

TOPOGRAPHIC WORKS EXECUTED FOR THE RAILWAY MODERNIZATION ON THE PLOIEȘTI-FOCȘANI SECTOR

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Abstract: The work aimed to create a geodetic network through GPS measurements, for the modernization of the railway line on the Ploiești-Focșani route. GPS techniques are used to establish primary control and mapping of railway lines. The operational and procedural specifications for the performance of GPS technologies depend on the accuracy required for a particular project or map. In order to carry out these projects in the most cost-effective way, the necessary criteria must be ensured, such as accuracy, detailed analysis of the planning phase, the latter being essential. The measurements are carried out in the field, in order to obtain plans and maps, or for special purposes, such as the modernization of the railways. The topographic elements that are measured consist of angles (horizontal and vertical) and distances (inclined, horizontal and vertical). The results of the measurements are downloaded with special programs, usually drawing on the field at the same time sketches and descriptions of the topographic points. Performing calculations in the office consists in systematizing and processing the numerical results of field measurements and bringing them in a form as simple and suitable as possible to be used / performed with the help of the computer and last but not least the complex AutoCAD program together with TOPO LT.

Keywords: topographic survey, railway modernization.

1. INTRODUCTION

The station is located in the central-southern area of Buzău, on the right side of a semicircular square located at the intersection of 1 Decembrie 1918 Boulevard with Gării Boulevard and Republicii Street. In this square there are two more historic buildings: the Bucegi Hotel and the house where Ion Luca Caragiale lived in 1894-1895. The station is the main node of the public transport network of Buzău.



Figure 1. Buzău railway station

The railway lines cross the southern area of Buzău in an east-west direction, and the station buildings are located on their northern side. The station has 5 lines (served by 3 platforms) for passenger trains and another 14 for the sorting of freight (cargo) trains. Access to the platforms of lines 2-3 and 4-5 is made on the surface at the ends of the platform, or through an underground passage in the eastern part of the platform, a passage that crosses the entire width of the station and has an exit to the bread factory. However, the passage is very little used, due to the state of degradation in which it is.

At the southern end of these lines is the building of the Boromir Prod bread factory, a building that dominates the landscape on the opposite side of the station building.

At the western end of the platform there is a terminus line, the so called line 20 and which is used as the end of the Buzău-Nehoiășu railway line. Five pairs of trains leave and arrive daily from that line, connecting with the localities in the Buzău valley.

Buzău train station is located on the CFR 500 bus, the most important railway nodes close on this bus being the Focșani and Mărășești stations to the north and Ploiești Sud to the southwest. The Buzău-Făurei railway line, part of the old Bucharest-Galați line opened in 1873 and today electrified and doubled, operates to the east from Buzău station as the CFR 702 highway. The simple non-electrified Buzău-Nehoiășu railway line also starts from Buzău station.

The main passenger trains running through Buzău station are the InterRegio and InterCity trains that come from Bucharest North station located 128 km and take the 500 highway in the main directions Marasesti-Roman-Suceava and Marasesti-Tecuci-Iasi, as well as the 702 highway. to Galați located at a distance of 131 kilometers. Other InterRegio trains that run through this station are the seasonal ones that run in summer and come from Oradea or Satu Mare through Ploiești Sud (69 km away) and go to Făurei-Fetești-Constanța (at a distance of 207 km by rail). A few international trains pass through Buzău and run to Chisinau or Moscow, from Bucharest and further to, Sofia (and reverse).

As the station is a railway junction, there are many Regio trains that end here and take various routes to other

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railway nodes in the region, such as to North Bucharest, Ploiesti South-Brazi, Marasesti, Făurei, Fetești, Galați or Adjud- Ghimeș Ciceu. The Transferoviar Grup operator uses the station as the terminus of its Buzău-Nehoiășu regional line.

2. MATERIAL AND METHOD

For the realization of complex topographic works in order to rehabilitate the railway structure, modern tools were used for topogeodesic and topographic surveys, respectively GNSS systems at high precision electronic levels. The Trimble R8s system is designed and built to the highest and strictest standards with the latest technologies. The Trimble R8s tool (Figure 2) Is extremely efficient and reliable, and can be used in the most severe Environments.



