

### **3D LAND MODELLING USING GPS TECHNOLOGY IN BENCECU DE SUS, TIMIS COUNTY, ROMANIA**

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**Abstract:** *This paper aims at developing the 3D land model of Bencecu de Sus, Timiş County, Romania, as a result of land survey. Land survey was done with a Leica GPS 1200 equipment, an extremely powerful instrument, that contains a number of applications. GPS 1200 can be used as either reference or rover for static or kinematic measurements (RTK); it can be used for topographic surveys, tracing, monitoring, and seismic measurements. GPS 1200 receivers are designed to work in the hardest conditions being able to operate in immersions up to 1 m; it is shock proof and vibration proof, it operates on rain, in dust, sand, and snow, at temperatures between  $-40^{\circ}\text{C}$  and  $+65^{\circ}\text{C}$ . In this paper, we used the RTK (Real Time Kinematic) method for GPS measurements using, for the 3D model of the land, the reference station in Timisoara, Romania, i.e. TIM 2.3. The measuring engine used by Leica GPS 1200 is of the SmartTrack type which reaches satellites in just a few seconds: it is ideal for the areas with obstructions where other receivers cannot reach any position. The antenna used to achieve the work is of double frequency (GX 1230) with SmartTrack and is designed to also support GLONASS signals, GPS L15 signals, as well as the signals of the future European GPS network GALILEO. Leica GPS 1200 uses a keyboard of the QWERTY type, touch screen or common screen and allows direct visualisation of the land survey; it has also available the ZOOM and PAN functions. Data can be exported directly by the GPS 1200 receiver but, for the present paper, data download was done with the Leica Geo Office Combined Programme. The reference system of the GPS is WGS 84 (World Geodetic System 1984) that is defined like the ITRF system of coordinates of the determined land points. Using on an increasingly larger scale of the positioning systems through satellite and of the global systems of mapping through satellite to carry out geodesic works can bring about serious practical difficulties if the results need to be reported to older maps or digital data. The main difficulty consists in turning geocentric data into local data describing old data or vice versa. After downloading, data processing and turning coordinates from ETRS89 into STEREO'70 with the TransDatRO 4.01 application, we calculated the 3D land model with the TopoLT Programme, a programme functioning on the AutoCad platform. Building up a 3D model consists in developing a continuous area through interpolation starting from the field data. Topographic survey, due to the quality of the data provided, is one of the most important methods of acquiring data at local scale and particularly of completing existing datasets with detail data. Using GPS (Global Positioning System) to acquire the data necessary for the development of the Numerical Land Model is a more economic alternative for classical topographic survey.*

**Key words:** *3DModel, GPS, ETRS89, STEROGRAFIC 1970, TopoLT, TransDatRO, WGS 1984*

#### **INTRODUCTION**

The emergence of modern total stations is a great step ahead in terrestrial measurements owing to increased precision, work speed and efficiency. The apparition of the GPS technology has been a great step in the same direction. Most likely this is the last stage in the field, as what will follow will be only a reduction in price and receiver dimensions correlated with an increase in autonomy and accuracy. However, as far as the operating principle is concerned, my personal opinion is that no other radically different system will be developed.

The use of GPS equipment has the advantage that it does not require angular and distance measurements and the inconvenience of using total stations is also eliminated. At the same time, it is worth mentioning that with the RTK method (Real Time Kinematic) it is possible to determine coordinates with an accuracy that is comparable to that of the total

stations and in a suitable period of time. One must also take into consideration the necessity to align Romania to the European and international standards by developing a GPS reference geodetic network of high-precision, whose points should be determined and included in the EUREF European GPS geodetic network.

