

## Application of a software package topocad in geodetic works

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*Software package Topocad is used for processing and analysis of geodetic measurements. The program is developed by Swedish company Adtollo. It contains all the options that are most frequent in the surveying jobs. This paper represents an overview of the project "Applying of software package Topocad in realization of main project at monitoring of sediments accumulation "Nova Grošnica", as well as how one project go through all stages of work, from preparation to implementation.*

**Key words:** surveying, software, topocad, project Nova Grosnica.

### 1 INTRODUCTION

The quality improvement in the area of surveying is something that we have to go with, as well as development of technology, industry and science. In the field of surveying, we have to introduce a quality management practice in our country, and that is why more and more quality improvement projects have been started. All this have to be based on properly software which will comprehend all geodetic works and could work with it as one unity. Considering to that we have to produce experts who have knowledge, competency and skills in geo-measurement, processing, interpretation, analysis and presentation of land-based spatial information with emphasis in the development, implementation, utilization and management of computer-based land and geographical information system.

This paper shows the possibilities of the software package *Topocad*, the software for collecting, processing, analyses and presenting of geospatial information. Concretely here, it's given the analyses of *Topocad's* application in geodetics activities in realization of the main project of monitoring the sediments accumulation "Nova Grosnica", near the city of Kragujevac.

These geodetics activities include the surveillance of cross profiles of the bottom of the accumulation and creation of a digital 3D terrain model using the software *Topocad*, then creation of cross sections and making different analyses by the program itself comparing the tada form two epochs

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The geodetic surveillance of the accumulation "Nova Grosnica" had been done in April, 2008. This measurement is the fifth in a row, and the chronology of this kind of work is as follows:

- the first measurement, during the construction of the dam,
- 1950 – the second measurement – after which the dam was exceeded,
- 1964 - the third measurement,
- 1982 - the fourth measurement for which there is a project documentation, and
- 2008 - the fifth control measurement, which is a part of the technical documentation that is necessary for the renewal of the importance of water management permits for the accumulation of "Nova Grosnica".

With the help of the geodetic software *Topocad* this project was successfully completed.

### 2. BASIC CHARACTERISTICS OF TOPOCAD

Topocad is a reliable, object-orientated CAD system especially made for survey, calculation, mapping, design and GIS. The software was made by a Swedish company Adtollo, in accordance with the standards and requirements developed in that area.

It has been used in:

- surveying,
- civil engineering,
- machine control and machine guidance,
- landscape architecture,
- 3D scanning,
- database management, etc.

In surveying, Topocad is used in many different fields. In the field of engineering, it has multiple roles: securing the basis for topographic survey, establishment of regulatory plans and geodetic networks, development of project documentation, making the databases, expropriation, design of different communications and objects, control of geometry objects, development of information systems, 3D scanning. Among other things, it is also used for various operations (for examples surface area and volume of excavation).

Digital flow of data in *Topocad* is as follows:

- communication and calculation,
- traverse and net adjustment,
- CAD, transformations and mapping,
- connection with ArcGIS and with open source FDO,
- plans and drawings, and
- projecting and designing.

*Topocad* communicates with the majority of the total stations (Leica, Trimble, Topcon and Sokkia) as well as with the GPS receivers and levels. The data transfer is possible in both directions.

The program has the ability to convert data in different formats, suitable for processing in other software systems such as DWG, LandXML, MX, DGN, DXF, XML, PSI, various coordinate files, ESRI shape files, Oracle Spatial data etc.

It can interpret the points and lines, modify them, add symbols, attributes, create a DTM, count line data and other roads directly in the field. It has implemented transformation of vector and raster. As the program code uses object-oriented architecture, the objects in the drawing, such as points and surfaces, behave intelligently and maintain their relationship with other objects. A user has a complete control over all the details of all the facilities at all times and all that can be displayed in 3D system. Transformations can be made from one system into another, supporting various projections and there by facilitating the possibility to set the maps.

