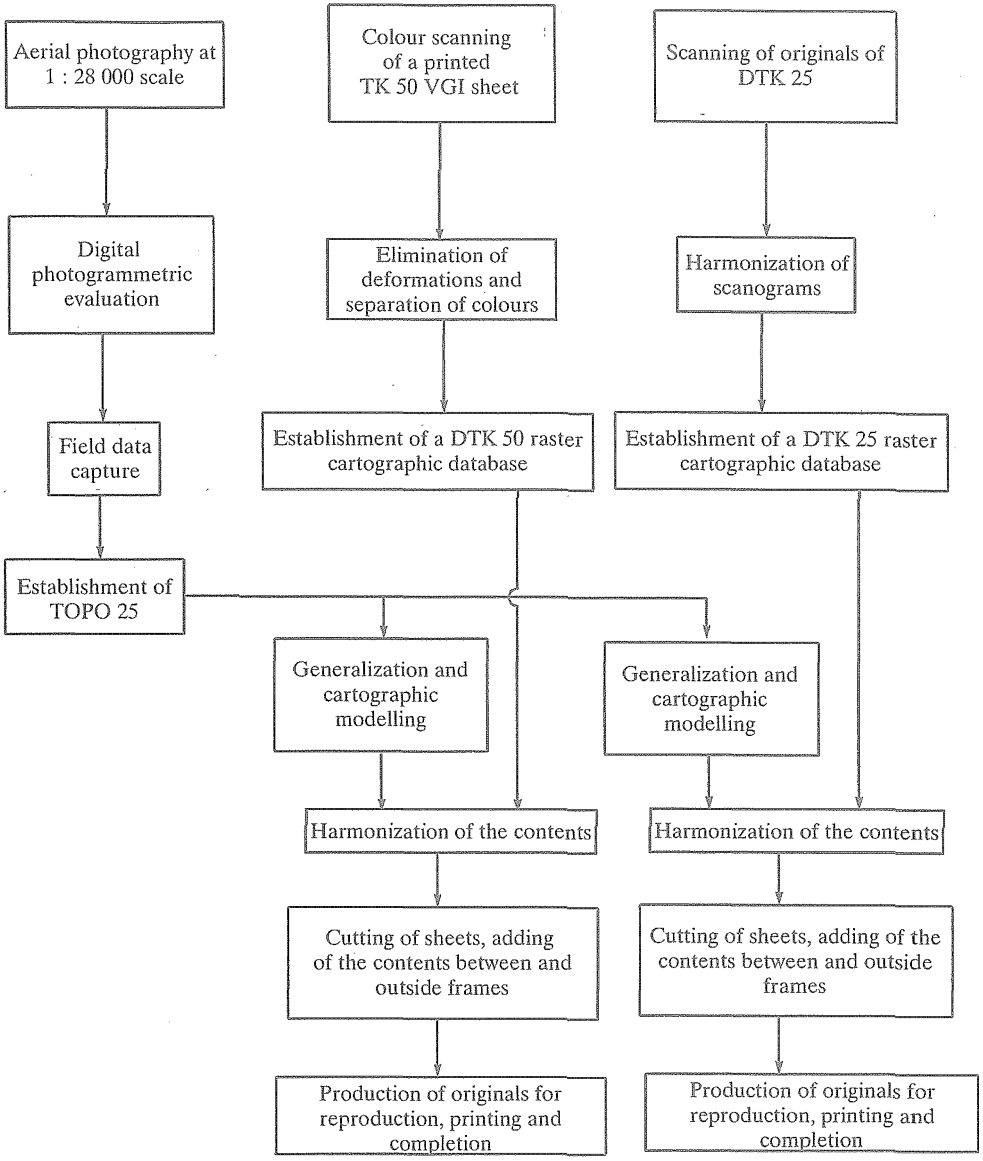

Figure: Procedure for map production and establishment of TOPO 25

The contents of the topographic database will be appropriately generalized to a map at 1 : 25 000 scale, in the event that the second issue of DTK 25 is produced simultaneously with the production of DTK 50, and to a 1 : 50 000 scale. In future, it will be possible to produce smaller-scale topographic maps in the same manner (1 : 100 000 and 1 : 200 000). Generalized vector data will be cartographically modelled and included into raster images for individual colours. The described

