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COMPARATIVE STUDY ON STATIC VERSUS REAL-TIME GNSS MEASUREMENTS AND ALTITUDE DIFFERENCES BETWEEN GNSS DETERMINATIONS AND HIGH-PRECISION LEVELING

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Abstract: *In Romania, it is possible to determine the position of points with the help of real-time GNSS receivers, using the ROMPOS application of the National Agency for Cadastre and Real Estate Advertising through the National Cartography Center. The application is usable where there is a signal on the mobile phone and ensures an acceptable accuracy not only in planimetric, but also in altimetric position. Lately, controversies have arisen regarding the accuracy of the results obtained with the help of the ROMPOS application, versus the static method, both horizontally and on altitude. This paper aims to demonstrate that the results obtained with the ROMPOS application fall within the precisions requirements for current works.*

Key words: *ROMPOS, static GNSS measurements, high precision leveling.*

1. Introduction

At the end of 2020, the National Cartography Center launched a tender entitled: Services for making orthophotoplans and ensuring the automation of the processes of reception, management, storage and dissemination of data for 150 territorial administrative units in urban areas (Bucharest and cities, municipalities and the county seat municipalities of Ilfov, Alba, Arad, Argeș, Călărași, Caraș Severin, Dâmbovița, Dolj, Giurgiu, Gorj, Hunedoara, Ialomița, Mehedinți, Olt, Prahova, Teleorman, Timiș and Vâlcea counties. The imposed technical conditions generated a lot of discussions between specialists because they seemed to exceed the current way of determining the position of ground control points (GCP), given that the technology has changed fundamentally and allows a different approach.

We will list some requirements demanding compliance with a technology used 40 years ago, while current technology provides us with tools that ensure the same accuracy within 10 times shorter time and with a substantially reduced financial effort.

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1.1. Number of Control Benchmarks (Checkpoints - GCP)

We quote the technical specifications of the National Cartography Center:

"2.3.1.3.2 Distribution of ground points

The blocks must constitute on the basis of the surface approved by the flight plan.

• GCP

The distribution of GCP points must be homogeneous and uniform within the block and within the photograms (not near the projection centers).

There must be two GCPs at each corner of the block. ***The minimum GCP points per block must be 40, of which a minimum of two GCPs must be chosen in the middle of the block.*** *Slope variables must be taken into account so that in the case of rugged terrain the number of GCP points will be increased to ensure the altimetric accuracy of the products. The density of GCP points must ensure the required accuracy of the products. GCPs that can be measured at least 6-8 adjacent photograms are considered acceptable. For the adjacent blocks, the same GCP must be used on the connection area.*

• checkpoints

The distribution of checkpoints must be homogeneous and uniform within the block within the photograms (not near the projection centers) so as to cover the areas between the projected GCPs. Checkpoints must be well defined at ground level with X, Y and Z coordinates. The number of checkpoints must comply with the condition 1 point / 4 km^2. Checkpoints that can be measured on at least 6-8 adjacent photograms are considered acceptable."

Comment: Currently, due to the GNSS receivers with which the aircrafts are equipped, the number of benchmarks (checkpoints) is a maximum of 5 per block. These points ensure a scaling of the orthophotoplan with very good planimetric accuracy, depending on the size of the pixel (if the pixel is 1 meter, we do not have a planimetric accuracy better than 1 meter - if the pixel is 2 cm, then the planimetric accuracy must be of 2-3 cm) [1]. At the moment, there are publications in prestigious journals that support this statement [2]. Also, there are flights performed in Romania where the number of benchmarks was a maximum of 5 points over the entire area and where the precision in both the plan and the altitude was within the limits imposed by the technical rules in force.

1.2. Checkpoints (Benchmarks) To Be Determined with GNSS Technology by the Static Method

We quote the technical specifications of the National Cartography Center:

"2.3.2.1 Pre-marking, description and determination of GCP coordinates

To determine the GCP coordinates and checkpoints using GNSS technology, ***the stationing time should be at least 2 hours, with a sampling rate of 10 s****.*

In a measurement session, at least simultaneous determinations must be performed in order to have connecting vectors between the determined points."