Starting with 2009, the National Network of Permanent GNSS Stations (NN-PGS) has 73 permanent stations. The first permanent GNSS station (BUCU) was installed at the Faculty of Geodesy, Technical University of Civil Engineering Bucharest in 1999, with the help of the Federal Agency for Cartography and Geodesy of Germany (BKG). A rapid development of NN-PGS started in 2004 with the modernisation of the already existing stations and the installation of new ones. The years 2005 – 2008 saw the modernisation of NN-PGS through the acquisition and installation by NACLR (National Agency for Cadastre and Land Registration) of state-of-the-art equipment and software. Starting with 2006, besides the European class (EUREF) permanent GPS station BUCU, which became a permanent station within the IGS (International GNSS Service) network, Romania has been part of the European Reference Frame – European Permanent Network, after the integration of four more permanent GNSS stations: BACA (in Bacau), BAIA (in Baia Mare), COST (in Constanta) and DEVA (in Deva). In June 2008, 48 permanent GNSS stations were installed. In December the same year, their number reached 58, and by 2009, it reached 73. The average distance between the permanent GNSS stations is about 70 km.

#### MATERIAL AND METHODS

The topographic elevations for this paper were performed with Leica GPS 1200, a very powerful device with many applications and functions that can satisfy the requirements of users worldwide.

GPS1200 can be used either as reference or rover for static or kinematic measurements (RTK); it can be used for topographic elevations, tracing, monitoring, and earthquake measurements. GPS1200 receivers are designed to operate under the roughest weather conditions. They are waterproof up to 1 m water depth, shock, vibration, rain, dust, sand and snowproof, able to operate at temperatures between  $-40^{\circ}\text{C}$  and  $+65^{\circ}\text{C}$ .

For this paper, the GPS measurements were taken with the RTK (Real Time Kinematic) method, using the TIM1\_2.3 reference station in Timisoara.

The measurement engine of Leica GPS1200 is a SmartTrack type that acquires satellites within seconds; it is ideal for construction areas where other receivers cannot find a proper position.

The aerial used for this paper is of dual frequency GX1230 type, SmartTrack being designed to support GLONASS, GPS L15 signals, as well as the signals of the future European GPS network GALILEO. Leica GPS1200 uses QWERTY keyboard, with touch screen or non-touchscreen, as requested. The elevation can be viewed directly in the field as well as from the office. ZOOM and PAN functions are also available.

The collected data can be exported directly by the GPS1200 receiver, but for the present paper they were downloaded with the *Leica Geo Office Combined* programme.

The GPS reference system is **WGS 84** (World Geodetic System 1984) that, like the ITRF system, is defined by the coordinates of the determined terrestrial points.

The wider and wider use of satellite positioning systems and satellite global mapping systems for geodetic operations may cause serious practical difficulties if the results of these spatial techniques must be related to older maps or digital data. The main difficulty lies in changing data from geocentric data to local data that describe older data or vice versa.

The *TransDatRO 4.01* software application is a transformation procedure similar to other international procedures. It embeds a spatial data distortion model in order to maintain spatial data integrity and topology in each datum. As a result, points with larger distortions are not eliminated. On the contrary, they are tested and included in the transformation, in order to describe as realistically as possible the characteristics of each area containing new points awaiting transformation.

*TopoLT* is a programme operating under AutoCAD. The *TopoLT* programme is of great help for those who develop topographic or cadastral plans in digital format.

In the development of the **3D** model, we can apply different colour levels for each facet of the model. Colours are applied from the minimum to the maximum of the point quotas (Z coordinates) through which a **3D** model is developed. Colours for level application can be edited. Colour palettes can be saved in files and re-loaded from saved files.

A **3D** model of the land can be developed using points whose coordinates are X, Y, Z or spatial lines and poly-lines. Interpolation in this version of the programme is a triangulation method with linear interpolation.

Generating a digital model of the land refers to *the way data is acquired*, to the model development proper through different *interpolation methods*, as well as to *the choice of the structure of data representation (raster or TIN)*. The best is the *Delaunay interpolation* allowing the development of triangles perfectly circumscribed to some circles, in which the distance between the points that make up the tips of the triangle is always minimum. **For each triangle** we memorise *the coordinates and attributes of the three tips, the topology and the slope and sloping direction of the triangle area*.