So, the TOP files is bigger than DWG or DGN because it contains more data information than ordinary CAD drawings, even more data than GIS files like Shape or MapInfo files. The TOP files as a coordinate files, contain X,Y and Z values, Point ID, Point Code. TOP as the drawing file contain layers, colors, line types, symbols, texts, line widths, arcs, circles, polylines, polygons, splines, dimensions etc. As the GIS file, it contains all kind of attribute data connected to any type of object.

An important factor for surveying is the possibility of network adjustment. Tools for Net Ad-

justment in *Topocad* allow us to input data for an area survey analyze and correct them (Fig.1). Measurement data are organized in databases. They can be integrated with other databases.

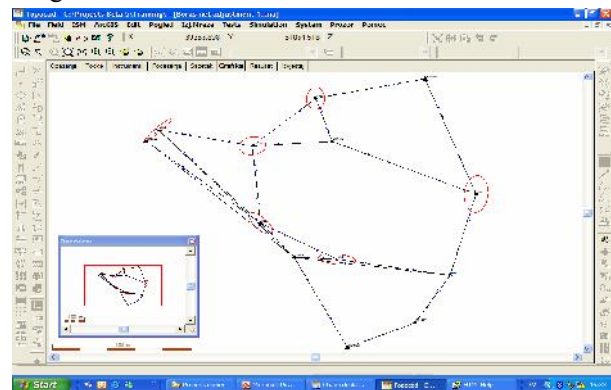


Figure 1 – *Topocad* Net Adjustment

*Topocad* calculates all kinds of differences in the database using the Least Squares method. This provides a good shape and configuration of the network and it allows the determination of adequate model of adjustment, optimization of measurement, in order to obtain a geodetic network of adequate quality. It is also possible to simulate the drawing made out of the same measurements in order to find the optimal solution for geodetic networks.

Bearing in mind that nowadays there is an increasing need of authorities and municipalities to include surveying and engineering work into their local GIS, *Topocad* fits perfectly into ArcGIS and is quite convenient. *Topocad* is connected to the databases (from Microsoft Excel to SQL database), and through the ISM (Independent Spatial Management) module, *Topocad* uses Oracle Spatial database.

*Topocad* reads and writes databases, with all the CAD possibilities to edit and upgrade the data. With *Topocad* database adapter-for ArcGIS we are able to connect the ArcSDE or our personal Geo-database, directly to and from *Topocad*.

The last database adapter that is developed was the open source adapter FDO. It reads and writes via the open source which has been adapted to *Topocad* and makes it possible to access data from several different geospatial data source. *Topocad* uses the following databases: Oracle, ESRI ArcSDE, MySQL, PostGIS, ESRI SHP, GDAL (Geospatial Data Abstraction Library), DGR (Vector format: SHP, GML, DGN, KML, MapInfo, etc. ...), SQLite.

Integration is the word that best describes *Topocad*. Not only due to the integration with the popular GIS formats, but also because of its integration with other databases such as Oracle Spatial Database.

*Topocad* tries to make all stages of work as smooth as possible. That what is special about *Topo-*

cad is its large number of “add-on” modules and packages that increase the field of applications, like Base module, Design module, Topocad field module, Topocad Plane module, Topocad GIS module.

*Topocad* possesses additional modules for the design of roads, railways, sewers, pipelines, excavations, the calculation of concrete and asphalt. All of this is possible by creating longitudinal and cross sections, lines, roads, digital terrain models and the like, as well as their various calculations and analysis.

*Topocad* profile uses a profile form and creates beautiful profile forms (Fig. 2). The module is also used for creation of the profiles from surveys, from profile form and terrain profiles. With this module you can also calculate surfaces and make surface check towards a road for instance.