Comment: In Romania, the ROMPOS application works, managed by the National Cartography Center it says that the planimetric accuracy is ±2-3 cm in planimetric position, and on altitude it differs depending on the calculated geoid (quasi-geoid) model. From our experience, as users of the ROMPOS system, we found that between static determinations and ROMPOS there are no significant differences in any area of the country. For this reason, the requirement seems strange because it greatly increases the time allocated to data acquisition and processing, implicitly costs, the results being identical. In response to the comments of specialists in the field on this requirement, the National Cartography Center argued that: *"The contracting authority has established the accuracy requirements for GNSS measurements (±5 cm for 3D coordinates and ±5 cm for ellipsoidal altitude) that can be achieved using static methods of determination. We mention that the ROMPOS network of permanent GNSS stations can ensure relative accuracies of approximately ±3 cm in ideal conditions for performing measurements, not influenced by external factors uncontrollable by the operator performing the measurements and the administrators of the network of permanent GNSS stations (as specified on the site rompos.ro). According to various specialized studies, the absolute accuracy of RTK determinations can vary significantly under improper measurement conditions (especially in the presence of the multispot effect and the cycle slip phenomenon), even with values of over 0.5 m. Thus, the static measurement methods ensure the correctness and a rigorous control of the accuracy of the determinations, not leaving to the discretion of the provider the method of determination, providing certainty to both the contracting authority and the provider regarding the required accuracy."* In the experiment we also chose points that could be affected by the multipath effect, to prove that the ROMPOS measurements can lead to a very good result.

1.3. Determination of Altitudes by Geometric Leveling

We quote the technical specifications of the National Cartography Center:

"2.3.2.1.2 Execution of geometric leveling measurements

The altitudes of the control points must be determined by geometric leveling which is performed on each line in the direction of "going" and "turning", using the leveling traverse method, by connecting to the State Leveling Network. The discrepancies between the level differences between the two directions must not exceed a tolerance of ±7 cm. In order to achieve the set objectives, it is necessary to use the necessary equipment according to the required tolerance."

Comment: The paper requires the creation of a digital terrain model, with an accuracy of ±20 cm. Nothing justifies the requirement of geometric leveling measurements that ensure very good accuracy (1 millimeter), but requires field teams of at least three people, very long sections, very long time to complete. It translates into very high costs and, as we will see, unnecessary [2].

2. Material and Methods

2.1. Carrying Out the Comparative Study

In order to demonstrate that the requirements of the Specifications are not in accordance with the reality that even the National Cartography Center manages, we decided to carry out a comparative study aimed at the following objectives:

a) determining the position of some points using GNSS technology - static method and ROMPOS;

b) the accuracy of determining the altitudes with ROMPOS;

c) multipath effect in sensitive areas.

