Topographic surveys for volume calculus in Milova, Arad County, Romania

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Abstract. Topographic surveys whose results are presented in this paper were made in Milova, Arad County, Romania. Topographic measurements aimed at calculating the volume of different sorts of mineral mine ballast aggregates such as ballast, sand 0-4, broken stones 4-8, broken stones 8-16, broken stones 16-32. Topo-cadastral measurements were made with a GPS equipment from Leica 1200 Series, and apparatus downloading and data processing were done with a LEICA Geo Office Combined Programme. Data processing aiming at developing a 3D model was done with a TopoLT software, and the GRID model of the amounts of mineral ballast aggregates as well as the volume calculus were done with a Surfer 8.0 software produced by Golden Software.

Measurements were made with ROMPOS (Romanian System for the Determining of the Position), a project of the National Agency for Cadastre and Real Estate, to ensure accurate reference positioning and ETRS European coordinates through the Permanent GNSS National Network Station.

ROMPOS relies on GNSS (Global Navigation Satellite Systems) (future GPS/GLONAS/GALILEO), supplying data for positioning goals to improve the precision of a position up to an order of one millimetre.

The permanent GNSS Station used to produce the results presented in this paper is the one in Timişoara, Timiş County, Romania.

Keywords: GIS, Network, transportation, minimum route.

1. INTRODUCTION

The GPS (Global Positioning System) technique is the most recent way to measure and process in a flexible, effective way, geodesic and topographic networks and detail points used in cadastral works. GPS relies on a constellation of 24 satellites that circumnavigate the planet Earth on six known orbits at very high altitudes. The altitude of the orbits on which the satellites gravitate prevents the system to interfere with soil wave systems. GPS is a high-precision technology, which renders exact item position on the Earth surface.

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 eliminated. At the same time, it is worth mentioning that with the Stop&Go method (or 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.

2. MATERIAL AND METHOD

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 as either 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 snow proof, able to operate at temperatures between -40°C and +65°C.

In this paper, we used the Stop&Go (or Real Time Kinematic) method to make the measurements, using the reference station at Făget – FAGE_2.3

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-touch screen, 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.

The transformation process takes place in two stages:

1) Helmert transformation and the determination of distortions in common points;

2) Interpolation of distortions in new points awaiting transformation.

Having processed the data and changed the coordinates from ETRS89 to STEREO70 with the **TransDatRO 4.01** application, the volumes were calculated based on the 1970 stereographic coordinates obtained with SURFER 8.0. **Surfer** is a very complex product of *Golden Software,* a company that specialises in computer graphics. It is very effective in making digital maps.

The spatial terrain model is based on the points with the X, Z, Y coordinates registered in ASCII-type files with *.DAT* extension. Based on these coordinate points that are disposed on the surface of the whole spatial model that is to be created, a network of points with X, Z, Y coordinates of GRID type is created (it is a grid-type network). The network has a certain point density that is registered in GRID-type files with .GRD extension.

3. RESULTS AND DISCUSSION

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

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

Information from measurements is stored on a **Compact Flash** card. Downloading is done with a **Compact Flash** card connected to a card reader and with a **Leica Survey Office Combined** programme, easy to use for both downloading the job and for uploading the job.

After creating and naming the new project, we choose the coordinates used. If there are other parameters calculated, we can choose them from the list and choose coordinates transformation parameters. In this case, transforming the coordinates WGS84 into stereographic coordinates 1970 is done directly from **Leica Geo Office Combined** without processing the file **Volumes Milova, Milova.txt** that was saved and introducing the file **Volumes Milova, Milova.txt** into the programme **TrasDatRO 4.01** for coordinate transformation. After these steps, we click the OK icon and the newly created project **Volume Lipova-Milova, Arad** is on the list with created projects.

The next step is to import data from the apparatus card using the command **Import Raw Data**.

After importing data, the coordinates thus obtained are displayed in the WGS84.

