SOUTH-WEST UNIVERSITY "NEOFIT RILSKY"
BLAGOEVGRAD, BULGARIA

VOLUME 2
2004

# SCIENTIFIC Research

ELECTRONIC ISSUE

# 3D CARTOGRAPHICAL DIGITAL MODEL OF STRUMA RIVER BASIN

Penka Kastreva

## INTRODUCTION

The latest achievements in cartography and similar disciplines have focused in technology of a digital cartographical modeling [1]. The new information technologies have radically changed the traditional cartographical models. The tree technologies, which transformed the traditional cartography, had the greatest influence upon this. With merging the possibilities of Geographical information systems (GIS), Global Positioning System (GPS) and remote-controlling methods, the achievement in cartographical modeling has become more important, as well as, the thematical cartography.

**The ability of GIS is quickly to overlay new information upon the existing database and also to display it on a colour computer screen. In this way the system helps users to conduct analyses and take the right decisions. GIS comprises software and hardware systems, connecting with the geographical database.**

GPS is the technology that completes GIS. It has become the fundament of modern cartography design and industry. GPS consists of 24 satellites, which go round the Earth in determined orbits. The system can determine quickly and accurately the spacious location (latitude, longitude, and altitude) of a points upon or above the surface. The achieved accuracy for geodesic implications is in centimeters if we use two receivers simultaneously. This ability reduces the price of collected special data, which is necessary for mapmaking. At the same time the accuracy of the cartographical information is higher.

The cartographical method of modeling gives us the opportunity to create graphic, mathematical similar models of real objects in digital way.

The most applied methods for designing and creating such models are: geodesic, photogrametric, space and methods where we use digitalizing, scanning and vectors to survey maps. Each method shows different precision. As a result the accuracy of the data from GIS depends only on the precision of the direct surveys and the scale of the map.

From research [5], [6], [7] we can see that the accuracy of digital methods, received via geodesic methods is in the limit of graphic precision (0.2M) for the relevant scale, while the accuracy of inlet data, received via digitalizing and scanning is just on the line of this accuracy.

## MAIN TASK OF THE PROJECT

The implementation of the research “Creating a 3D model of Struma river basin” is part of the project “System forecasting and warning for floods in Struma river basin”. The project is funded by the PHARE program.

The precise 3D digital model with complete information for Southwest Bulgaria was created as a result of the close collaboration of experts from different Bulgarian Institutions (National Institute of Hydrology and Meteorology and Geoprecise Engineering LTD).

The model presents the whole water catcher of Struma River located on the territory of Republic of Bulgaria. It covers an area of about 8550 $km^2$ (square kilometers) and it is exposed on over 33 map sheets in a scale of 1:50000.

The digital model is created mainly by digitalizing of the existing map sheets. The final product is in format, which relates to ARCINFO format, WGS84 coordinate system and UTM map projection.

**CONTENTS OF THE MODEL**

The created model is made on AutoCAD 2000 and it is tree-dimencial model:

- elevated isolines of the surface with specific points from the surface;
- hydrographical net developed in 3D space;
- 2D road net of the mine road of communication artery;
- railway network;
- outlines of populated areas;
- names and texts with explanation.

Average destiny of the model is about 200 000 coordinate points in area of 400 $km^2$ (square kilometers).

The model is presented in WGS 84 coordinate system– UTM /Universal Transversal Merkator Projection/.

**METHODOLOGY FOR DESIGNING THE MODEL**

To create the model were used the following algorithmic steps:

1. Each map sheet is scanned into two halves on a scanner with precision of 400 pixel/inch.
2. Final double images are inserted consequently in AUTOCAD where the deformations are corrected, adjusted and linked in one image via the whole map sheets.
3. For the purpose of 2D vectors each sheet is leveled in a standard frame with coordinate 0,0-400,400 units.
4. Via studying the isolines, roads, rivers, ets. with polylines in the frame of each sheet, we make 2D vectors. The accuracy varies according to the thickness of the lines-approximately the center of the lines. The density of the points has to be optimal, so after their smoothing (function fit or spline) they have to reflect the full image and at the same time we have to avoid high saturation which will make difficult the process of arranging the information.