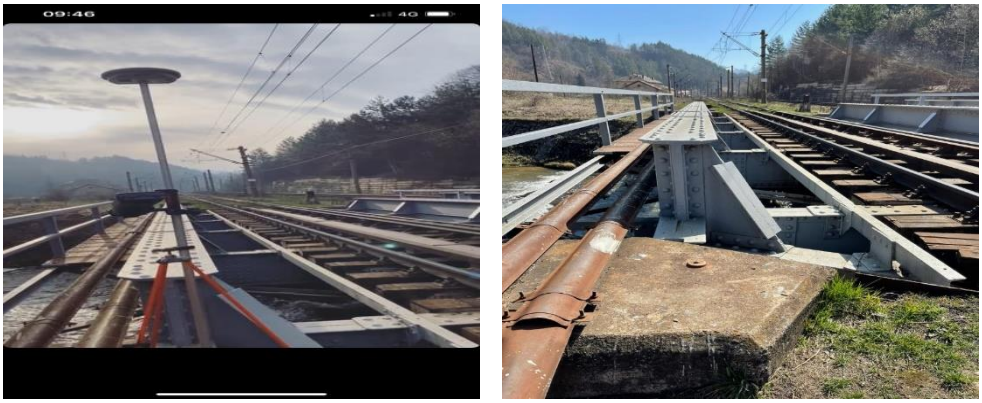
2.2. Creating a Working Group

In order to give weight to the study, we decided to create a working group from different entities, respectively academic environment, Professional Associations recognized at national and international level, private companies with recognized activity in the field of GNSS and the National Cartography Center. In this regard, we sent invitations and the following entities responded positively: Technical University of Constructions Bucharest through the Faculty of Geodesy, Romanian Society of Photogrammetry and Remote Sensing, Employers' Association of Cadastre, Geodesy and Cartography, Union of Romanian Surveyors, SC Cornel & Cornel Topoexim srl, SC TopGeocart srl, SC Heveceo srl. As there was an appeal in court, I also summoned a judicial expert, namely engineer Surveyor Sorin Negru. In this way, we considered that the study will be able to have scientific weight being endorsed by a large number of participants with recognized activity in the field. The National Cartography Center refused to participate on the grounds that there is a dispute and there is no need to influence the court. We considered, on the contrary, that the court could take into account the opinion of some specialists, given that the judges do not have specialized knowledge. Within the working group, each entity nominated the people who will participate in the data collection and in their processing. The Technical University of Constructions of Bucharest through the Faculty of Geodesy nominated the associate professor doctor engineer Tiberiu Rus, the holder of the GNSS course and the architect of the ROMPOS application, former employee of the National Cartography Center, as well as the assistant doctor engineer Andrei Ilie. The Romanian Society of Photogrammetry and Remote Sensing nominated the following: professor doctor engineer Alexandru Badea, and the head of works doctor engineer Octavian Balotă, the first being the president of the Association and director of the Romanian Space Agency. The Employers' Association of Cadastre, Geodesy and Cartography nominated Mr. Dr. Engineer Valeriu Marian Manolache. The Union of Geodesists in Romania nominated Mr. assistant doctor engineer Alexandru Iliescu. SC Cornel & Cornel Topoexim srl nominated the professor doctor engineer Cornel Păunescu, the holder of the GNSS course at USAMVB and the engineer Alexandru Cioacă. SC TopGeocart srl nominated engineer Sorin George Dumitriu, who maintains the permanent ROMPOS stations. SC Heveco srl nominated Mr. Costin Trandafir.

2.3. Choosing the Stationing Points

The points chosen for the case study had to meet several conditions, so as to demonstrate without a doubt that the ROMPOS application fully complies with the requirements of the Specifications and that the imposition of outdated technologies does not provide any additional precision. Point 2 a) could be demonstrated wherever we chose the points, because the difference between the static method and ROMPOS is very small regardless of the position of the points. For point 2 b), we had to choose stationing points that are from the national leveling network or in the immediate vicinity, so that the altitude of the chosen point is transmitted from 2 to 6 geometric leveling stations or a single trigonometric leveling station. For point 2 c) points had to be chosen where the multipath effect was strong. Given the requirements of points 2 b) and 2 c), we chose the following 6 locations:

1. Bănița point, the leveling benchmark of the I order, located on a railway bridge, over the Bănița brook. The GNSS receiver was located right on the leveling benchmark. It is also important for the fact that in the area the geoid ripple is high. The measurements were performed by SC Cornel & Cornel Topoexim srl with Leica type receivers. This point it is shown in Figure 1.



a) *b)*

Fig. 1. *Bănița point a) static measurements; b) mathematical point-leveling benchmark*

2. Bretea point, located near the leveling benchmark I order, fixed in the wall of a building in Bretea Streiului train station. The point was marked with a wooden stake. The altitude was transmitted by direct measurement between the point and the leveling benchmark. The distance between the benchmark and the point was 28.756 m, and the zenith angle was measured 3 times, the 3 level differences differing to one tenth of a millimeter, insignificant for the accuracy of the study. In the calculation we worked with the average of the three values. The measurements were performed by SC Cornel & Cornel Topoexim srl with Leica type receivers. These explanations are illustrated in Figure 2.

a) *b)*

Fig. 2. *Bretea point a) static measurements.*
From the station there is direct visibility to the leveling benchmark embedded in the wall of the building; b) the leveling benchmark

a) *b)*

Fig. 3. *Balotești point a) the benchmark embedded in the CFR canton;*
b) the materialized point, static measurements

a) *b)*

Fig. 4. *Herăstrău point*

3. Balotești point, located near the leveling benchmark I order fixed in the wall of the CFR canton at the entrance in Balotești station, Ilfov county. The point was materialized with a Feno milestone at a distance of 98 meters from the leveling benchmark. The altitude was transmitted by a geometric leveling closed on the starting point, being created a polygon with 6 stations. The non-closing in the polygon was of 0.7 mm, the determination accuracy being of 0.06 mm. The measurements were performed by SC Cornel & Cornel Topoexim srl with Leica type receivers. The explanations for this point are illustrated in Figure 3.