Permanent GNSS Station used to make the measurements:

GEOCENTRIC CARTESIAN COORDINATES – ETRS89				
Name of permanent station	Class	Xc	Yc	Zc
Faget (FAGE_2.3)	A	4120872.648	1679781.156	4554158.791
ELLIPSOID COORDINATES – ETRS89				
Name of permanent station	Class	B[m]	L[m]	He[m]
Faget (FAGE_2.3)	A	45°51'16.42753"N	22°10'37.78289"E	216,4898
1970 STEREOGRAPHIC COORDINATES				
Name of permanent station	Class	X(m)	Y(m)	Z(m)
Faget (FAGE_2.3)	A	48749.641	280960.451	173.080

4. THE CREATION OF THE 3D LAND MODEL AND OF THE VOLUME CALCULUS

1. Volume calculus for ballast 1
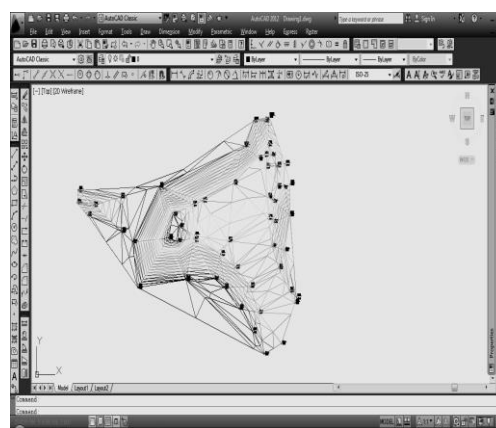*Visualising the 3D land model* – AutoCAD (Figure 1)

Figure. 1 3D land model in AutoCAD - ballast 1

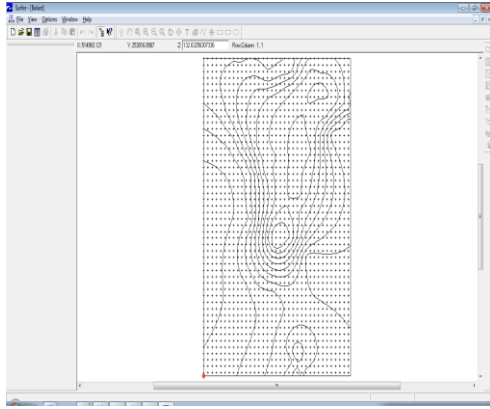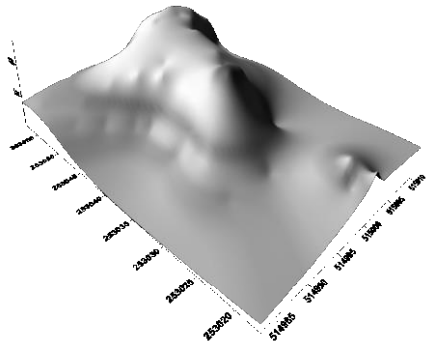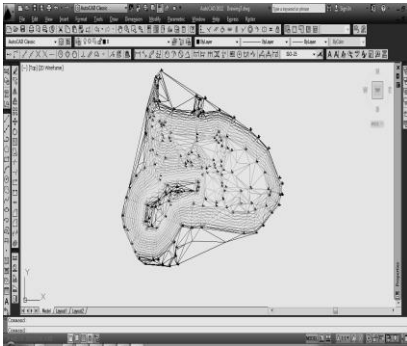**The GRID** *land model* developed to calculate the volume (Figure 2).

Figure. 2 Development of the GRID model in SURFER 8.0

The SURFER V8.0 model
Ballast 1 volume: 978 m³

Visualising the 3D land model – AutoCAD
(Figure 3)