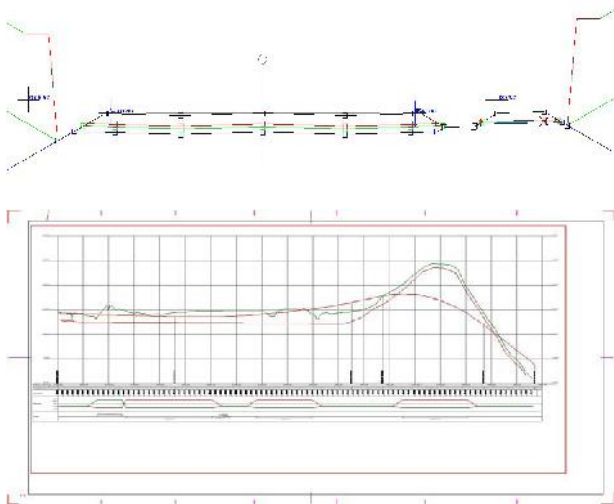


Figure 2 - Cross section profile and longitudinal profile

The *Topocad* Volume by DTM's calculates masses and volumes from two digital terrain models and creates very nice looking drawings of the volume result in form of contour lines and raster. The *Topocad* Volume by cross sections is a very high-effective design module. It calculates cross sections from two DTM's comparing them with the theoretic cross section. The theoretic section can use road lines, longitudinal road profiles, cambers for help and the section can have any number of layers in the superstructure (space between the theoretic top road level to your terrace level) as asphalt layers, etc. (The part of this is shown in Fig. 3)

It is very easy to get data out from this, to the plan drawing in 3D in cross sections or lines along the road or to a LandXML format for immediate stake out or machine control.

The tunnel module is for calculation of volumes and for creation of digital terrain models when it co-

mes to tunnels. It makes almost the same thing for tunnels as volume by cross sections does for roads.

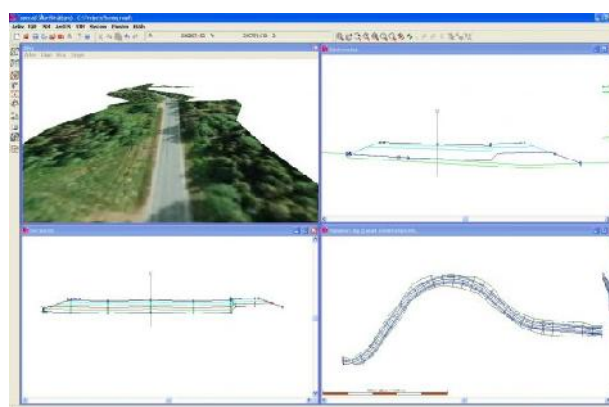
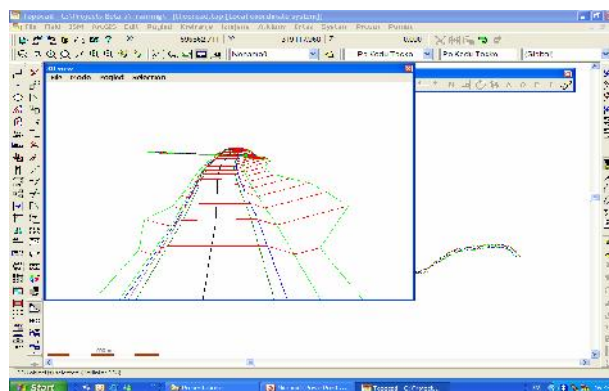


Figure 3 - Creating of road and its 3D view

### 3. THE PROJECT DESIGNING

Every project begins with program requirements and terms of reference, defined and composed by the investor. The performance of all the surveying activities is successful only if an appropriate technical geodetic documentation is created and implemented. In order the performance of geodetic activities in engineering to be successful it is necessary to operate in accordance with the principles of engineering:

**Terms of Reference → Project →  
Implementation of the project → Study on the  
project**

Following these engineering principles and with the corresponding geodetic-technical documentation, one makes the program of geodetic work that basically includes:

- General documentation on the project (terms of reference, textual, numeric, graphical documentation and other additional documentation), and
- Text documents that particularly refer to technical report, quantity calculation of work and technical conditions.