To visualise, the 3D model can be rotated in real time.

## RESULTS AND DISCUSSION

The Digital Elevation Model (DEM) is the starting point for both the calculus of some morphometric elements of the relief and the development of digital geomorphologic maps and the space analysis and mathematical modelling – methods specific to GIS (Geographical Information Systems) for the solution of theoretical and practical problems in geography and not only.

DEM are “tools” that are absolutely necessary in almost any type of analysis or modelling. This is why, even in the 1950s, at the beginning of the development of mathematical modelling of the land area, digital methods of elevation represented basic components of GIS; they are now considered sub-systems of GIS (Digital Terrain Modelling Systems).

The term “digital terrain model” was first used in 1958 by Miller and Laflamme who defined it as “a static representation of the continuous area of a land using a large number of points whose horizontal coordinates (x, y) and altitude (z) are known, representation developed in an arbitrary coordinate system.”

The quality of the land digital methods is determined by the quality of the pixel values (in the case of DEM) or their equivalent in other methods. Their quality is a function of a number of variables: Land hardness, Data source quality, Data acquisition method, Sample density, Interpolation algorithm, and Vertical resolution.

DEM is made up of a number of ordered information concerning the plan metric position and the quota of some points describing the configuration of the space display of relief structures; it facilitates the reconstruction of their area in new points.

Area modelling is the process of representing graphically a natural or artificial area through one or more mathematical equations.

Digital Elevation Model (DEM) refers, in general, to the digital representation of the land surface through altitude values. They are displayed evenly and make up a matrix represented by a network of regular form cells, most often square and most rarely triangular or hexagonal. This name is familiar in the USA and Canada.

At present, the term is also used to represent numerically values (other than altitude ones) or phenomena that vary continuously in the space and that can thus be represented by continuous areas. In this case, the starting data no longer represent land altitude but the magnitude of the phenomenon on those points; we can thus obtain digital models with wide applicability (e.g., the digital model of air temperature, of precipitations, of piezometric level, etc.).

### PREPARING TOPOGRAPHIC MEASUREMENTS

After establishing with accuracy the buildings to be measured, we applied for information from the Timisoara B.C.P.I. to obtain the coordinates of the contour points of the buildings in the area. Then, with the area framing plan at the scale of 1:10000 (Figure 1) and o the details in the database, we could identify the sole in the field.

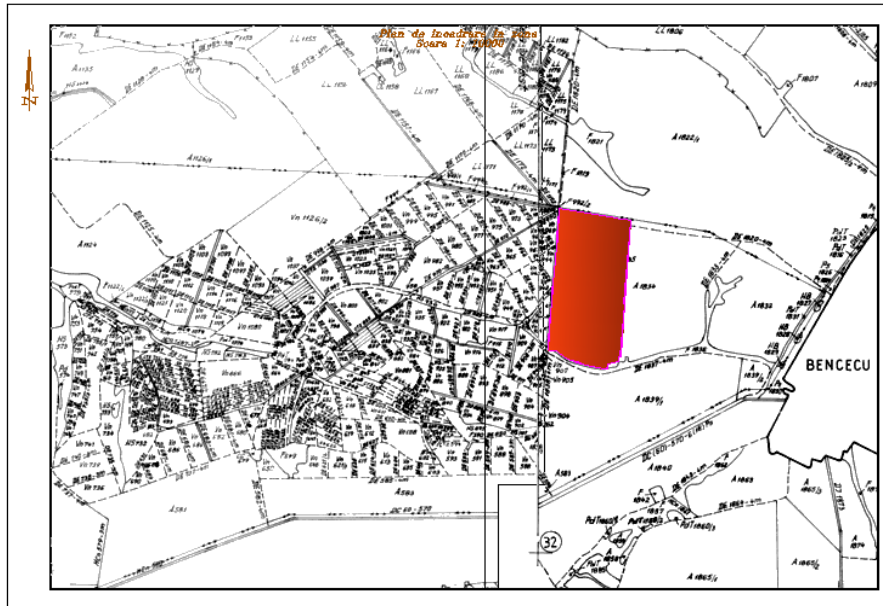


Figure 1 – Area framing plan

After identifying the sole in the field, we made the topographic survey necessary for the development of the 3D model. To do so, after configuring the apparatus, we chose the reference station to make the measurements. In this paper, the reference station used is presented in Table 1 below.