Figure 2. Trimble R8s Receiver

The Trimble TSC3 tool (Figure 3) has an extremely intuitive interface, a multitude of functions and features, respectively a powerful data management. Users can switch between GNSS and TPS instantly.



Figure 3. Trimble TSC3

The Trimble TSC3 instrument (Fig.3) has an extremely intuitive interface. The new high-performance GNSS technology of the Trimble R8s tool allows you to perform any type of survey, faster, more accurate and more efficient than before and most importantly, reduce costs and increase profits. It is a fast, accurate, robust and reliable tool, being quite powerful, but still easy to use. Trimble R8s has a multitude of features and functions to meet the different needs of users around the world, being very easy to use, a multitude of functions and features, respectively a powerful data management. Users can switch between GNSS and TPS instantly.

The graphical operation concept of TSC3 explains itself and guides the user to what he wants. You can use the default settings or you can set the functions as needed in your measurements. The Trimble TSC3 instrument can

be operated using the qwerty keyboard or touch screen, depending on the user's preferences.

You can define points, lines and areas to build a plan for displaying observations. It will be possible to see immediately what has been observed. You can attach codes, attributes, and information needed to enter the mapping software.

Status icons indicate current measurements, operating modes, recording, battery status, instrument settings, and so on.

The program menu provides direct access to all loaded application programs, such as remarks, tabs, and other optional application programs. High resolution, color LCD screen, easy to read in any light intensity.

The menu used can be configured according to how the teams want to operate, showing what you need, and the other commands are not displayed on the screen.

The touch screen provides immediate access without using the keyboard. You can see data and information about points and objects and of course you can apply various functions via the screen.

With the Trimble TSC3, different display methods can be defined so that the system will look the way the user wants. The settings are displayed according to the type of survey you want and of course the required information is also displayed, this tool adapting exactly to the user's needs.

Managed database, files, quality controls, etc. They can be viewed, edited, deleted and searched in the database with or without filters. The coordinates of the measured points are most often on average provided that they are within the specified tolerances.

The planning of a GPS project consists in choosing an optimal measurement method, the necessary instrumentation, as well as the actual planning of the observations. Planning differs significantly from the planning of classical geodetic observations, as GPS measurements can be performed at virtually any time and at any time of the day. In addition, there must be no visibility between the points of the network, but a clear horizon to the sky from an elevation of 150 m and above is claimed.

When planning observations in a GPS project, several factors must be taken into account:

- satellite configuration;
- number and type of receivers available;
- economic aspects.

The network configuration plays a smaller role in GPS measurements, and should only be taken into account when the GPS network needs to be connected to the national network. For this we must have at least 3 known points, well distributed compared to the GPS network.

2.1 CHOOSING THE MEASUREMENT METHOD

For geodetic purposes, due to the high accuracy required, only the relative positioning methods are used, with the help of phase measurements on the carrier waves.

2.2 OBSERVATION PLANNING

These are made with programs specially delivered by the construction companies together with the processing software. After defining and opening the project, the points with their geographical positions are included in the

project and sketches are drawn for each point with the obstructions that obscure the horizon over an elevation of 150 m.

The first phase in the design provides for the choice of an optimal period for performing the measurements, which will be subdivided into working sessions. The optimal period (window) is characterized by a sufficiently large number of visible satellites, which are studied on a graph.

The design of GPS observations therefore consists in choosing an optimal work window supported by graphical representations.

These representations are essentially based on the calculation of the azimuth and elevation for each satellite depending on the time and place where the observations are made.

Another criterion that could be taken into account for the choice of the work window is the influence of ionospheric refraction, which at night is much lower than during the day. When establishing the working sessions in the relative positioning, 4 factors must be taken into account:

- base length;
- number of visible satellites;
- geometry of the satellite constellation;
- signal-to-noise ratio for the satellite signal.

Sessions must be chosen so that there is contact to at least 4 common satellites at an elevation of 150 m at all points included in a session, and the PDOP factor must not exceed 6 for the entire measurement duration. These issues can be considered in GPS session planning software. The following must be ensured during the field works:

- correct centering of the antenna on the station point;
- measuring the height on the station point;
- correct connection of the cables to the antenna and receiver, respectively controller receiver;
- commissioning of the receiver at the predetermined time in the session schedule;
- correct setting of the working mode;
- periodic monitoring of data recording.