2. Volume calculus for ballast 2

Figure 3. 3D land model in AutoCAD - ballast 2

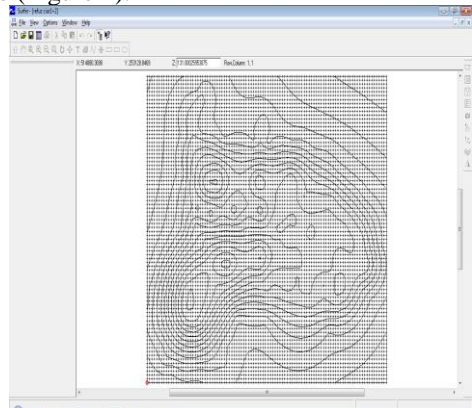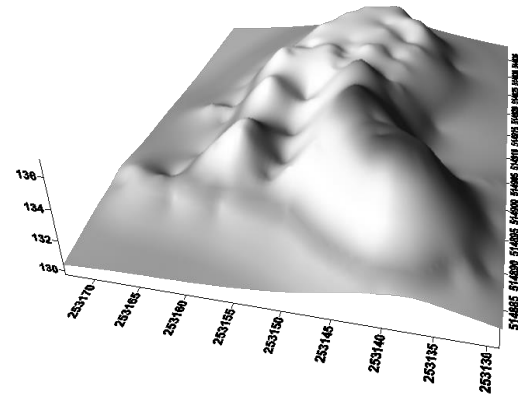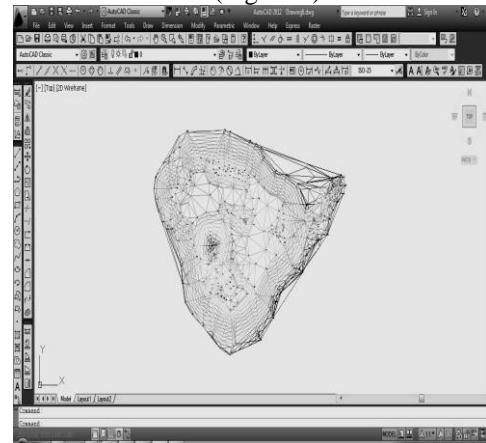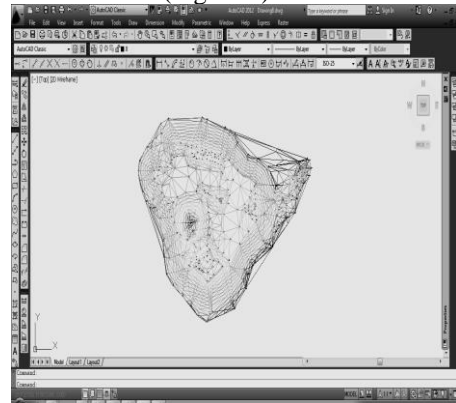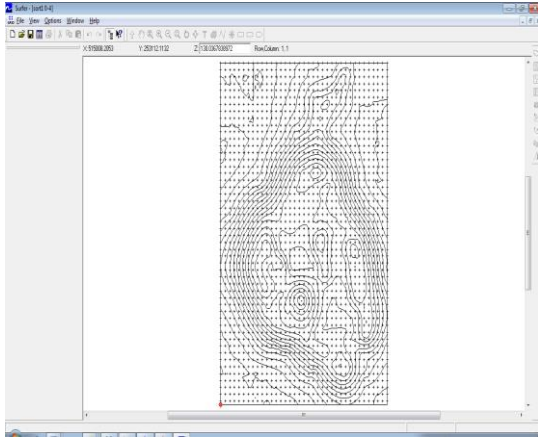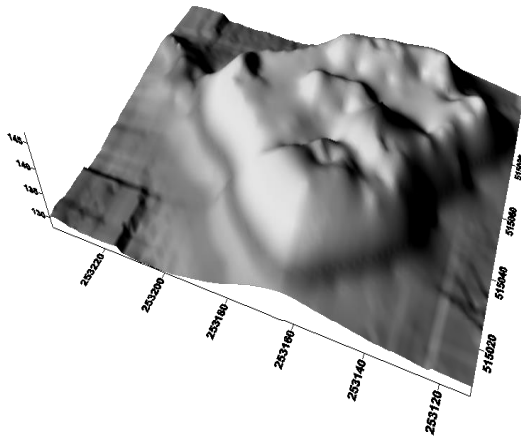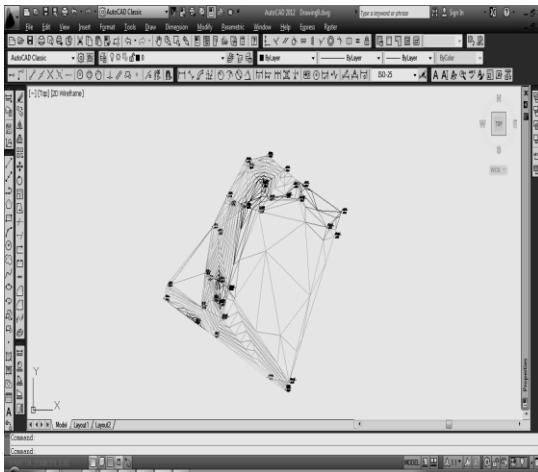*The **GRID** land model* developed to calculate the volume (Figure 4).