Table 1

Permanent GNSS station used				
GEOCENTRIC CARTESIAN COORDINATES				
Permanent station	Class	Xc	Yc	Zc
Timisoara (TIM1_2.3)	A	4153556,883	1613641.291	4548330.869
ELLIPSOID COORDINATES				
Permanent station	Class	B[m]	L[m]	He[m]

Timisoara (TIM1_2.3)	A	45°46'47.65271"N	21°13'51.46281"E	154,7278
1970 STEREOGRAPHIC COORDINATES				
Permanent station	Class	X(m)	Y(m)	Z(m)
Timisoara (TIM1_2.3)	A	482495.124	207132.249	111.641

**UNLOADING THE GPS LEICA 1200 AND DATA PROCESSING**

Information resulted from measurements is stored on a *Compact Flash* card type. It can be unloaded with this card, which is connected to a card reader, and specialised Leica software called *Leica Survey Office Combined*, which is easy to use both for unloading and uploading data.

A NEW PROJECT (figure 2) is created by pressing the *Project* icon. A *New project* box appears. Our project is called "**BENCEC 3D**" and uses the parameters for transforming the coordinates from the WGS84 system to the 1970 stereographic system.

When the new project has been created and named, the coordinates are chosen. We have other calculated Helmert parameters and in this case the transformation from the WGS84 system to the 1970 stereographic system takes place directly, with *Leica Geo Office Combined*. It is not necessary to process the file with the *TrasDatRO 4.01* file to transform the coordinates. A click on OK will send the new project entitled "**BENCEC 3D**" on the project list.

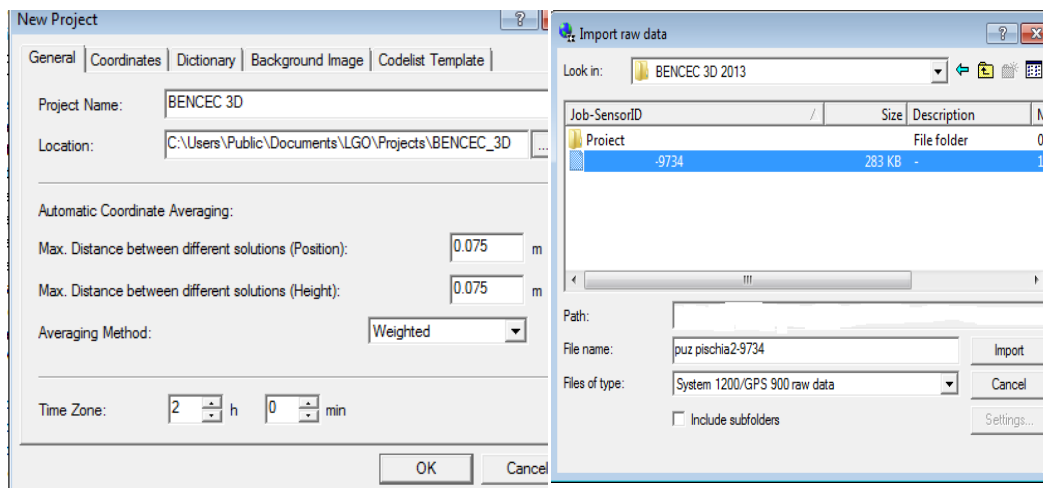


Figure 2 – Name of the new project and import of raw data

The next step is to import the data from the card in the device, using the *Import Raw Data* command. After that, the measurements file will be obtained from the GPS Leica 1200.

