TRANSFORMING CROATIAN BASE MAP (HOK) IN DIGITAL FORM

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Abstract:

This article describes process of digitalization (with detail retrospection on technical characteristic of scanner KartoScan FB and capabilities of software for vectorization TopoCap) of existing analog Croatian Base Map (HOK), including solution for their archiving and distribution to customers, both in raster and vector format. Presented methodology is developed by State Geodetic Administration (SGA), as a part of Croatian – Norwegian geoinformation project, that has for a goal further improvement of capabilities for creating cadastral and topographic data bases.

1. Introduction

Development of spatial data infrastructure, as a support for whole economy of one modern country, is demanding and long lasting process that has been taken by most of developing countries. As a base for spatial data infrastructure, development of complex topographic system for multiple applications and orientation to professional customers is essential. Well organized, regularly updated spatial data base improves quality and functionality of both topographic and cartographic data in relation to old analog maps, plus it serves for their creation.

As a part of a Croatian – Norwegian project called CRONO GIP II, that has for a goal further improvement capabilities for creating cadastral and topographic data bases, that were developed under CRONO GIP I project, SGA started with development of methodology for scanning and vectorizing 9800 analog map sheets, including solution for their archiving and distribution to customers, both in raster and vector format. This article describes methodology and technical solutions for scanning and vectorizing, as well as plans for future development.

2. Croatian Base Map (HOK)

Croatian Base Map (HOK) at scale 1:5000, earlier known as Base State Map (ODK), is being produced since middle of twentieth century, mostly by aerophotogrametric mesurements. Production of HOK was performed by croatian geodetic companies and it was mostly financed by Croatia republic – sometimes with support from govermental institutions. Production of HOK was most intense in seventies and eighties, when was produced bigger part of 80% from 9800 that we have today (Fig. 1.). In spite of good coverage, current status isn’t satisfactory. Bigger part of map contents is out of date, because map haven’t been maintained, nor updated. Content obsoletion can be best seen on urban areas, where the changes are biggest (SGA, 2003.).
Fair drafts are produced on drawing leaves, and content is separated on three layers (height layer colored brown, water layer in blue, and situation layer in black), and somewhere fourth for forest layer in green. While for majority of topographic maps from former military production SGA possess only multicolor prints, for HOK, SGA possess source documentation – including fair drafts, because production of HOK was relied to Croatian capabilities. These cartographic products are made by highest scientific and professional standards, and although their quality in technical point of view is undoubtedly high, from lexicographic point of view there are some inadequancies (SGA, 2003.).

Till the end of eighties, HOK was produced in analog way, and since then they are produced in modern computerized way. First attempts to produce HOK in digital way were made by several institutions and companies that were digitizing contents of some HOK sheets. Positional accuracy of those data depend on digitizers quality and operators competency (SGA, 2003.).

In the year 1995. Photogrammetric Institute Inc., Zagreb created first 18 map sheets of HOK (then called Croatian State Digital Map – HDDK) at scale 1:5000 produced digitally as a part of the project, for the are of Zagreb and Zagreb county. For the need of this project, data model was created as well as the appropriate cartographic key in which were all cartographic signs and signatures adopted to computer usage. Aerophotogrammetric survey with direct digital record in CAD system was applied. Beside situation data (in 3D form), data for creating DMR and data for inner description were collected (SGA, 2003.).

Till 2001. production of most maps in digital form was based to the project mentioned above. In 2001. data model was synchronized with CROTIS (Croatian Topographic Information System) data model. In 2001. Institute for Cartography at the Faculty of Geodesy, University of Zagreb created new “Cartographic key with instructions for symbol usage for HOK at scale 1:5000” (SGA, 2003.).
2.1. Mathematical Rudiment of HOK

HOK map sheets at scale 1:5000 are printed on cartographic paper with dimension 50 x 70 cm. Useful area on map is 0.27 m² wide (format 45cm x 60cm, except for enlarged maps), rounded with 0.1 mm line, and it represents rectangular area (2250m x 3000m) of 6.75 km² (675 ha) in reality. For those map sheets that are beside border meridian (16°30'), special rules for forming useful area are applied. Hermanskögl geodetic datum is used for state maps creation. Bessel 1841 ellipsoid is a reference ellipsoid, and normal orthometric heights are measured from normal point in Trieste.