3. RESULTS AND DISCUSSION

This topographic survey aimed to collect data from the field in order to modernize the railway route, owned by the Romanian Railways, from Ploiești to Focșani.

In order to develop the methods used, the equipment with which this survey was carried out, as well as the organization necessary to carry out such a topographic survey, we chose as a presentation topic a section that includes Buzău station.

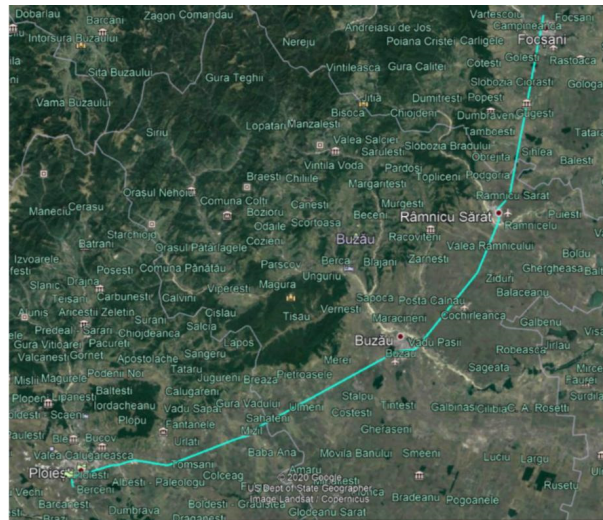


Figure 4. The complete railway route

The image above shows the entire route of the topographic survey, Ploiești-Focșani, through a .kml file opened with the Google Earth PRO program. The route is indicated by the cyan color line on the satellite image in Figure 4.

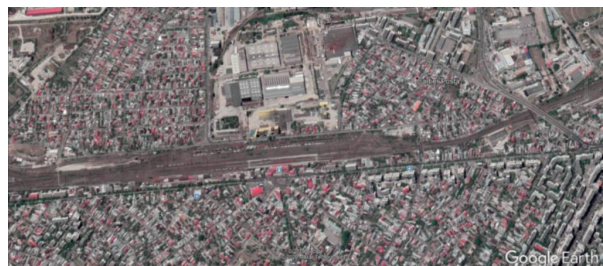


Figure 5. Buzău railway station

In the following image (Figure 5) the chosen section is presented in more detail. In this image, from Google Earth, you can see in more detail the Buzău railway station, elements that are part of the chosen section.

The measurements in this area were made in order to draw up a digital format necessary for the railway modernization procedures.

3.1. MEASUREMENT PLANNING

In order to plan these measurements, the following steps were followed:

- Training the teams in order to collect field data with informative data about the composition and operation of the mechanical elements on the railway route;
- Identifying the access ways to the railway in order to facilitate the movement and to make the measurement time more efficient;
- Identification of relief forms and access on the railway side;
- Identifying difficulties, such as moving through areas with vegetation;
- Identification and verification of leveling landmarks located on railway stations and bridges;
- Establishing the positioning of the terminals on the field;
- Ensuring the operation of the equipment in the inventory.

In order to plant the terminals in the field, the following aspects were taken into account:

- The positioning of the terminals must be sufficiently far from the high-voltage lines above the railway lines, as well as from forested or densely vegetated areas;
- Their location on solid surfaces, which do not move and which do not present the risk of being involuntarily moved by machines or people;
- Access to these terminals must be easy.

3.2. ESTABLISHING THE WORKING METHOD

As a working method, it was chosen to thicken the geodetic network by static measurements with GPS and to take data by RTK base-rover method. After analyzing the information in the field, it was found the need for support points for future measurements and it was decided to thicken the geodetic network for topographic surveys.

For areas without radio signal and areas where increased accuracy is needed (bridges), the measurement method with the total station was chosen.

4. STATISTICAL DATA COLLECTION

The static GPS measurement method was used to determine the terminals required for RTK measurements.

In principle, a GPS receiver measures the time a signal propagates from the satellite to the receiver. The distance between the satellite and the receiver can be calculated by multiplying the propagation time by the speed of light ($c = 299792458\text{m} / \text{s}$). Thus, with measurements from several satellites, the exact location of the receiver can be determined.

