THE MULTIPLICATION OF THE GEODESY NETWORK BY SATELLITE METHODS FOR HIDROTEHNIC NODE TOPOLOVATU MIC, TIMIS COUNTY

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Abstract

The present paper aims to create a geodesy network using satellite methods in order to make the measurements for the dam on the Bega River and the water discharge channel to the Timiş River belonging to the Topolovat Mic hydrological node from Timiş County. In order to carry out the measurements by satellite methods, were marked the points by placing four concrete landmarks Feno and a concrete landmark was made of CSA type. Two pairs of landmarks were placed, two by two, where the first pair of landmarks was located, on the side of the dam on the Bega River and the other two towards the water discharge channel on the river Timis. The method of acquisition the GNSS data, chosen for filling the geodesy network from this hydrotechnical node is the Statica method, where for carrying out the work in the field was realized a GPS, taking into account several parameters. A very important parameter was the standby time for each landmark, taking into account the longest base. Based on the office calculations we made the decision to purchase data in Rinnex form from the reference stations: Timis, Faget and Moldova Noua (Arad and Resita could not provide Rinnex data from the time when the measurements were made). For realizing measurements in the field, we used 4 GPS receivers, namely: a Leica 1200 GPS receiver, a Leica GS08 receiver and two Leica GS08plus receivers. After the measurements are made in the field, the next step was the acquisition of RINNEX data from the Cadaster and Real Estate Publicity Offices of Timis, Faget and Moldova Noua, in order to achieve the post- processing of the data and obtaining the final WGS 1984 post-processing coordinates. The stationary time for each GPS receiver was approximately 1h and 30min. Land surveying elevations were made with Leica GPS equipment. Post- processing of the data was done with Leica Geo Office Combined program. After the static post-processing is done, the next step was the multiplication of the network by placing the bolts in order to he perform the measurements. To verify the correctness of the measurements we determined the terminals and the bolts using the Cinematica method (Real Time Kinematik) and the coordinates thus obtained were compared with the results obtained by the Statica method and obtained by post- processing of the data.

Key words: Leica GS08, Leica 1200, RTK, Feno landmarks, TransDatRO, WGS 1984**,** TopoLT

INTRODUCTION

The Topolovatu Mic hydrological node is part of the hydrotechnical arrangement: "The double connection Timis _ Bega", which was designed by the Dutch engineer Maximilian Emmanuel de Fremaut and was built in 1758. In order to protect the city of Timisoara from large waters, the dam from Topolovat controls on Beghei a maximum flow of 40 m^3/s, and the plus of flow add-o is discharged in Timis through a 5.5 km channel.

Also, in order to ensure the navigation level on the Bega Canal, through the Costei dam is supplying the Bega Canal from the Timis River through a 10 km channel with necessary flow.

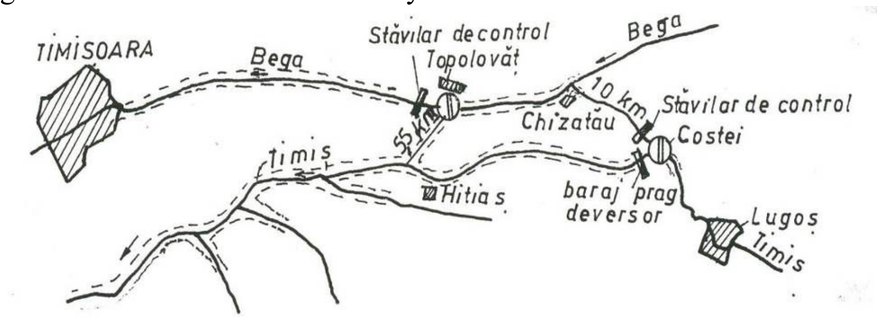

Fig. 1. The scheme of the Timis - Bega Hydrotechnical System

Timis - Bega interconnection is an anthropic and natural of water courses. The overflow threshold (dam) from Costie is located downstream of Lugoj (Fig. 1). The spillway threshold was built in the 18th century to drive water from Timis in Bega, through the Timis-Bega supplying channel, 10 km long, in order to ensure the water supply of the Bega Channel and implicitly of Timisoara city.

The Topolovatu Mic hydrotechnical node is one of the five hydrotechnical nodes administered by the Banat Waters Directorate:

- Topolovat Hydrotechnical node - with derivation role
- Timisoara Hydrotechnical node - with the role of checking
- Sânmihaiu Roman Hydrotechnical node - checking and navigation
- Uivar Hydrotechnic node - checking and navigation.
- Costei Hydrotechnical node - is the only hydrotechnical system located on the Timis River, the other four hydrotechnical nodes being built on Bega. In those over 200 years of existence, the arrangement has undergone various deterioration and restoration, so that in 1998 the entire hydrotechnical node was damaged by floods, resulting a series of infiltrations, erosions and breaks in the dam body.