**THE MEASUREMENT FILE** obtained after the measurements is presented below only partially because the measurements through *Display Fieldbook* cover 122 pages:

**Fieldbook Report**

03/25/2012 10:33:20

**Job Information**

Job name: Bencec 3d  
 Time zone: 2h 00'

Coordinate system name: PARAMETRES PE TIM  
 Application software: LEICA Geo Office 6.0  
 Firmware version: 5.60  
 Codelist name: SYSTEM1200  
 Average limit (Position): 0.0500 m  
 Average limit (Height): 0.0750 m  
 Job name: Bencec 3d

**Coordinate System Information**

Coordinate system name: WGS84  
 Transformation name: -  
 Transformation type: Classical 3D  
 Height mode: Orthometric  
 Residuals: No distribution  
 Local Ellipsoid: Krassowski  
 Projection: Romania Stereo 70  
 Geoid model: -  
 CSCS model: -

**GPS Coordinates**

**Baseline Reference: RTCM-Ref 0000 Rover: 1**

WGS 84 Coordinates:  
 Latitude: 45°46'47.65271"N 45° 53' 08.94863" N  
 Longitude: 21°13'51.46281"E 21° 25' 19.79625" E  
 Ellip. Hgt: 154,7278 233.1222 m  
 Quality: Sd. Lat: 0.2738 m Sd. Lon: 0.2239 m Sd. Hgt: 0.4814 m  
 Posn. Qlty: 0.3537 m Sd. Slope: 0.1983 m

**Baseline Reference: RTCM-Ref 0000 Rover: 2**

WGS 84 Coordinates:  
 Latitude: 45°46'47.65271"N 45° 53' 09.12660" N  
 Longitude: 21°13'51.46281"E 21° 25' 19.50456" E  
 Ellip. Hgt: 154,7278 232.8215 m  
 Quality: Sd. Lat: 0.0191 m Sd. Lon: 0.0156 m Sd. Hgt: 0.0336 m  
 Posn. Qlty: 0.0247 m Sd. Slope: 0.0138 m

**Baseline Reference: RTCM-Ref 0000 Rover: 3**

WGS 84 Coordinates:  
 Latitude: 45°46'47.65271"N 45° 53' 09.47839" N  
 Longitude: 21°13'51.46281"E 21° 25' 18.85778" E  
 Ellip. Hgt: 154,7278 233.2813 m  
 Quality: Sd. Lat: 0.1312 m Sd. Lon: 0.0993 m Sd. Hgt: 0.2523 m  
 Posn. Qlty: 0.1645 m Sd. Slope: 0.1066 m

**Baseline Reference: RTCM-Ref 0000 Rover: 4**

WGS 84 Coordinates:

Latitude:	45°46'47.65271"N	45° 53' 09.74923" N
Longitude:	21°13'51.46281"E	21° 25' 18.07441" E
Ellip. Hgt:	154,7278	234.2275 m
Quality:	Sd. Lat: 0.0854 m Posn. Qlty: 0.1112 m	Sd. Lon: 0.0713 m Sd. Slope: 0.0568 m
<b>Baseline Reference: RTCM-Ref 0000 Rover: 5</b>		
WGS 84 Coordinates:		
Latitude:	45°46'47.65271"N	45° 53' 10.12605" N
Longitude:	21°13'51.46281"E	21° 25' 17.22108" E
Ellip. Hgt:	154,7278	234.6989 m
Quality:	Sd. Lat: 0.0260 m Posn. Qlty: 0.0334 m	Sd. Lon: 0.0210 m Sd. Slope: 0.0168 m
<b>Baseline Reference: RTCM-Ref 0000 Rover: 6</b>		

#### TRANSFORMING COORDINATES USING THE SOFTWARE TRANSDATRO 4.01

The software application *TransDatRO 4.01* we used is a transforming procedure similar to other procedures worldwide that consists of a distortion model of space data to maintain space data integrity and topology in each datum. In conclusion, points with larger distortion are not exempt from transformation; on the contrary, they are tested and included in the transformation to describe as realistically as possible each zone of the new points to be transformed.