Therefore, to determine the coordinates of the reference terminals in Buzau station, two Trimble R8s GNSS receivers were used, each paired with a Trimble TSC3 controller.

For the static measurements, several teams with different GPS receivers were involved. The static measurement was made in several stations and stops on the Focșani-Ploiești route, the two receivers above being used in Buzău station.



Figure 6. Leveling the receiver using the spherical level.

The static measurement was performed by standing on terminals for at least 45 minutes, with the bases standing for up to 2 hours, this being a very important parameter. For static preparation, follow the steps: on the

predetermined place, chosen based on the criteria decided in the planning phase, a bolt is struck, or a terminal is mounted. After mounting the terminal and marking it, mount the receiver on the tripod and mount using the spherical mounting level attached to the receiver milestone (Figure 6).

After mounting the device, you can start static lifting from the controller by selecting the RTK lifting / static measurement / fastStatic measurement option. After selecting the measurement option, enter the name of the point, the point code and the height of the milestone on which the receiver is located, after which you can start raising.

By this method the abscissa and the ordinate of the terminals were determined, remaining to determine the dimension by leveling.

The limit of the terminals was determined using a professional level Bosch GOL 32 G (Figure 7).



Figure 7. Bosch Professional GOL 32 G

With the help of leveling points mounted on stations, through the level differences, it was possible to determine with an accuracy of up to one millimeter, the dimension of the terminals from the measurements by the static method.

4.1 RTK MEASUREMENTS

After determining the terminals for the reference bases, the actual topographic survey can be started.

On the statically determined terminals, is mount the base for RTK survey. Measurements by the RTK (Real-Time Kinematics) method, or popularly called base-rover, involve the need for a reference point with very well-defined coordinates, hence the need for static measurements. The RTK method has many very important facilities for field work, such as better accuracy and higher signal reliability, the connection between the base and the rover being made by radio.

In order to carry out the work, a survey was made in the 1970 Stereo projection system for the elaboration of a topographic plan according to the technical norms in force. When performing the work, the RTK method was used with the real-time use of the corrections coming from the radio signal from the base located on the statically determined terminals. A Trimble R8-2 GPS was

used as the equipment, and two Trimble R8s and a Trimble R8 were used as rovers. They were paired with two Trimble TSC3 and a Trimble TSC2 controller respectively. A Trimble TDL 450 radio amplifier, which operates over a wide range of frequencies, was used to increase the coverage of the base.

4.2 THE OFFICE STAGE

The download of the GPS devices was done through a field book where the 3 Trimble controllers, the two Trimble TSC3 and Trimble TSC2 were downloaded.

Both models can export data stored in various electronic formats. For importing them in AutoCAD, the .txt and .xlsx shape file documents were used. These formats are directly compatible with the TopoLT program and facilitate the import of points into AutoCAD.

In the office stage, the point cloud reported by TopoLT can be obtained from the downloaded files. There are two ways to report of detail points in AutoCAD:

- The first method involves using the RAPPCT command in the command bar in AutoCAD (Figure 8);

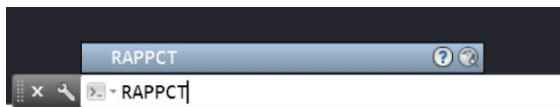


Figure 8. RAPPCT command

-The second method involves selecting the TopoLT / Coordinates / Draw Points command from the options bar (Figure 9);

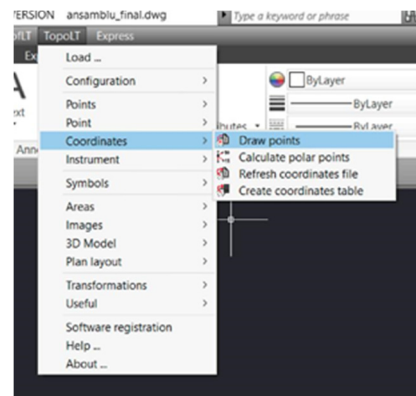


Figure 9. Reporting detail points in the options bar

Both methods will open the same TopoLT window, where by clicking Add file you can select the .txt or .csv file that contains the points taken from the field (Figure 10). After selecting the file, click Ok and the file will be reported as a point cloud in AutoCAD (Figure 11).