HOK at scale 1:5000 is created in Gauss-Krügers projection in two meridian zones that grip 3° of geographic width. Mean meridians of both zones are 15° and 18° from Greenwich, and border between those two zones is meridian φ₀=16°30’. Zones are labelled with numbers 5 and 6. Rectangular coordinate system with origin in intersection of equator and mean zone meridian is used. y coordinate, constant 500 000 is given, with zone number in front. Linear scale on mean meridian is mo=0,9999 (SGA, 2003.).

Two projection zones (5. and 6.), makes map usage difficult. For that reason, it is planned to make new, unique cartographic projection as well as new coordinate system. Changes of geodetic datum, reference ellipsoid and height system in Croatia will sigh for certain changes in measurement and state maps production.

2.2. Map accuracy

Phrase map accuracy consists of two elements:

- contents accuracy
- positional accuracy (horizontal and height accuracy)

Speaking of contents accuracy, HOK, as a croatian most detailed map has biggest quantity of spatial information. Terrain evaluation procedure is very detail, so generally speaking, contents accuracy is very good.

Analogue maps horizontal positional accuracy is inside graphical accuracy of 0.2 mm (that represent 1m in map scale). Graphical accuracy is minimal point size that can be drawn on map, read or measure from it, without help of any mechanical devices (magnifier, microscope...).

On several map sheets of HOK at scale 1:5000, coordinate network and fundamental geodetic points accuracy was inspected. Coordinate network mean square error is about ±0.7 m, while fundamental geodetic points mean square error vary between ±0.58 m and ±1.50 m (SGA, 1995.).

Height representation on analog maps is given with contour lines and height points. On hilly regions, contour lines were acquired directly with stereophotogrametric instruments, while on plane areas, where combination of tacheometry and levelling was applied, contour lines were interpolated by hand. For hilly regions equidistance is 5m, while for plane areas equidistance is 0,5m. Height points are mapped on stereophotogrametric instruments or measured directly on terrain. Height points elevation is given in decimeters (SGA, 1995.).

On maps with direct digital data collection and processing, height representation production is derived from DTM. DTM is mathematical model created from different height data: mass and characteristic points, break and structure lines, etc. Processing it with adequate software package creates height representation with contour lines. Automated interpolation accuracy depends on algorithm used in software, height points for DTM calculation density, and entering values heaviness.

3. Scanning

Whole process of digitizing fair draughts, which includes scanning, georeferencing and vectorization is undertaken in Linux operating system, Red Hat distribution (Fig. 2.)
KartoScan FB IV (Fig. 3.) is fourth generation of FlatBed scanners from Norwegian company Kongsberg Scanners, as a result of fifteen years continuous work and experience in accurate and complex scanning. With intention to create raster images of highest accuracy from transparent fair draughts, this scanner has tilted construction that allows easy usage (URL1).

KartoScan FB IV is equipped with front lights, that in combination with back lights optimize scanning of transparent fair draughts. Protection glass plate secure sensitive originals from damaging. Laser calibration provides height accuracy of ±0,05 mm for whole scanning area of 1100 x 1600 mm, while radiometric calibration protect from data loss during scanning process (URL1).

KartoScan FB IV allow binary, 8-bit scanning in grey scale and 24-bit color scanning. For this project, fair draughts are scanned binary, with 508 dpi resolution.
4. Georeferencing

For georeferencing, software PREMNS from Norwegian company ProCaptura is used (Fig. 4.).

![Fig 4. PREMNS interface](image)

Fair draughts are produced on plastic leafs, so conformality is best maintained. For elimination of all sheet deformations, Helmert transformation is used. Optimal transformation on four corner points is calculated using least squares method. New image is created by aligning map axis with image itself. Newly created image is transformed in ideal dimensions and it is placed on appropriate position inside Gauss-Krüger projection, via map corners coordinates. Georeferenced raster is cropped over map content frame, so that can be used for later vectorization. Georeferenced data is saved in standard .tfw file.