After making the 2D model with help of the special prepared programmes for this purpose, the next step is preparing and estimating the 3D model of the reflect and hydrographic net.

5. The high of each isoline (horizontal) describing the terrain is symbolically assignment. As a result a 3D image of the relief is appeared, via series of elevated in space isolines.
6. The river net in 3D is made as in the process of terracing of the river bed elevations are taken down where the river runs and the distances between them are line interpolined.
7. Inserting of specific points, signs and text.

8. Scaling, smoothing of the sheets between them and avoiding the differences via the vector-process.

**5. DESCRIPTION OF THE DATABASE OF THE MODEL**

The model is decomposed into two parts – North and South, for ease access to database according to the information and the files. The decomposing is done as follow:

North Part – including information from map sheets with numbers 9-22-b to 9-44-g;

South Part – including information from map sheets with numbers 9-53-b to 9-64-g.

Each part of the model is arranged from the combination of the relevant map sheets. Specific feature of the model is the fact that isolines making the description of the border upon every two map sheets, are separated into two contrast parts on the linking line. This fact provides the opportunity each map sheet to be drawn separately, as a block in a separate file.

The information included in the files is contributed on different layers according to the character of the depiction with the following structure:

1. Layers ranging from 00 up to 3000 above sea level– contain information for the relief of the area is presented as elevated contour isolines /polylines/ with a section of 20m. which are grouped according to the sea level in hundreds of separate layers. The names of the layers varies in the range from 00 for hills of 0m up to 99m; layers-up to 3000 for hills of 2900m up to 3000m-above the sea level.
2. Specific points of the terrain, like hills, specific points on the surface, hillock, etc. are presented in 3 types of blocks, located in layers with the following names: Point -Ter and Koti. And the descriptive information for the sea level of the points is written on a layer called Attribute.
3. Basic road routes are presented by 5–unit-thick lines, in a plan with 0 elevation in a layer called Roads.
4. Railway net is presented by 10-unit-thick isolines in a plan with 0 elevation in a layer called Railway.
5. Outlines of populated areas are presented in a plan by lines a in a layer called Villages.
6. Rivers, canals, dens and other hydro-equipment with line character are described by 3D polylines located in a layer called River Real.
7. Conventional signs (symbols) of springs, fountains, shafts etc, as well as water catchers are presented in blocks, located in a layer called RiverNet.
8. The names of populated areas, terrenes, etc., are located in a layer called Text.

Besides the above mentioned layers in the model, there are also several layers containing information with the following meaning:

Coordinates– a layer with coordinates of the map sheets corners in WGS84-UTM.

Border – a layer containing the frames of the separate map sheets;

Map Titles –a layer with the names of the maps sheets;

Boundary – a layer containing information about the state border of Republic of Bulgaria;

Watershed – a layer containing information about the border of the water catch region of the river Struma on the territory of Bulgaria.

## 6. CO-USE OF GPS AND GIS TECHNOLOGIES FOR CREATING THE DIGITAL CARTOGRAPHICAL MODEL

### 6.1 Application of geoinformative GPS system

As we have mentioned above to create the digital model we have used mainly the digitalizing method of existing maps. The projection differs from the existing map projection and coordinate system in Bulgaria. In this case have used information from other sources (direct surveys) with order to transform the resulted graphic image in WGS 84 coordinate system. For this purpose we have used coordinates of common points in the model, determined in the two coordinate system-"1970", "WGS 84". To provide more precise surveys we have used modern GPS technology. The surveys are provided with a pair of double frequent receivers. Leisa System 200 on the territory of Southwest Bulgaria.

In this way all geodesic points (mainly triangular points of high rank) are defined by coordinates X, y, Z. Coordinates of points, received by GPS are in WGS 84 system (Worldwide geocentric coordinate system 1984) and they can be transformed in different way according to the national coordinate system. As usual this system refers to accepted in our country referent ellipsoid. To make connection between the two systems WGS 84 and "Coordinate system 1970' are implemented the transformation models [2], [3].

Because of the fact that the object is located in the quite big area, we have used the mathematical model of polynom transformation for plain coordinates, as separately are made the pace in the location and height.