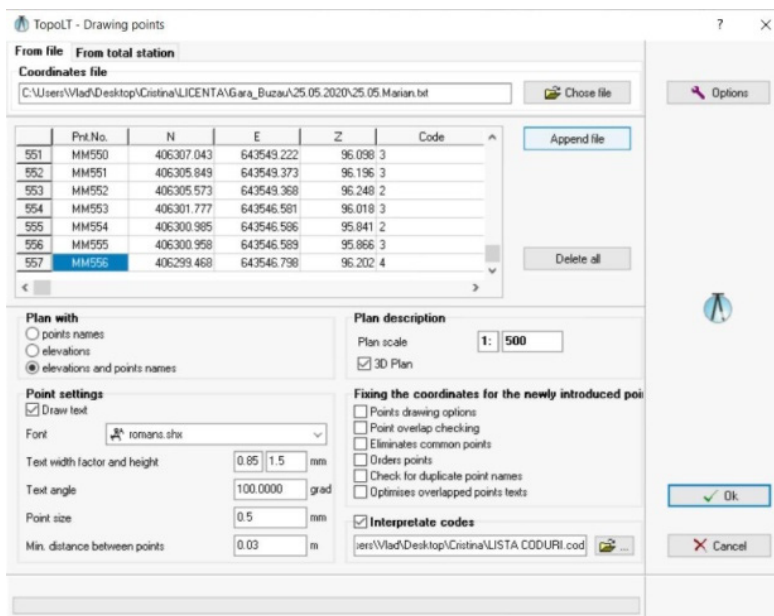


Figure 10. Reporting detail points in TopoLT

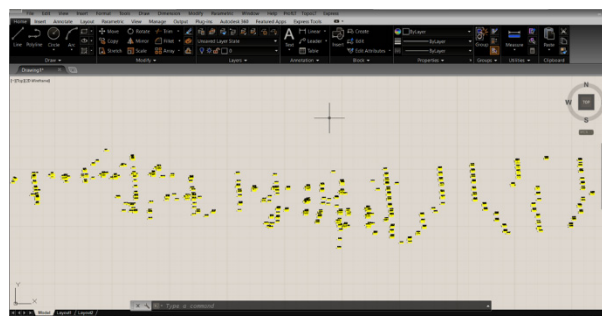


Figure 11. Cloud of detail points reported

After reporting the point cloud, you can proceed to join the points according to the codes mentioned above.

The final work must contain the dimensions of the points, as well as conventional symbols.



Figure 12. The final result of Buzău railway station

5. CONCLUSIONS

Through this paper, the techniques involving a special topographic survey were presented. The train station in Buzău was chosen as the subject, having all the details necessary to present as many techniques as possible.

Considering the approached methods, we can conclude the following characteristics of the techniques used:

- By the method of static measurement can be determined very precisely reference points that can help to thicken the geodetic network of Romania;

- A long stay on the terminals is, in the end, a better and more precise result of the coordinates of the points;

- With the help of statically measured points we can easily use the RTK base-rover measurement method;

- The points, taken statically can also be used in the interest of other topographic survey works that require precise reference points, regardless of the measurement method, be it the RTK measurement method or with the total station;

- The measurement method with rover base is very precise, having an accuracy of 5-10 mm on the abscissa and ordered and maximum 15 mm on the . This method is also very reliable at a distance of up to 3-4 km, this distance being easily increased with the help of a radio wave amplifier, such as Trimble TDL 450;

- With the help of TopoLT, the points taken from the field can be reported directly in AutoCAD, without the need to enter them manually;

- If the survey is done according to some codes, the conventional symbols can be entered with a simple push of a button, thus facilitating the office stage.

Although our geodetic system is still in continuous development, we believe that improvements can be made with minimal economic effort. We believe that an increase in the number of ROMPOS stations will considerably increase the accuracy and reliability of the service provided by the national ROMPOS network, thus bringing additional revenue to the state.

Also, the creation of permanent landmarks can facilitate the work of surveyors in the future, and can drastically reduce the execution time of works.

Considering the precision, in general a more expensive receiver can measure more accurately, faster and can be more reliable in certain situations, so it is recommended help from the state of companies that want to buy new equipment.

On the other hand, as for the software part, it is recommended to use licensed software for the assistance provided by the manufacturing company in case of an error during the work that can lead to the deletion of the open document.

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