The Topolovat Hydrotechnic Node has a particular importance for the area of Banat, which supplies with water with quasi-constant the Bega Channel, thus decreasing the probability that Timisoara city to be affected by the drought being favorable also to navigation on the Bega Canal, which can be carried out all the time year, and floods on this river can be controlled, so the localities downstream the dam are somewhat protected from unexpected floods. Also, the threshold from Costei was destroyed and repaired several times during the floods, and in 2005 suffered serious damages, being rebuilt almost entirely before the flood from 2006.

MATERIAL AND METHOD

Static and kinematic measurements were done in Topolovatu Mic with GPS equipment from Leica series 1200, Leica GS08 and Leica GS08 plus, an apparatus with multiple applications. It can be used either as reference station, or as rover for both static and kinematic (RTK) measurements. To make GPS measurements we used, the *static* method; data acquisition was done at 5 sec where we activated the Long Raw Observation (5s) function. To post-process data from the field (by stationing with GS equipment on concrete landmarks) we acquired RINNEX data from Permanent Stations at 5 sec; together with data from the field, we post-processed and obtained WGS 1984 coordinates for the stationed landmarks.

Turning raw data from the ETRS89 system into the STEREO'70 system was done with the ***TransDatRO*** Programme. Data comparison was done between GPS RTK values, Static GPS values from post-processing and GPS Radio values from post-processing. The trans-calculus of the coordinates from the reference system ETRS'89 into the system Stereografphic'70 was done with the soft TransDat 4.01 produced by CREPO. Permanent GNSS stations from which we operated TINNEX data at 5 sec are Timisoara, Moldova Noua and Arad (Table1).

Table 1

Permanent GNSS stations used in post-processing

ELIPSOID COORDINATES - ETRS89					
Permanent station	**Class**	**B[m]**	**L[m]**	**He[m]**	**Antenna Serial**
Arad (ARAD)	A	46° 10' 23.51004" N	21° 20' 40.51052" E	167.6742m	3830135 TPSCR.G3 TPSH
Moldova Noua	A	45° 51' 16.42753" N	22° 10' 37.78289" E	216.4898m	LEIAR25.R22 LEIT
Timisoara 1 (TIM1)	A	45° 46' 47.65271" N	21° 13' 51.46281" E	154.7278m	200496 LEIAT504GG_LEIS TIM1

RESULTS AND DISCUSSION

Through static measurements, the coordinates of the points of thickening and surveying networks will be obtained through relative measurements in relation to the National Geodesic Network GNSS (NGN GNSS) made up of permanent GNSS stations (Class A) and thickening landmarks (Class B or Class C). Thus, the points of the survey networks (minimum 2 points) will be determined through the static or rapid static method. The geodesic survey network will be introduced into the NGN GNSS through minimum 2 points (2 permanent GNSS stations 2 landmarks Class B or C, 1 landmark and 1 permanent GNSS station). We will take into account the visibility between the points of the survey network.

In the case of kinematic measurements, to determine detail points with GNSS technology, we can use the (rapid) static, kinematic or pseudo-kinematic measuring methods. Any determination of the position of detail points shall be done only after the survey geodesic network is done according to Annexe 15b. The points of the survey network will also be the points from where the (self)checking of kinematic measurements will be done.

For the trans-calculus of the coordinates determined cinematically from the geocentric into the national reference system according to Decision no. 1/2009, we use the TransDat soft supplied free of charge by the CREPO.

To make kinematic measurements, we followed the steps below:

