Abstract: Mapping and map production of topographic map in scale 1:25,000 (and smaller) were in the former federal state reserved for the Military Geographical Institute from Belgrade. As the map was considered as a military secret, the Croatian republic administration and companies could only order printed sheets with reduced contents (so called "civilian" maps).

In the period from 1994 to 1996 studies were started by State Geodetic Administration (SGA) setting new foundation for the topographic-cartographic system in Croatia – the Study and the General Design of the Official Topographic-Cartographic Information System (STOKIS) and the Study of the Replacement of the reproduction originals and updating of the contents of the topographic maps.

Soon after these studies, the first contract for mapping and production of topographic map in scale 1: 25 000 in region Istria was signed with three Croatian surveying companies.

Although Croatian companies had no experience in topographic mapping in scale 1:25 000, through the work they established working procedures, cartographic key (ver. 1.3.), internal control system and managed to solve most of the mapping process problems.

In the same time, SGA started a project by the name Croatian Topographic Information System (CROTIS). The work on this project goes along parallel and combined with the mapping process, so that the mapping process (accuracy, data model …) is compatible with CROTIS. In year 2000 CROTIS data model was approved by SGA and framework for production of digital topographic database was established. This implies a shift from main focus on maps in analogue form to focus on object oriented digital databases.

1 INTRODUCTION

In accordance with all conditions which have some influence on the results of above-mentioned activities, their arrangement and organization, Croatia is trying to find its own way by following the international and European positive experiences with necessary tailoring to the specific Croatian situation and with the main intention to make transition period as short, efficient and productive as can be achieved.

The great influence made on the whole process was and still is strongly connected with international and European globalization processes, democratization of the state and state administration, very fast and quite radical general and specific technological changes, restructuring, privatization, transition to the market economy and protection of private ownership, geodetic and surveying heritage from former state, level of organization and efficiency of Croatian administration and other professional institutions, economic and financial potential of the state, etc. (Rožić, 2004.)

Present situation in Croatia regarding general setting at the state level with respect to the official geographic data production and quality control is a significant consequence of the new Law of State Survey and Real Estate Cadastre (National Gazette, 1999) proposed by the SGA and delivered by Croatian Parliament and started to be implemented from the beginning of 1999.

The Strategy yields so called “Croatian model” which is based on interaction and coordination between three main subjects at national level, e.g. State Geodetic Administration (SGA), Croatian Geodetic Institute (CGI) and private companies licensed for carrying out state survey works. Each subject has precise role and responsibility in the process of producing geographical (topographical) data or "geodetic products” specified by SGA product specifications.

Their competences and responsibilities, functions, fields of work and roles in joint and coordinated production of national geographic data and building of National Spatial Data Infrastructure are defined and determined precisely enough starting from visions and strategies, including planning, financing and organizing over to the execution and finally fulfillment of the user needs. The products are at disposal to all users from private persons or companies to governmental and non governmental institutions.

Croatian answer to mentioned alternatives is a “model” defined on few following main elements:

- Specific and standardized geodetic products (geographical data and information's), their definition, specification, planning of production, financing, distribution to users (customers), etc. are the responsibility of the appropriate state civil administration body, i.e. SGA. Produced data or products have got no status of state secret data but copyright belongs to the state. Different users, from private persons or companies to other government institutions have the possibility to use and pay the usage of data or products for declared purpose in accordance with transparent and acceptable SGA price list. Production is financed partly from the state budget (taxpayer's money), partly by local municipalities or some other investors interested in specific product, for example: Croatian Waters, Croatian Forests, etc. Main orientation in planning of production is defined by user needs and SGA capability to achieve actuality and...
availability of products with appropriate delivery time (that can be achieved within the frame of objective presentCroatian conditions).

- Production of previously mentioned specific and standardized products is completely directed to the private companies specialized and infrastructurally capable for organizing and executing efficient production with appropriate level of quality and homogeneity of products in accordance with SGA product specifications. Production is connected with public and transparent procurement procedures organized and conducted by SGA with main purpose to achieve most efficient and productive results - guarantied quality of products in accordance with product specifications produced for less money.