Fig. 5. *Sintești point*

4. Băneasa Point was located in front of Băneasa railway station in Bucharest. A leveling benchdmark is located in front of the station, but the benchmark altitude was not found. The point was placed on a metal bolt already embedded in a concrete road divider. An altitude transmission was made at this point from the benchmark of Băneasa station, but, not having the altitude, it could not be calculated. It remained only as a comparative experiment for the difference between static measurements and ROMPOS. You can see more details in Figure 6.

The measurements were performed by SC Cornel & Cornel Topoexim srl with Leica type receivers. Bănița and Bretea Streiului points have two altitudes, one from the inventory of the National Cartography Center and the other from the inventory of the former Military Topographic Directorate.

a)

b)

c)

d)

Fig. 6. *Băneasa Point a) ROMPOS measurements; b) Representatives of APCGC, Topoexim, forensic expert; c) Representatives of the Faculty of Geodesy, Topoexim, UGR; d) representatives of Topoexim, UGR*

2.4. Data Collection

It was established that the static measurements will be performed on 13.04.2021 between 9 and 12 am and that the ROMPOS determinations should be performed before the start of the static measurements, but also after them.

In order not to have disputes that the static determinations and ROMPOS were performed on the same day and almost at the same time, we agreed that the ROMPOS determinations be performed on other days. So:

The Bănița point was determined ROMPOS four times in three different days; on 11.04.2021 at 15.58, on 12.04.2021 at 11.32 and on 13.04.2021 at 07.56 and 13.17.

The Bretea point was determined ROMPOS three times in two different days; on 11.04.2021 at 18.01 and on 13.04.2021 at 09.26 and 12.11.

The Balotești point was determined ROMPOS four times in three different days; on 09.04.2021 at 11.08, on 10.04.2021 at 9.40 and on 13.04.2021 at 08.59 and 12.46.

The Herăstrău point was determined ROMPOS four times in three different days; on 09.04.2021 at 10.12, on 10.04.2021 at 10.41 and on 13.04.2021 at 09.40 and 12.06.

This point is illustrated in Figure 4.

The Sintești point was determined ROMPOS three times in two different days; on 09.04.2021 at 12.20 and on 13.04.2021 at 09.38 and 12.07. The Băneasa point was determined ROMPOS four times in three different days; on 09.04.2021 at 10.37, on 10.04.2021 at 10.27 and on 13.04.2021 at 09.34 and 12.10.

2.5. Data Processing

The data resulting from the static measurements were transmitted to all study participants to be processed independently and to obtain a set of coordinates from each. The files were saved in RINEX format to be calculated with the programs that each of the participants owns. During processing, each of the 6 points was determined from the

nearest 5 permanent stations. No compensation was made as a network of the 6 points, because this was not the purpose of the work. Data from ROMPOS determinations were also transmitted to each participant. These data were centralized and are presented in Annex 1. For the calculations we worked with the arithmetic mean of the three or four values. The data provided by the equipment resulted in the determination accuracy of each determination. Apart from these data, we calculated with the least square's method, direct measurements, the accuracy of the arithmetic mean. The values are presented in Table 1. It can be seen that the differences between the independent values, from different days, differ by a maximum of 1.3 cm for a single value, the rest being less than 1 cm - Annex 1.

Values determined with the ROMPOS application - precisions Table 1

No.	Point name	Stereo70 / MN75 coordinates - ROMPOS			Determination precisions of the data in the application			The mean square error of the arithmetic mean [m]
		X [m]	Y [m]	H [m]	3D [m]	2D [m]	1D [m]	
1	Bănița	439751.9694	371097.6882	637.1624	0.0203	0.0133	0.0154	0.0064
2	Bretea	463387.0332	344004.7334	276.4262	0.0100	0.0045	0.0089	0.0100
3	Baloteşti	343774.5516	586857.9810	96.5262	0.0084	0.0066	0.0052	0.0084
4	Herăstrău	331057.4032	586797.7302	80.9935	0.0061	0.0049	0.0037	0.0061
5	Sinteşti	313636.8304	588252.1569	67.8734	0.0089	0.0067	0.0058	0.0089
6	Băneasa	332236.2074	585568.0287	87.0243	0.0058	0.0038	0.0044	0.0058