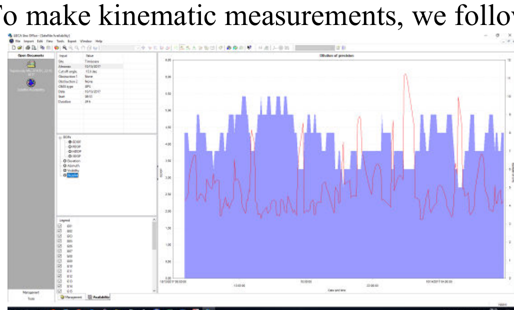

Fig. 2. GDOP value at Topolovatu Mic

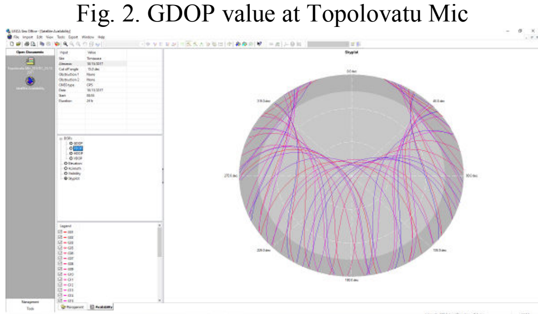

Fig. 3. Constellation and trajectory of the satellites for Topolovatu Mic

__Planning GPS measurements.__ In this stage, we tried to use time intervals in which the value of Geometric Dilution of Precision (GDOP) is low. Figure 2 shows the GDOP values for Topololovatu Mic on Octomber 13, 2017, and Figure 3 shows the constellation and trajectory of the satellites for Topolovatu Mic.

2. Another important element to be taken into account during measurements is **satellite elevation**.

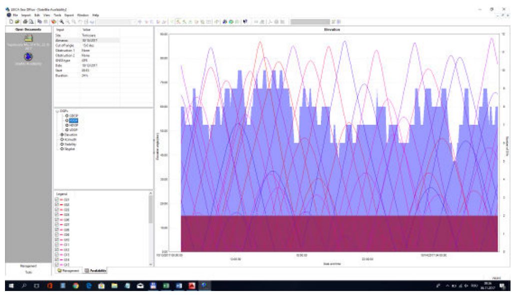

Fig. 4. Satellite Elevation in October 13, 2017

Here we can also study the **Almanach**, where we can see if the GDOP values meet the conditions. Figure 4 presents satellite elevation.

3. <u>Preparing stage.</u> In this stage, we need to get as many data as possible and to compared them before starting the field stage. It consists in **data collecting** (Fig. 5) and **establishing the working method and the necessary equipment**.

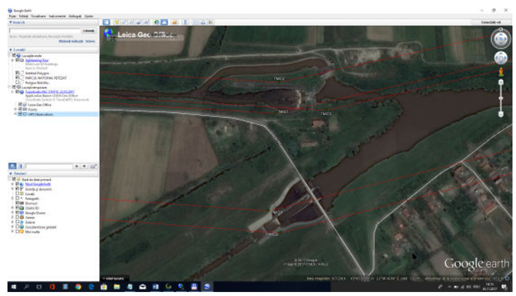

Fig. 5. Higher order signals and reference stations TM, MDN and FG

Fig. 6. Equipments preparation and land recognition

4. <u>Field stage</u>. Before planting the landmarks in the field, we paid attention to the absence of magnetic fields or reflective surfaces, to the absence of obstacles that could prevent point observations, to the setting of obstacles at the limit of the cadastral plots to avoid their destruction by agricultural implements, the accessibility of the landmarks, and the setting of the landmarks as far as possible from high-voltage lines (Fig. 6).

5. **Office stage**

Processing field data is the last and maybe the most important stage of the study: it needs lots of attention particularly during the introduction of the raw data from different working sessions and during their proper correlation. Though current softs process data automatically, special care should be given to post-processing: the post-processing result is good when point determination accuracy is minute.

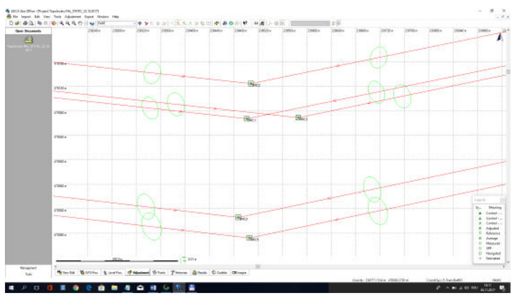

Fig. 7. Graphic presentation for Static measurements, Topolovatu Mic

Data post-processing:

In this stage, all data files downloaded from receivers are loaded and field charts are examined. In our case, we monitored the filling in of the data regarding the height of the instrument.

Data files were imported in RINEX, a universally known format. Figures 7 represent the STATIC networks.

In the following are presented the data entered in the processing software presented in Table 2 and in Table 3 it can observe the fulfillment or non-fulfillment of the ambiguities as well as the obtained data.