- Quality assurance and quality control of products produced by private companies is the main responsibility of CGI. In principle CGI is, apart a fact that is connected in work with SGA on same programs, stand alone (independent) professional institution specialized for undertaking quality control activities to assure quality and homogeneity of products. Line of responsibility between SGA and CGI is very clear due to fact that SGA is administrative government body with administrative and normative responsibilities and functions and CGI is professional one. Quality control system is based on transparency, taking into account the fact that best controllers of products quality should be producers themselves, e.g. private companies. (Rožić, 2004.)

2 CROTIS

Trough CROTIS Project (Croatian topographic information system) standardization of topographic spatial data is comprised, that gives main and detailed solutions of topographic spatial system in domain of data model, their collecting, processing, accuracy, way of presentation, topologic relations and their interchange. The purpose is establishing flexible, useful, simple but quality geo-information system based on modern technologies beside Earth surface modelling with emphasis of functionally important object categories for spatial management (SGA, 2001).

Basic principles and concepts of CROTIS involve gathering, processing and presentation of objects and their parts relevant for spatial management. The basic guiding line in functionally oriented modelling is to point out, give more weight to gathering and presenting the data having greater importance for spatial management. The main traffic routes, infrastructure in general, constructed objects and their main access routes are the basic feature classes relevant for functioning and exploitation of space. Functionally less significant objects (concrete path between two buildings or staircase beside a house) are neither collected nor can be referred to as feature classes of official geoinformation systems (CROTIS). The possibility of their collecting and presenting can be realized only if specially requested by users (designing of certain infrastructure lines etc).

The basic purpose of CROTIS is its application in all spheres of spatial data management. It is therefore almost impossible to predict all possible applications of this system and specific needs of individual users through a data model. CROTIS is conceived as a basic topographic information system of the Republic of Croatia containing the information needed by every user. Such a system serves as a base for establishing specialized system for any application. The instructions do not present the solution of all cases, and although these regulations are extensive, it is not possible to predict all possible examples. They are therefore used as a model of principles and assistance in making decisions (SGA, 2002a).

Since we deal with basic graphic elements (point, line) in the process of data gathering, the boundary-based presentation of spatial objects has been chosen. In order to describe the information about feature classes we use surfaces described by the boundaries that are defined with basic graphic elements; lines and points. The task of topology is to describe the connections between single surfaces with all neighbouring ones. The information about the neighbourhood (boundaries) is the stuff making the topology of a model, and geometric definition of surfaces, curves and points make the geometry of a model. Geometric – topological model encompasses geometric, as well as topological information about spatial objects with the topological information being the frame that the geometric information can be placed into (SGA, 2001). Process of topographic data topology processing can be seen on Figure 1.
2.1 Data Capture Object Selection Criteria

Criteria and the manner of gathering the data about feature classes defined in CROTIS accompanied by general cases illustrated through examples is described in the document Data Capture Object Selection Criteria (SGA, 2002b) as a part of Product Specification. Selection criteria and the manner of presenting feature classes and their attributes are technical instructions and detailed specifications for establishing and applying topographic information system of the Republic of Croatia (CROTIS).

The determination of a detail degree defined in these instructions is intended to define more precisely the manner of gathering and presenting the objects for the purpose of better usability, maintenance and homogeneity of data. However, too many details should be avoided.

2.2 Feature classes presentation

Data capture needed for the topographic information system consists of a few phases. The first and the most extensive phase includes capturing the data about the geometry of space and objects in it. The next phase refers to the collection of descriptive data about the presented objects that are foreseen by the attributes of each feature class in the conceptual data model. Accurate planning and execution of the first phase can significantly diminish the extent of the work needed in the phase of collecting the attribute data. The capture of data about the object geometry should not be a mere description of space. It should be in the function of processing the data and their final structure within the geoinformation system. Hence, the classification of objects is made already in the first phase in accordance with the data model, and also possible attribute data are collected. The process describing the space geometrically must partly answer the question “what” along with answering the question “where”.