3. Results

The values obtained from the static processing by each participant are presented in Annex 2. It can be seen that there are very small differences on the x and y axes between the different static determinations, of maximum 2 cm in absolute value, i.e. ±1 cm. In the case of results by altitudes, it can be seen that the results obtained by the Union of Surveyors are the furthest from the determinations of the others 5. Probably the program version use by them not take into account all the calculation elements or is old version. Considering that the results by altitude obtained by the Union of Surveyors are affected by errors, we will continue to take into account only the results of the other 5 participants. In this case, the largest difference between two determinations is of 12 cm in absolute value between the determination of Heveco and expert Sorin Negru. The result is a deviation of ±6 cm. The values obtained with the ROMPOS application are very close both on the x and y axes and on the altitudes. The maximum deviation is 1.5 cm in absolute value. Given that there are determinations made on different days and at different times, we can say that the accuracy of the determination is very good. Between static and ROMPOS determinations, the differences on the x and y axes are less than 2 cm in absolute value. The largest difference on altitude has an absolute value of 10 cm and is compared with the determination of the expert Sorin Negru. Comparing the values of the altitudes obtained with the ROMPOS application against the altitudes calculated from the leveling network for the 3 points: Bănița, Bretea and Baloteşti, the results are presented in Table 2. As can be seen, the largest difference in absolute values is 10.63 cm at the Bretea point, compared to the IGF inventory. Compared to the DTM inventory, the difference is only 6.94 cm. These being absolute values.

Table 2

Differences in altitudes between determinations in altitude ROMPOS and in the leveling network

No.	Point name	Determinations ROMPOS RTK			Elevation MN75_IGF [m]	Elevation MN75_DTM [m]	Difference against IGF [m]	Difference against DTM [m]
		x [m]	y [m]	h [m]				
1	Bănița	439751.97	371097.69	637.15				
2	Bretea	463387.03	344004.73	276.43	276.32	276.36	-0.106	-0.069
3	Baloteşti	343774.55	586857.98	96.53	96.50	96.52	-0.028	-0.006

4. Interpretation of Results

In order to better visualize the results, we made the graphs of the differences for the first point, Bănița, between the result of the ROMPOS determination and the static determinations of each participant. You can see the bellow the results in Figures 7, 8 and 9.

Bănița axa x	Diff. [mm]
TOPOEXIM	17.0
HEVECO	12.5
TOPOGEOCART	14.0
EXPERT NEGRU SORIN	17.5
UNIUNEA GEODEZILOR	14.5
UTCB – FACULTATEA DE GEODEZIE	-2.5

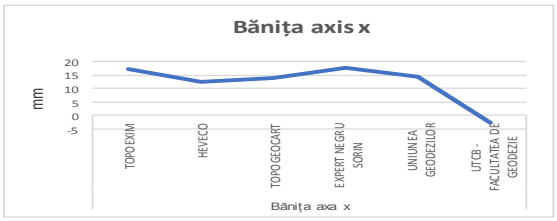


Fig. 7. *Differences for coordinate x between ROMPOS and static determinations for Bănița point*

Bănița axa y	Diff. [mm]
TOPOEXIM	-0.45
HEVECO	-4.15
TOPOGEOCART	-1.85
EXPERT NEGRU SORIN	1.85
UNIUNEA GEODEZILOR	18.85
UTCB – FACULTATEA DE GEODEZIE	13.85

Fig. 8. *Differences for the coordinate y between the ROMPOS and static determinations for the Bănița point*

Bănița axa altitudes	Diff. [mm]
TOPOEXIM	22.9
HEVECO	14.2
TOPOGEOCART	33.2
EXPERT NEGRU SORIN	27.2
UNIUNEA GEODEZILOR	-10.8
UTCB – FACULTATEA DE GEODEZIE	-2.5

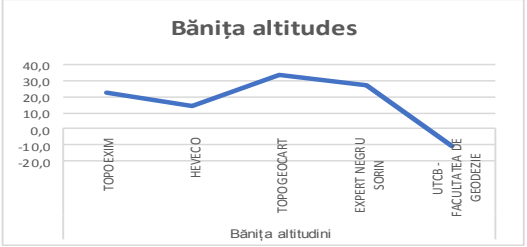


Fig. 9. *Differences in altitude between ROMPOS and static determinations for Bănița point*