Further on, we transformed the coordinates with a *TrasDatRO 4.01* programme (Figure 3).

We chose the way to transform the points, i.e. from ETRS89 into Stereografic 1970. Transforming the WGS84 coordinates can be done individually for each coordinate, which would need a lot of time (Figure 3) or interactiv files by processing the file with the extension txt and by introducing the file through ENTRY FILE (we looked for the location where the file was saved) and by pointing to the path where the file was to be saved through EXIT FILE (Figure 3).

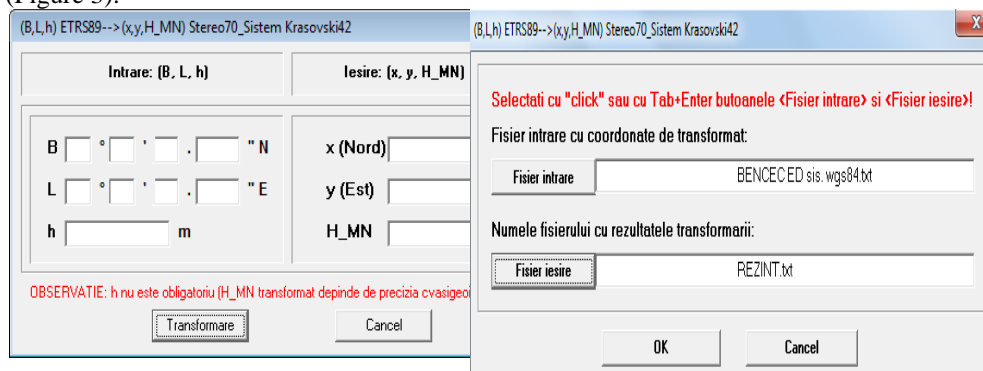


Figure 3 – Transforming WGS84 coordinates into stereographic coordinates 1970

### JOINING THE OBTAINED POINTS AND DRAFTING THE PLANE

We can thus obtain the coordinates in the stereographic projection system 1970 for all the points. They are then imported into the **AutoCAD 2012** with the **RAPPCT command** from the sub-menu of the **TopoLT** Programme. Below we present partially the stereographic coordinates 1970 obtained through the transformation of the WGS84 coordinates with the **TrasDatRO 4.01** Programme.

Once the points are loaded in AutoCad, they are joined using the Polyline command. When the polyline is closed, the area of the polygon is calculated. The scale chosen for plane representation when drafting the technical documentation is 1:1000 (figure 4), so that all survey details are highlighted.

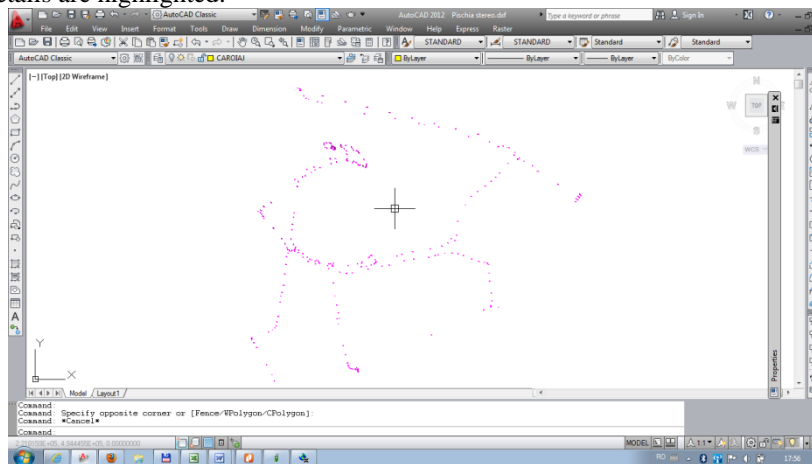


Figure 4 – Presentation of the downloaded points

After linking the points downloaded and processed (Figure 5), we checked the data by overlapping the information obtained and the orthophotoplan **TM\_Pischia\_image.sid.xml** presented in Figure 6. Figure 7 presents the 3D model representation, and Figure 8 presents the 3D model with the **TopoLT** programme. Figure 9 presents the situation plan developed in AutoCad emphasising level curves.