The geometric description of space is made with two basic graphic elements, a point and a line. The lines describe linear objects, but at the same time, in accordance with boundary-based presentation of spatial objects, they also describe the borders of areal objects. Using these elements we can unanimously answer the question “where what is”, however, the information about what these elements present must be contained in the structure of the elements themselves. Some doubts may rise if linear and areal objects, or more linear objects mutually overlap. While the areas are unmistakably defined by setting up adequate code that determines the feature class defined with the lines in the vicinity of the code, the linear objects must vary graphically and thus their affiliation to certain feature class is defined. In case one line should determine at the same time the boundary of the surface object and the linear object itself, then it...
should be in the function of presenting the linear object. The geometry of that line, regardless of its characteristics, determines the surface geometry, and the information about the type of the surface in contained in the accompanying code, hence the characteristics of the line should give unmistakable information about the feature class that this line presents. Thus the basic rule about data capture is defined: linear object have got higher priority than areal objects (SGA, 2002b).

2.3 Definition of feature classes

The catalogue of feature classes (SGA, 2002c) presents all objects being an integral part of a certain geoinformation system according to classification. Obligatory attributes and the criteria for their collecting, as well as the accuracy, along with the manner of geometric presentation, are the most important elements that the creator of some information system should permanently take into consideration. Also, in the process of data capture one should continuously bear in mind the principles of functional hierarchy. Every feature class must be defined by means of basic graphic elements (point, line, surface), and the accompanying code. Feature classes defined in this way, graphically exactly structured are completely conformal to topological processing and definition of feature classes and their relation in the relational and object-oriented database.

Topographic data are divided according to CROTIS data model in 6 feature classes, 26 feature groups and 79 feature types, while data for production of DEM are divided in 4 feature classes, 7 feature groups and 27 feature types (SGA, 2002a).

2.4 Selection criteria for feature classes

The selection criteria for feature classes are defined for each feature category individually. The basic selection criteria for the feature class are its functional significance and its dimensions. If the feature class does not have a relevant function and the dimensions are smaller than the standard minimum ones, the object is not presented, except in special cases described further in the text (SGA, 2002b).

Points

The points are used for presenting the objects of point-like character. The selection criteria are not the object dimensions but the affiliation to some feature class and its significance. The selection criterion for a point-like object is defined by the data model itself that describes the objects to be presented regardless of their dimensions and functionality.

Lines

The lines are used to present the objects of linear character (e.g. utility lines) and narrow and longitudinal objects narrower than the minimum width. The selection criterion is the length of an object. In order to present some object of linear character, it must be longer than the minimum length. The width of a narrow and elongated object does not present the selection criterion for the line object, but it determines its affiliation to a certain feature class. It means that the width of a river, for example, does not determine whether it will be presented or not, but it defines whether it belongs to the feature class river or the feature class narrow river. For each of these objects types there are the selection criteria defined that are taken into consideration after it has been determined to which feature class the object belongs to.

Areas

The areas are used for presenting the areal objects having the area larger than the minimum one. The basic selection criterion for such feature classes is their area, and in specific cases the selection criterion is also the width of the object. Certain elongated objects can be of larger area than the minimum ones, however, if they are narrower than the minimum width, they will not be presented. A typical example is the transmission line profile through the wood that can cover a very large area, but if its narrower than the minimum standardised dimensions, it will not be presented but allocated to the neighbouring types of land cover.

Minimum dimensions

The following table (Figure 2.) offers minimum dimensions of buildings and other construction objects, utility lines and land coverage. The length refers to the linear objects within a certain object entity, and the width and the area to the area objects. Minimum dimensions present the dimensions that an individual object must have in order to be captured, unless otherwise defined according to the criteria for a single feature class. The width refers to the average width of an object.

<table>
<thead>
<tr>
<th>FEATURE CATEGORY</th>
<th>LENGTH [m]</th>
<th>WIDTH [m]</th>
<th>AREA [m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buildings, commercial and public buildings</td>
<td>5</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>Utility lines</td>
<td>10</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Vegetation and land usage</td>
<td>10</td>
<td>5</td>
<td>500</td>
</tr>
</tbody>
</table>
Special exceptions to this rule are for example when a land cover area is broken up by a road system which leaves a small landcover area in the middle.