Figure 4. Development of the GRID model in SURFER 8.0

The SURFER V8.0 model
Ballast 2 volume: 978 m³

Visualising the 3D land model – AutoCAD
(Figure 5)

3. Volume calculus for sand 0-4

Visualising the 3D land model – AutoCAD
(Figure 5)

Figure 5. 3D land model in AutoCAD - sand 0-4
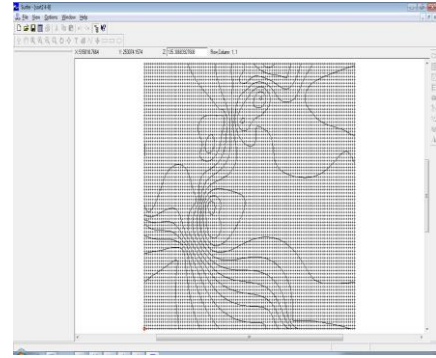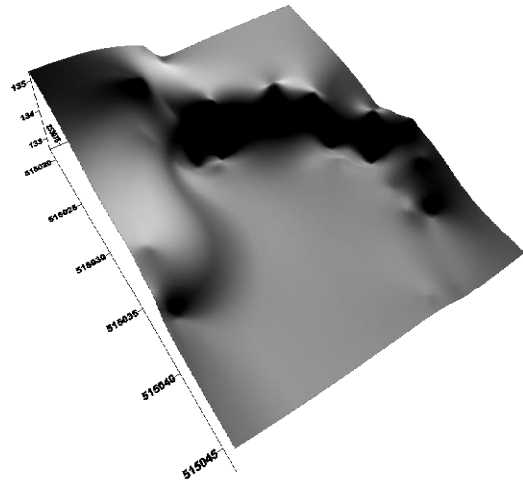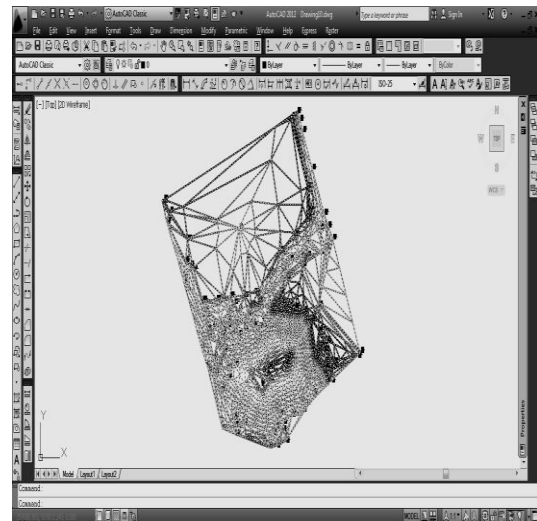*The **GRID** land model* developed to calculate the volume (Figure 6).

Figure 6. Development of the GRID model in SURFER 8.0

Figure 8. Development of the GRID model in SURFER 8.0

The SURFER V8.0 model
Sand 1 0÷4, volume: 53050 m³

The SURFER V8.0 model
Broken stone 2 4÷8, volume: 741 m³

5. Volume calculus for broken stone 8-16
Visualising the 3D land model – AutoCAD
(Figure 9)

. Volume calculus for broken stone 4-8
Visualising the 3D land model – AutoCAD
(Figure 7)

Figure 7. 3D land model in AutoCAD - sand 4-8

Figure 9. 3D land model in AutoCAD - sand 8-16

The GRID *land model* developed to calculate the volume (Figure 8).