procedure of capture of supplements will not be limited to map sheet area, but to a stereomodel. Raster images for individual colours will be obtained by separating the colour scanogram for a 1 : 50 000 map and for a 1 : 25 000 map by scanning originals; they will then be combined and harmonised at junctions, thus obtaining a comprehensive raster cartographic database for the entire area in the presentation. The new content will then be co-ordinated with the existing one and the contents between and outside frames added. A test print will be produced and files will be prepared for the production of originals for individual colours. The printing procedures will remain the same as for the existing ones, because the offset process is the most suitable for printing of maps in over 1,000 copies. In the near future, this may be replaced with digital printing.

Since the offered solution (which in the circumstances described would mean a considerable optimization of topographic map production) was not found among the software available on the world market, it can be assumed that other countries might be interested in it.

3 CHANGES IN CONTENT

There have been many proposed changes regarding map content and appearance with regard to MGI's maps and with regard to the first issue of DTK 25. Contentual changes are planned regarding the presented object types. MGI's TK 50 and DTK 25 maps are produced in accordance with the cartographic key from 1981. This was adapted to suit the presentation of objects and phenomena in the territory of the entire former Yugoslavia, and it therefore contains certain objects and phenomena which do not appear in Slovenia and the boundary areas of our neighbouring countries, which will also be included in DTK 25 and DTK 50. In the 17 years since the production of this cartographic key, the significance of individual objects has also changed; some of them are no longer important for orientation, and new ones have appeared. The categorization of certain objects is also inappropriate for the current circumstances, primarily for roads, paths and bodies of water. In spite of all this, the new contents will be adapted as much as possible to the existing content of topographic maps, because this would preserve the high-quality content basis of topographic maps, facilitate the users' transition to using new maps and reduce the costs of production to the lowest possible level.

No changes are envisaged regarding the contents between and outside frames. In accordance with the available space, the presentation of the cartographic key will be expanded (primarily for new objects), and an inclined scale and schematic of communes in the area covered by the sheet will be added. Regarding sheet design, the most important suggestion is that sheet format should be changed from portrait to landscape. Instead of the previous 15´ x 15´, 1 : 50 000 map sheets will present an area of 20´ in the direction of parallels of latitude and 12´ in the direction of meridians, while 1 : 25 000 map sheets will present an area of 10´ in the direction of parallels of latitude and 6´ in the direction of meridians rather than the previous 7,5´ x 7,5´. In addition to easier use of the landscape format in offices and during field work, the reasons for this change also include co-ordination with map formats from the neighbouring countries and NATO. The change in format also means a new design of the contents between and outside framesand the reverse side with the cover

page and division in sheets.

Naturally, design changes in internal map contents will also result from changes in the cartographic key. The newly included and re-categorized object types will be presented using new cartographic symbols, and certain previous cartographic symbols will be changed due to different production technology (classical and computer-aided production). Map colour design will be a compromise between the MGI's maps and new topographic maps of other countries. Experience in printing DTK 25 has shown that cartographic paper is the most appropriate for all purposes; this needs to be taken into account in assessing the final colour appearance of printed sheets.

4 UNSOLVED PROBLEMS AND UNCLEAR ISSUES

In our work to date we have run into a few professional, organizational and also entirely user-related issues which need to be solved prior to the start of sheet production. The first issue is the sheet format change previously mentioned. In spite of the listed reasons in favour of this change, it will slightly increase the costs of map production (in boundary areas, the area covered will change). It may also cause confusion among users for some time. Another issue is professionally more demanding and refers to the projection and selected reference ellipsoid. On one hand, there are the existing maps made in the Gauss-Krueger projection on the Bessel ellipsoid and all national spatial records and databases. On the other hand, NATO military union standards, with which the Slovenian Army will have to comply due to the interoperability requirement, envisage maps in the UTM projection on the WGS 84 ellipsoid. Such a change would also please all users of the GPS system, whose number is expected to increase considerably when the network of reference stations is set up. Both rectangular co-ordinate grids will almost certainly be printed on the map, irrespective of the projection, which will mean additional difficulties for non-geodetic users.