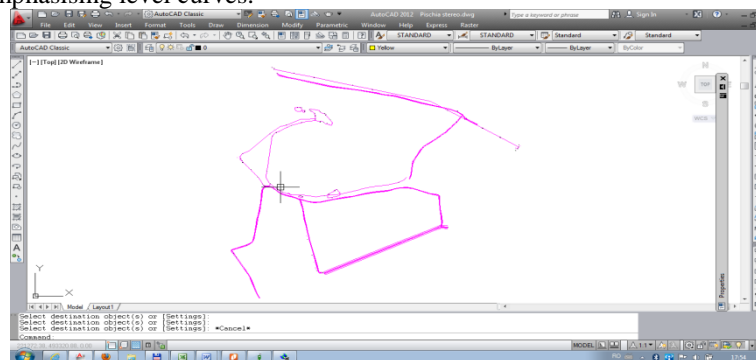


Figure 5 – Linking the points obtained after downloading the apparatus and after processing



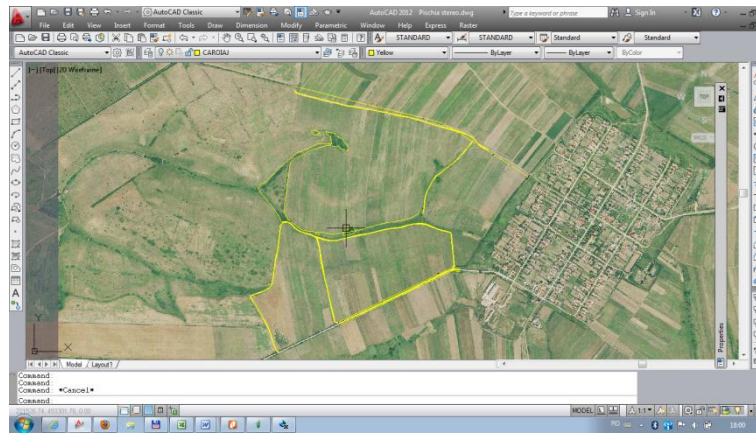


Figure 6 – Checking the correctness of the data obtained by overlapping the orthophotoplan TM\_Timisoara\_image.sid.xml (1)