A well-prepared offer takes expertise, resources, time to do that, but it is important to have all the information relevant to the subject of the offer. It is useful if the supplier has its own database. All those necessary elements have been manufactured by the software package *Topocad*.

*Topocad* allows you make a good relation: deadline-price-quality.

#### 4. THE PROJECT REALIZATION

Nova Gnostic is an artificial lake near Kragujevac that was constructed on the river Grosnica with the purpose to water supply of Kragujevac.

For the purpose of the realization of the main project it is necessary to ensure a high-quality basis for geodetic survey that is of an appropriate content and proportion.

The bases for the complete realization of the main project, in addition to the bases of the design represent the official regulations of the authorities and requirements and solutions of the terms of reference.

The first stage in the development of topographic surface based on the data gathered through measurement is the production of various types of situational plans and the required profile.

During the project itself for the purpose of monitoring sediments accumulation "Nova Grosnica" the Investor had given a study on the accumulation (made in 1980) to the contractor in order to make a comparative analysis. Using *Topocad*, the information relevant to the analysis in this study was transferred from analog to digital and vector form.

The accumulation "Nova Grosnica" was defined by the 25 basic profiles that the contractor received from the investors.

Comparing the existing profiles and the profiles obtained by the digital terrain model based on measurement data processing by *Topocad*, one get the data which were used for the analysis of monitoring the bottom of the reservoir "Nova Grosnica".

Taking into consideration all the laws, terms of reference and other conditions the project was successfully implemented.

#### 5. THE PROJECT REPORT

After collecting the data we got access to realize the geodetic measurements. First, it was necessary to set out a high-quality geodetic basis, i.e. create a high-quality geodetic network around the lake. The points from the State control network (third and fourth order) were used as the given geodetic basis points for recording. The basic network is consisted of five points: T202/G8/KG, T424/G8, T447/G8,

T49/K13/KG, T725/KG. Considering the accuracy and reliability of the network, it was, therefore, best to straighten the network as free or with a minimum number of the given values.

Creating a geodetic network provides the 3D spatial rectangular system, creating of digital terrain model (DTM) and projected profiles.

Some preparations were carried out in order to realize the terms of reference. For example: collecting data about the trigonometric network of the Republic Geodetic Authority, calculating the parameters of localization and control measurements.

When the calculation was completed, the transformation from the current coordinate system (usually WGS84) into the existing coordinate system in which the coordinates are demanded was done. This transformation was performed through several different projections and coordinate systems. In *Topocad* this is called GTrans.

Then we approached to the measurement. We have been realized measurement of cross sections of the bottom of the lake and it was done by the system "GPS Echo sounder" where GPS defining position and echo sounder measuring the depth of the lake, in order to obtain the picture of the bottom. A boat with this GPS Echo sounder system was directed by the previously defined profiles that were pre-designed in the software *Topocad* and exported into the instrument. On the field, the program directs the boat according to the designed profiles of the survey.

With the "GPS echo sounder" system it is possible to determine three-dimensional spatial coordinates (X, Y, Z) for each depth point and it was performed on every meter of each profile, on both sides.

Geodetic cross sections of the bottom of the lake was carried out by the instruments:

- GPS System 1200, dual frequency RTK receivers
- Echo sounder "ATLAS DESO 300", Probe 210 kHz (accuracy 1 cm), and
- Motor boat.

Geodetic Survey of the reconstructed points of mirrors of the lake was carried out by a combination of:

- Topcon Total Station (The angular accuracy of 1 ["], accuracy measurements of length of 2.2 ppm), and
- GPS System 1200 dual frequency RTK receivers"(accuracy 1.5 cm).

Expert team was consisted of:

- -Mr Borko Draskovic,.
- -Bojana Zikic, and
- -Vladimir Beljakovic.