Table 2

Gross data entered in LGO, Topolovatu Mic with corrected stations

Point ID	Point Class	Duration	GNSS Type	Type	Height Reading
TIM1	Control	9h 59' 55"	GPS/GLONASS	Static	0,0000
MOLD	Control	9h 59' 55"	GPS/GLONASS	Static	0,0000
FAGE	Control	9h 59' 55"	GPS/GLONASS	Static	0,0000
TMIC2	Navigated	2h 18' 20"	GPS/GLONASS	Static	2,0000
TMIC1	Navigated	1h 52' 49"	GPS/GLONASS	Static	2,0000
TMIC3	Navigated	1h 55' 55"	GPS/GLONASS	Static	2,0000
TMIC8	Navigated	1h 23' 30"	GPS/GLONASS	Static	2,0000
TMIC9	Navigated	1h 23' 15"	GPS/GLONASS	Static	2,0000

After data processing, the network was adjusted with the Leica Geo Office Combined program and **data obtained were compared, those obtained through static methods with those obtained through RTK method** (Table 4 and 5).

Table 3

Post-processing of static thickening network through satellite measurements at Topolovatu Mic, WGS 1984 coordinates with corrected stations

Point ID	Ellip. Hgt.	Ortho. Hgt.	Geoid. Sep.	Posn. Qlty	Hgt. Qlty	Posn.+Hgt. Qlty
TMIC2	361.919	1.024.098	-662.179	0.0064	0.0026	0.0069
TMIC2	361.645	1.023.824	-662.179	0.0004	0.0007	0.0008
TMIC2	363.487	1.025.665	-662.179	0.0004	0.0006	0.0007
TMIC1	357.380	1.019.559	-662.179	0.0013	0.0009	0.0016
TMIC1	355.909	1.018.089	-662.179	0.0005	0.0008	0.0010
TMIC1	357.909	1.020.088	-662.179	0.0003	0.0005	0.0006
TMIC3	388.222	1.050.411	-662.190	0.0045	0.0038	0.0059
TMIC3	385.761	1.047.950	-662.190	0.0004	0.0007	0.0008
TMIC3	387.686	1.049.876	-662.190	0.0004	0.0006	0.0007
TMIC8	363.351	1.025.532	-662.181	0.0021	0.0014	0.0026
TMIC8	362.025	1.024.206	-662.181	0.0005	0.0007	0.0009
TMIC8	363.957	1.026.138	-662.181	0.0004	0.0006	0.0007
TMIC9	364.074	1.026.258	-662.184	0.0056	0.0040	0.0069
TMIC9	361.688	1.023.872	-662.184	0.0005	0.0007	0.0009
TMIC9	363.626	1.025.810	-662.184	0.0005	0.0007	0.0008

Table 4

Stereographic Coordinates 1970 obtained by CINEMATIC measurements (RTK)

No. point	Stereographic Coordinates 1970 Static Reading (RTK)		
	X (m)	Y (m)	Z (m)
TMIC1	479067,286	238501,567	102,111
TMIC2	479124,943	238508,712	102,647
TMIC3	479069,033	238586,241	105,086
TMIC8	478905,988	238487,673	102,689
TMIC9	478872,351	238506,115	102,642

Table 5

Stereographic coordinates 1970 obtained by STATIC measurements after post-processing

No. point	Stereographic Coordinates 1970 Results from post-processing (STATIC)		
	X (m)	Y (m)	Z (m)
TMIC1	479067,239	238501,561	101,950
TMIC2	479124,933	238508,710	102,483
TMIC3	479069,010	238586,244	104,900
TMIC8	478905,976	238487,679	102,539
TMIC9	478872,351	238506,119	102,491

CONCLUSIONS

In order to carry out the scientific work on multiplication of the geodesy network, the following measurements were made in the field:

a. The values obtained from GPS measurements using RTK method (Real Time Kinematic); **b.** The values obtained from the GPS measurements using the STATIC method; **c.** Comparing the values obtained by post-processing raw data (Static method) with those obtained through Cinematic measurements (RTK). The results obtained from the verification reveal the good quality of the GPS determinations and especially of the static ones. It can be seen from the comparison of RTK values with the Static one that they have the lowest values for X in point TMIC9 being 0cm and the largest difference being 4.7cm at TMIC1. For direction Y, the lower value is 0.2cm on the TMIC2 point and the highest of 0.6cm on the TMIC1 point. As for the difference in quota, they are between 15cm at the TMIC8 point and 18cm at the TMIC3 point. Regarding reporting points in AutoCad and comparing RTK values with Static values, can be observed a difference between 0cm for the TMIC9 point and the largest difference being 5cm at the TMIC2 point (Table 6).

Table 6

Coordinate differences between CINEMATIC (RTK) and the Static measurements

No. point	Coordinate differences, RTK vs. STEREO		
	X (m)	Y (m)	Z (m)
TMIC1	0,047	0,006	0,161
TMIC2	0,010	0,002	0,164
TMIC3	0,023	-0,003	0,186
TMIC8	0,012	-0,006	0,150
TMIC9	0,000	-0,004	0,151

Acknowledgments

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