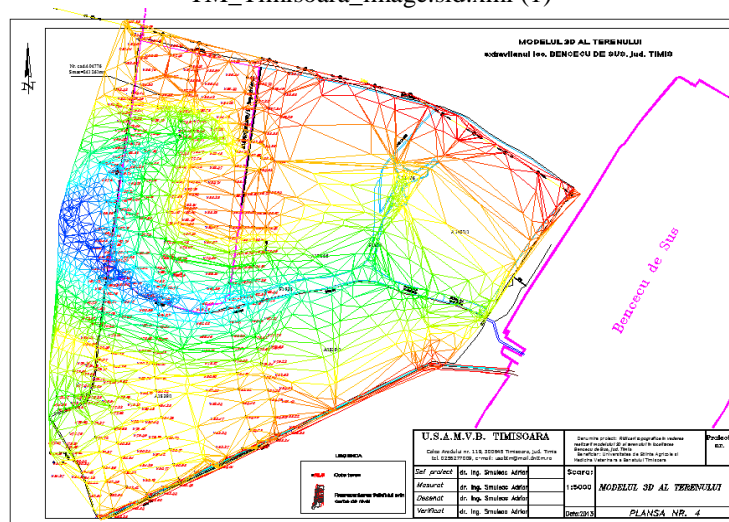


Figure 7 – Situation plan with 3D terrain representation model

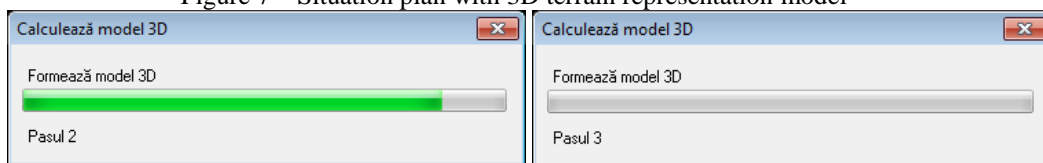


Figure 8 – Developing the 3D model with the TopoLT programme

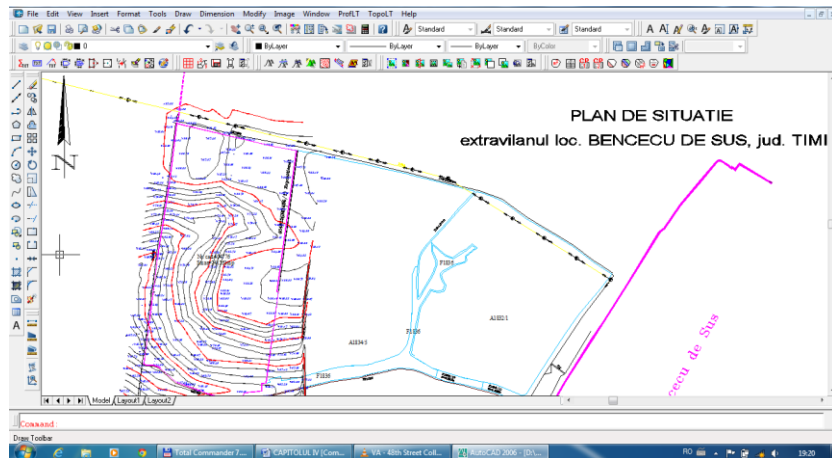


Figure 9 – Situation plan developed in AutoCad by emphasising level curves

### CONCLUSIONS

This paper aimed at carrying out a topographic survey to develop a land 3D model; the topographic survey was made with a Leica 1200 GPS, downloading was done with a Leica Geo Office Combined, and the 3D terrain model was done with a TopoLT programme operating under AutoCAD, a programme of great help for topographers making digital topographic or cadastral plans.

The survey method is of the Stop and Go type, which supposes the alternate movement and stationing of a receiver, with measurements done when stationary. The station time is between a few seconds to several minutes. The most important quality of the method is its precision, as a result of the time accumulation in several steps when their mean is also calculated (an observation step lasts 5 seconds).

The *Stop and Go* working method can be used to determine detail points for real estate cadastre, in geodesic engineering, etc. Through the development of the technology, GPS receivers will become available for a larger number of users; thus, the *Stop and Go* method will probably replace classical land measurement methods. This is why the *Stop and Go* is believed to have a great future ahead.

### BIBLIOGRAPHY

1. NEUNER J., SISTEME DE POZIȚIONARE GLOBALĂ, ED. MATRIXROM, BUCUREȘTI, 2000
2. POPESCU C., TELEDETECTIE SI SISTEME INFORMATICE GEOGRAFICE IN AGRICULTURA, ED. EUROBIT, 2007
4. \*\*\*[www.ancpi.ro](http://www.ancpi.ro)
5. \*\*\*[http://earth.unibuc.ro/tutoriale/realizarea-unui-model-3d\\_folosind-saga-gis](http://earth.unibuc.ro/tutoriale/realizarea-unui-model-3d_folosind-saga-gis)
6. \*\*\*[http://enciclopediaromaniei.ro/wiki/bencecu\\_de\\_sus](http://enciclopediaromaniei.ro/wiki/bencecu_de_sus)