5. Vectorization

Term vectorization is used for translating raster file (in this case, binary .tiff file) in vector form, adequate for CAD and GIS applications. For HOK vectorization, software TopoCap (Fig 5.) is used. Development of TopoCap software begun in 1995. with cooperation of Norwegian Mapping Authority and ProCaptura company for the needs of vectorizing contour lines. That project has ended in 2002. and it resulted with more then 20 000 vectorized maps (URL2).
Because Croatian fair draughts, that are used for HOK production, are separated in three layers that represents water, situation and relief (somewhere exists fourth layer representing forests), software (or software modules) are specially adjusted for each one.

Content complexity disables fully automated vectorization, so after initial vectorization, operator needs to edit computer vectorized data. Vectorizing methodology has been changed parallelly with software development. Beside problems with software stability and operations, that we need to cope with at the begging of porject, software development needed to be synchronized with Croatian topographic data model. Also, some suggestions for software functionality were made to create software that satisfy heigh standards for data collection and transformation.

5.1. Height layer

Contour lines, height points and special relief objects present important information in modern cartographic data bases. Norwegian Mapping Authority uses those data for producing DTM that has wide area of usage (planning and construction of roads, railways, pipes, telecomunication networks...) as a assistance for choosing optima l solution in both financial and aesthetic terms (URL2).

Vectorization itself of height layer in TopoCap software is carried out through several steps. First phase is initial, automatic, vectorization which last, depending od contents complexity, till five minutes.

After that, all irregularities should be corected and all missing objects should be redrawn by operator. This is most time-consuming procedure which can sometimes last for several days. During manual editing, attributization on certain level is performed.

As it is mentioned before, this software was originaly developed for vectorization of Norwegian official topographic maps. Because Croatia and Norway have some geomorphologic differencies, as well as different cartographic representation approach, many software inadequancies (such as problems with recognizing some objects, their classification, recognizing number as contour lines...) caused everlasting editing of computer vectorized data.
As this project's main goal is to develop an automated process of transforming fair draughts in digital form, this software has been gradually adopted to Croatian particularities. It is important to point out that although this software had some imperfections at the beginning, quality of whole product can be manifested with its adoption to Croatian conditions. We hope that the final result of this international cooperation will be functional and time-efficient product for computer-supported vectorization that will satisfy specific needs.

Next step in the process of creating HOK in vector form secures that the whole map is totally controlled. It is achieved by creating polygons that are enclosed by contour lines (Fig. 6.). This step is used for controlling logical consistency of objects as well for creating topology. After this step is done, it is secured that the height of each object, and for every position on the map, can be determined directly or by interpolation, for sure.

![Fig 6. Map presentation before and after creation of polygons](image)

Because numbers that refer to height points don't have uniform appearance, nor emplacement, automatic recognition is not possible. To speed up the process of inputting elevations of height points, multiplying method is applied. Operator selects number of one height point, copies it, past it on position of other height point and increase/decrease it via keyboard to this new points value (Fig. 7.).

![Fig 7. Height points input](image)

Because the heights of contour lines are determined indirectly, via polygon heights they are surrounding, it is necessary to determine elevation of every polygon (Fig. 8.).

![Fig 8. Calculated polygons heights](image)
When the whole map gets its unique and unambiguous height, it is necessary to assign appropriate elevations to contour lines (Fig. 9.). This procedure is carried out automatically, as it is described before. With this step, operators work on editing vectorized data is done.

Fig 8. Contour lines with appropriate heights

Standard ESRI shape format is choosed for exporting data, because its simple structure. Data stored in that form are ready for revision and further transfer.

6. Conclusion

To put to end the whole procedure and to prepare data for transfer in database, quality of every map needs to be checked. That means that completeness of each layer needs to be reviewed, and after that logical consistence (with overlapping all layers) needs to be inspected.

HOK digitalization is long lasting and complex process. Geometry itself doesn't fulfill required demands of this project. As it was point out earlier, in this process topology is created as well as joining attributes that can be read from the map to appropriate objects.

In this article vectorization of water and situation layer is not described because they are still under development. Only after they will be completed, this product will be whole.

With HOK transformation in vector form, prerequisite for quality updating of existing cartographic contents will be made, as well as synchronization of cartographic appearance with user requirements. SGA plans to collect all spatial data in digital form and to adapt EU standards for spatial data updating by the end of 2010.

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