2.5 Quality Control – Tolerances

With reference to the document 301D301 Quality Control Principles of Geographic Information, Quality Elements and tolerances are established. The tolerances are specified for six ISO Quality Elements (Overview, Spatial Characteristics, Completeness, Logical Consistency, Thematic Accuracy and Positional Accuracy) as values for acceptance/rejection criteria. If not complying fully with these criteria, the delivery will be rejected at the first occurrence of non-compliance. The tolerances are stated in separate document 301D180 Tolerances. According to those Tolerances, positional accuracy of well defined data is 0.75m, which makes this database very accurate. CGI will not feel obliged to check all parts of the delivery. As soon as one criterion is not met, the delivery is rejected without fulfilling the quality control work. It is thus expected that all deliveries has undergone a through internal quality control by the Producer (SGA, 2002d).

2.6 Geographic Coverage and Reference System

Topographic Data covers whole territory of Croatia, up to the borders of neighbouring countries. At the time of database implementation the map projection was Gauss Krueger zone 5 or 6 according to the Law on state survey and real estate cadastre (National Gazette, 1999) and the ellipsoid datum is Bessel 1841. The coordinates should include false easting of 5,500,000 for data in zone 5 (with central meridian set to 15°) and 6,500,000 for data in zone 6 (with central meridian set to 18°). The central meridian scale factor for both zones is 0.9999. Before data is uploaded to the database it has to be transformed into one common homogenous coordinate system for Croatia. If not, the database would not be seamless. Secondly, storing data in two “dislocated” geographic zones would undermine the whole purpose of the database, namely to store all the data for Croatia in one homogenous pool of seamless data. Only this will give the full benefit of a spatial database during data management and spatial analysis. Proposal for official homogenous coordinate system for whole territory of Croatia came from the Geodetic Faculty in Zagreb.

The following is the definition of this coordinate system (SGA, 2004a):
- The name of the coordinate system is set to HR_GK (Hrvatska Gauss Kruger)
- The central meridian for the projection is 16.5. For Croatian coordinate systems zone 5 and 6 this parameter is 15 and 18 degrees respectively.
- The scale reduction for the projection is 0.9997. This is different compared to coordinate systems for zone 5 and 6, which uses 0.9999
- The false easting is 2.5 million.

Heights are normal orthometric. The zero level is mean sea level determined on basis of measurements in 1875 at tide gauge in Trieste (location: Molo Sartorio). The height zero level, normal orthometric height of the origin Benchmark of the height system BV1 is 3.3520 meters.

3 CROTIS DATABASE MODEL

Topographic database in accordance with CROTIS data model is established at the end of CRONOGIP 1 (Croatian Norwegian Geoinformation Project). The implemented data model is a simplified model of the CROTIS data model. The CROTIS data model contains well defined groups and categories of geographic features. But because the existing CROTIS model defines different attribute names and types even within the same group/category of feature objects it doesn’t map well to a relational database design (SGA, 2004b).

It was also the consultants opinion that the CROTIS data model contains a number of attributes that are not relevant to a topographic database, and thus which should be not stored among topographic data. For example, detailed information about utility data like electricity lines, and detailed information on physical characteristics of transportation features do not belong in a topographic database but rather with the governmental entities which manage those data. Thus, to make an efficient implementation of CROTIS in a spatial database some compromises have been done (SGA, 2004b).

Now possible to create a UML model that defines a base class which contains a common set of attributes. Further, specialisations of classes could be defined for the classes that require additional attributes. It is also a valid question whether the original CROTIS was really designed to accommodate an efficient implementation in a relational database system. It is evident that many of the attributes found in the original CROTIS model does not belong in a topographic database. The information that many of those attributes describe rather belong with the entity or institution that manages that data, for example the road or electricity authority (SGA, 2004b).
A typical example of this way of thinking can be found at Ordnance Survey in the UK. They have a OS MasterMap database covering whole Britain. They clearly state that they only manage a very few classes of topographic data. They do not store or manage information/attributes that are the responsibility of other utilities and government institutions. Their MasterMap data simply contains buildings, roads, names, and landcover features, and their appropriate attributes in a topographic context.