The new dimencioal model of the cartographical area, built on the basis of the existing maps is a combination of the two images. The first one is situational (in 2D ground planned space- fig.1). It is a result of digitizing. The second one relates to the relief (in 3D space-look fig.2). Using the drawn transformational parameters we have made a transformation of the whole map content, i.e. the real objects on the Earth surface are presented in WGS84 coordinate system. This part of the project-GPS surveys their first calculations and transformation of the coordinates using the least squares method and transformation calculations are made by the author of this report.

### 6.2 Inserting data from GPS measurements in the existing GIS software

With uninterrupting development of the geoinformation technologies a combination of tools has been already proposed, consisting of outer laptop with GIS decision and GPS components. In this way topographical measurements could be feasible in digital way and the objects are inserted in location. In our case, such work is made for GPS measurements, related to the created geodesic net for making transformation calculations of the model in WGS84 system. The rest part of the data till forming the digital model on the territory are made in the study in area of AutoCAD 2000. The new founded files can be read by GIS software products ArcView 3.0, ArcView 3.2 and AutoCAD Map2000, which give the opportunities to make spacious analyzes in connection with the subject, already mentioned- "Forecasting and warning for floods in Struma river basin".

**7. FUTURE APPLICATION OF THE 3D DIGITAL MODEL**

There's no point that in such way the geodata base in complicated, challenging and responsible activity. Using this model from other organizations, having relation to the disposed information, present various economic decisions. The digital model, according to the task of the project, is arranged to be used for forecasting and warning for eventual floods in Struma river basin. The model works as fundalmet in development of GIS, connected with the PHARE Project in Bulgaria and Greece, and it is funded by European Bank.

The model could be successfully applied in mapmaking of road net as a basis for geophysical, geological, geomorphological and hydro-geological research.

Another application of the digital model is for discovering, identifying and exploring of dangerous areas, as well as, their analyzing and interaction.