On the basis of processing the data in *Topocad*, the cross sections are obtained in digital form, as well as the 3D digital model, which makes it possible to make different analyses. The defined points of the ends of the profile - the mirror of the lake served as a basis for making the profile.

After writing the points, i.e. their coordinates, *Topocad* performed an interpolation followed by a digital terrain modeling. (Fig. 4: creating a 3D terrain model of the lake).



Figure 4 - Creating DTM and its 3D view

After that, a sketch of each profile based on digital terrain model was obtained, and also the maximum size of each profile was calculated. The area represents the area between the measured profile and the profile of water with the elevation of 312.38 m. The attached graphic shows the sediment surface or erosion.

The profile form in *Topocad* is very quick and easy to operate and it consists of only a few steps for each profile individually. First, the profile is mathematically defined by its height and position. After this selection of the desirable data was made, an order in which the information would be displayed was set, as well as the selection of the colors and types of lines. (Fig. 5).

Based on these data, the sketch of each profile with components, and also a maximum size of each profile are obtained. The attached graphic shows the components of profiles and sediment or surface erosion.

That allows the ability for analysis of the sediments accumulation of "Nova Grosnica". It was performed in relation to the activities of the previous epoch by comparing the profiles.

## 6. CONCLUSION

This paper should create a clear picture of how precisely and in what way it is possible to gain an

insight into the organization of geodetic survey and the application of the software in all of the phases of the colors and types of lines. (Fig. 5).

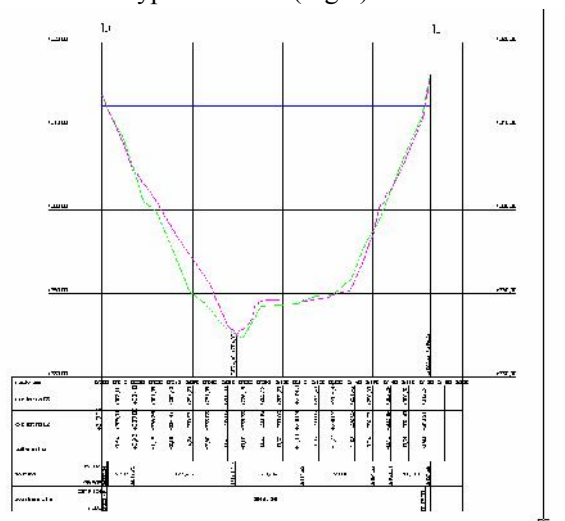


Figure 5 - Profile with all its components

This work had a task to get introduced you into a *Topocad*'s mission which includes the *Topocad* as a user-oriented program that has a role in the design of different types of objects in the field of construction building, civil engineering, hydraulic engineering, architecture, etc. It is a very good development of the information system that meets the needs of surveyors.

As the future of geodesy is based on automatic measuring devices which can, in a short period of time, gather as many high quality and detailed information as possible concerning the area, with the greatest possible accuracy and reliability of the entire system, it was necessary to built in the 3D laser scanning component as well. Automatic measurement of spatial coordinates, detailed points of the earth's surface and objects on it, high speed of the gathering of data, a high level of the automatization of the measuring process and a high degree of accuracy in the measurement make this method most appropriate for the demonstration of complex geometric data. *Topocad*'s module for the 3D scan helps in the collection, visualization, extraction, analysis and representation of data from the point clouds.

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## REZIME

### PRIMENA SOFTVERSKOG PAKETA TOPOCAD U GEODETSKIM RADOVIMA

*Rad detaljno opisuje neophodne aktivnosti u okviru prikupljanja prostornih podataka s ciljem izrade modela topografskih površi, stvaranja DTM, uzdužnih i poprecnih profila, kao i drugih neophodnih analiza, softverskim paketom Topocad. Topocad je predstavljen kao celina i pokazane se njegove mogućnosti u pogledu zadovoljenja i najsloženijih geodetskih terenskih poslova i zadataka.*

**Ključne reči:** *geodezija, geodetski program Topocad, projekat Nova Grosnica.*