Figure 3. Topographic data viewed in Internet browser via Mapserver

3.1 Overview of system and data flow

The implemented system is based on the integration of several commercial and opensource client and server GIS systems. The core engine in the system is an Oracle Spatial 9i database running on a high availability Windows server computer.

The flow of data from production to entering the database is outlined below (SGA, 2004a):
- Data producer delivers Topographic Data and/or Digital Terrain Model Data in DGN format to SGA. DGN file structured according to Product specifications developed during CRONO GIP I.
- SGA dispatches the DGN data to Croatian Geodetic Institute (CGI) for quality control and conversion.
- CGI uses FME to quality control and convert the data to an object oriented GIS format. The data is now structured as features with attributes and sent back to SGA in that format. Data is also transformed into a common coordinate system defined for whole Croatia.
- SGA receives the quality controlled and converted data and use a simple FME workbench file to upload the data to the Oracle Spatial database. SGA does not do any additional quality control on the data but simply upload it directly. However, a few attributes created by CGI are checked by SGA prior to uploading. These attributes are the QCID – Quality Control identifier and the CONTRACT_ID – Production Contract Identifier. These attributes are established by CGI during quality control and are very important for data management purposes in SGA.
- When data is uploaded to the database each and every feature object is given a timestamp for upload as well as unique identifier. These are automatically allocated by the database system.
- Whenever SGA database operators update features in the database their corresponding “last_updated” attribute is also updated. Thus, if SGA updates data that was previously approved by CGI it is possible to determine this fact when investigating the object at a later time.

After data has been uploaded to the database it can be used by in different ways by users connected to the database server via the Local Area Network. It can be edited in Geomedia Professional, graphically browsed using an Internet browser (Figure 3), analyzed and queried using direct SQL interface, or it can be exported to any GIS format/structure using the FME Oracle extraction functionality (Figure 4.)
3.2 Hardware installations and configurations

The implementation of the hardware systems was mostly done by SGA itself during the CRONO GIP I project. The following is a summary of the hardware for the database system:

- Database Server with high availability disk array
- 3 high-end PC Workstations for database applications, with large monitors.
- Networking and backup equipment

The database server is a high availability HP/Compaq server with a FibreChannel disk array, running Windows 2000 Server. Currently approximately 60 GB of storage capacity has been allocated from the disk array for topographic data. Storage space in the disk array is also used for other purposes in SGA’s network. Currently approximately 400 GB is physically available on the array, thus only a small part is currently allocated for usage by the topographic database. The array’s storage capacity can be expanded with additional disks to a total of two terabyte (SGA 2004a).

4 CONCLUSION

Until now area that covers 51 of 594 TK25 sheets have been set in database (SGA, 2005). All production processes that are predecessors of topological processing are precisely and exactly explained and defined in Product Specifications and hereby quality control process for all segments is defined in Croatian Geodetic Institute. By the end of 2007 topographic database will cover whole territory of Croatia and all TK25 sheets will be produced and topologically processed with data age from 1 to 10 years (Vilus, 2005).

Trough performance of Program of State Survey and Real Estate Cadastre for the Period 2006-2010, system of topographic database data maintenance, functional applications for needs of thematic cartography and needs of modern visualisation forms will be established, as well as official topographic maps in smaller scales will be produced from database.

In 2010 the first update of database data should be finished and data oldness between 1 and 5 years should be achieved and standards of developed EU states would be reached.
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?? Skaniranje i vektorizacija hrvatske osnovne karte: Cartography, Geoinformation and new technologies, Croatian Cartographic Society's Congress, 2004, Zagreb, Croatia
?? Product specifications – Proceedings of the Third Croatian Congress on Cadastre with international participation (INTERGEO East), 2005, Zagreb, Croatia