The GRID *land model* developed to calculate the volume (Figure 10).
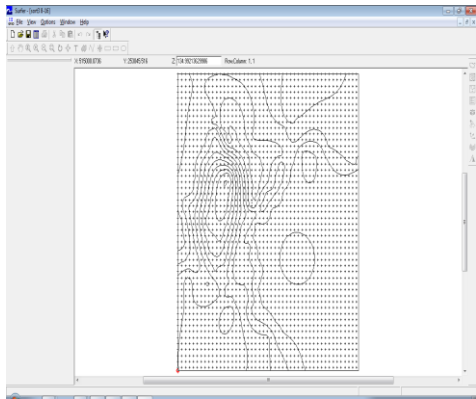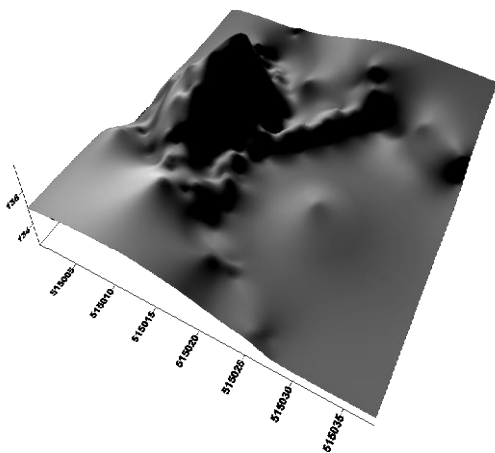
Figure 10. Development of the GRID model in
SURFER 8.0

The SURFER V8.0 model
Broken stone 3 8÷16, volume: 335 m³

6. Volume calculus for broken stone 16-32
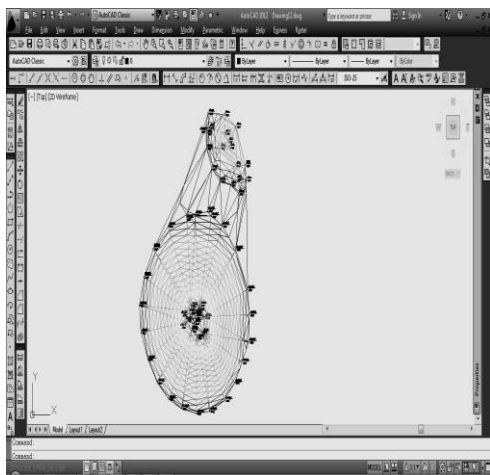*Visualising the 3D land model – AutoCAD*
(Figure 11)

Figure 11. 3D land model in AutoCAD - sand 16-
32

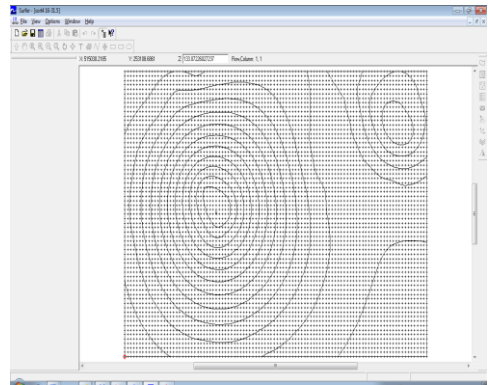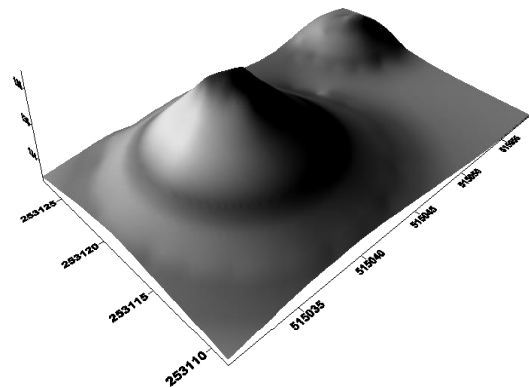*The GRID land model* developed to calculate the
volume (Figure 12).

Figure 12. Development of the GRID model in
SURFER 8.0

The SURFER V8.0 model
Broken stone 4 16÷31.5, volume: 400 m³

5   CONCLUSIONS

A spatial land model can be created relying on
points whose coordinates are X, Y, Z recorded in files
of the ASCII type with a .DAT extension. Based on
these coordinate points displayed on the area whose
space model is to be created, we develop a network of
points whose coordinates X, Y, Z of the GRID type
(agrid-type network) has a certain point density
recorded in a GRID file whose extension is .GRD.

Generating the digital land model concerns data
collection, the creation proper of the model through
different interpolation methods, as well as the choice
of the data representation structure (raster or TIN)
Interpolation methods are of the triangulation type,
that produce a TIN (Triangular Irregular Network)
structure. The best interpolation is Delauney that
allows triangles that are perfectly circumscribed to
circles, which makes the distance between the triangle
points always minimum. For each triangle, we store
the coordinates and the attribute of the three points,
the topology as well as the slope and slope direction
of the triangle area.

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