The majority of the remaining issues are of more concern to users than professional in nature. One of them is the question on the presentation of terrain relief shading. This shading can be produced with computer technology using the contour line layer from the Generalized Cartographic Database. This is currently the best terrain relief database, which completely covers the entire territory of Slovenia. Shading increases the map's plastic effect and is especially suitable for less professionally trained users. However, the grey colour reduces the clarity of other map elements. Concerning road categorization, one wonders whether users would benefit more from a division of roads according to their official classification (main, regional, local roads) or according to construction properties (structure of the upper layer, width, carrying capacity). There are also a few questions regarding the presentation of individual public facilities, trigonometric points and objects at sea.

5 THE NEXT STEPS

A test sheet which was presented at the Geodetic Workshop contains the contentual and design solutions proposed in the project. The methodology and technology of production fit the description in the project, but supplements are not captured from TOPO 25, which is not yet established for the test area. It is our desire to collect as many responses as possible from potential users of DTK 50 and DTK 25,

along with those from the wider geodetic professional public. In this manner, the preparation of the final project may take into account all organizational, professional and consumer aspects and views of the establishment and maintenance of the system of topographic databases and maps. We are currently involved primarily in the establishment of TOPO 25. The process of aerial triangulation and digital photogrammetric data capture is in progress, to be followed by field capture. For all activities, we will determine in detail the extent and method of work and thus acquire more accurate estimates of the time and financial framework for establishing the system. Field capture contains many unclear issues. The established TOPO 25 contents for two test areas will be included in raster images for maps, and three sheets will be produced according to the procedure planned in the project: DTK 50 Novo Mesto sheet, DTK 50 Kranj sheet, DTK 25 Kranj sheet. In addition to a comprehensive supplementing of the contents on the basis of TOPO 25 data, we will try to take into account in the production of these sheets all the comments we have received on the presented DTK 50 Novo Mesto test sheet.

Naturally, the last phase will be project completion and preparation of the final materials for establishment of the system of topographic databases and maps:

- production of an editing plan
- preparation of employee instructions
- preparation of project organization (time and costs of the entire implementation, personnel and equipment needs)
- establishment of a service to manage and monitor production.

The preparation of two educational programmes is also planned. The first will be intended for the contractors included in the establishment and modernization of the system of topographic maps and databases, and the second for users, both geodetic professionals and members of the wider public. Production of the first sheets of new DTK 50 and DTK 25 maps, together with the establishment of TOPO 25, is scheduled to begin in 1999. The first produced sheets can be expected in 2000, and their production cycle is planned to be between five and seven years. Of special significance in the preparation of the Project for the Production of DTK 50, DTK 25 and TOPO 25 is that that this methodology will be transferable to the production and maintenance of the entire system of national topographic maps at 1 : 25 000 to 1 : 200 000 scales in the coming years.

Sources and literature:

Peterca, M. et al., Kartografija. Vojaškogeografski inštitut, Beograd, 1974

Petrovič, D. et al., Izdelava prototipov digitalno izdelanih topografskih kart. Ljubljana, 1997

Petrovič, D. et al., Projekt izdelave prototipa topografske karte v merilu 1 : 50 000 na osnovi tiskanega izvoda TK 50 (VGI) in reprodukcijskih originalov DTK 25. Ljubljana, 1996

Petrovič, D. et al., Zasnova projekta državne topografske karte merila 1 : 50 000 (DTK 50) z redakcijskim načrtom. Ljubljana, 1998

Radovan, D. et al., Idejni projekt vzpostavitve in vodenja topografske baze srednje natančnosti. Ljubljana, 1994

Radovan, D. et al., Test kvalitete in vzdrževanje generalizirane kartografske baze. Ljubljana, 1996

Radovan, D. et al., Zasnova strategije topografsko-kartografskega sistema Slovenije. Ljubljana, 1996

Rojc, B. et al., Pregledne karte Republike Slovenije, sistem tematskih prikazov vojaške vsebine – Vojaška topografska karta 1 : 50 000 (VTK 50). Ljubljana, 1998
Rojc, B. et al., Projekt izdelave Državne topografske karte v merilu 1 : 25 000. Ljubljana, 1995

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