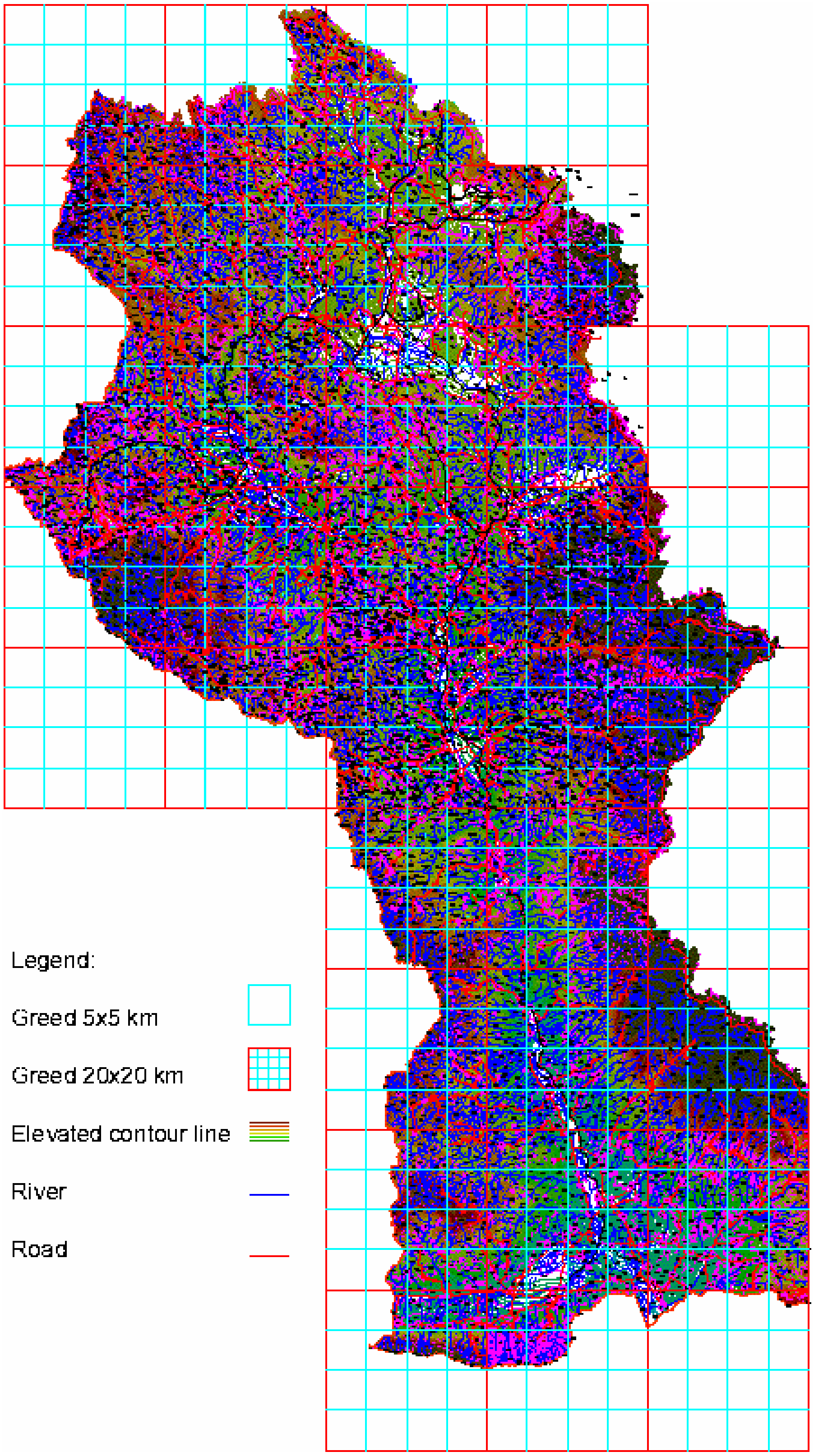


Fig.1. 2D digital model of the Struma river basin

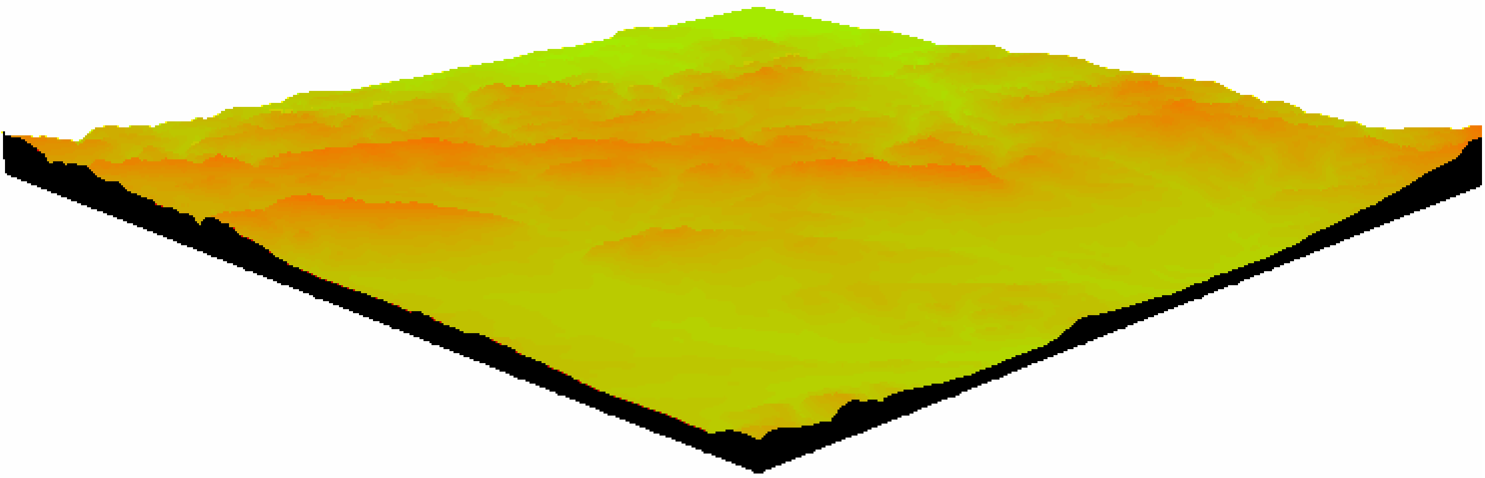

Fig2. 3D digital model of the Struma river basin