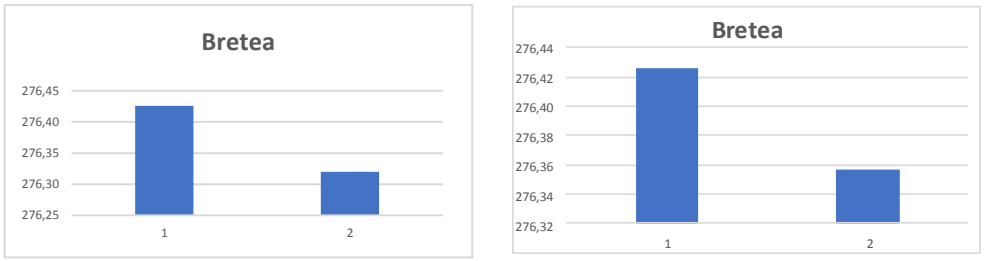


Fig. 10. *Difference in altitude between ROMPOS determination and the determination by leveling a) with IGF altitude, b) with DTM altitude (from Table 2)*

In Figure 10 are shown the results in altitude between ROMPOS determination and the determination by leveling. In the graph for differences in altitudes, we eliminated the UGR results for the reasons explained above.

5. Conclusions

The aim of this study was to demonstrate that ROMPOS determinations and static determinations using GNSS receivers do not differ much from each other. The National Center requested that the accuracy of determining 3D coordinates be ±5 cm and the accuracy of the ellipsoidal elevation be ±5 cm. For the altitudes ±7 cm. In order to obtain these accuracies, static GNSS measurements and high-precision geometric leveling are required. From Annexes 1 and 2 it results that the differences between the static method and ROMPOS for planimetry are at most 2 cm in absolute value, respectively an accuracy of ±1 cm, but in most cases much smaller. In the case of altitudes, as shown in Annexes 1 and 2, the largest difference shall be 10 cm in absolute value, respectively an accuracy of ±5 cm. But the correct comparison, according to the requirements, is the ROMPOS result with the altitudes determined from the national leveling network. Here, as noted, there are two rows of altitudes: from IGF and from DTM. The largest absolute difference is at Bretea point, between the IGF and ROMPOS altitude, having a difference of 10.63 cm, i.e. an accuracy of ±5.31 cm, below the ±7 cm condition required by the CNC. Compared to the DTM altitude, the difference is of 6.94 cm, i.e. an accuracy of ±3.47 cm, meeting the requirements. Regarding the multipath effect, although the Herăstrău point was between lakes and the Sineşti point between houses covered with tin and with a very sloping roof, this did not manifest. In fact, there is currently the possibility, especially for the ROMPOS application, to receive corrections from satellites in real time and to exclude satellites that can lead to this effect because the position calculated with the reflected signal does not fall within the average of the determinations. The conclusion is that the ROMPOS application of the National Cartography Center fully corresponds to the conditions required by the Specifications. Imposing these conditions leads to unnecessary measurements, to an impressive number of specialists, to unnecessary spending of time and worst of all, to an artificially increased price.

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Appendix 1

Nr. crt	Item name	Det. date	Det. time	Solution	Stereo70 / MN75 coordinate solution			Determination accuracy		
					x [m]	y [m]	h [m]	3D [m]	2D [m]	1D [m]
1	Herăstrău	09.04.2021	10:12	Fixed RTK	331057.3980	586797.7374	80.9842	0.0112	0.0054	0.0098
2	Herăstrău	10.04.2021	10:41	Fixed RTK	331057.4140	586797.7234	80,9989	0.0157	0.0088	0.0130
3	Herăstrău	13.04.2021	09:40	Fixed RTK	331057.3970	586797.7310	81.0000	0.0044	0.002	0.004
4	Herăstrău	13.04.2021	12:06	Fixed RTK	331057.4040	586797.7290	80.9910	0.0044	0.002	0.004
	Average				**331057.4032**	**586797.7302**	**80.9935**	**0.0061**	**0.0049**	**0.0037**
1	Băneasa	09.04.2021	10:37	Fixed RTK	332236.2120	585568.0275	87.0212	0.0184	0.0071	0.0170
2	Băneasa	10.04.2021	10:27	Fixed RTK	332236.2019	585568.0206	87.0342	0.0163	0.0067	0.0148
3	Băneasa	13.04.2021	9.34	Fixed RTK	332236.2083	585568.0356	87.02784	0.0124	0.0065	0.0105
4	Băneasa	13.04.2021	12:10	Fixed RTK	332236.2075	585568.0312	87.01382	0.0235	0.0121	0.0201
	Average				**332236.2074**	**585568.0287**	**87.0243**	**0.0058**	**0.0038**	**0.0044**
1	Balotești	09.04.2021	11:08	Fixed RTK	343774.5497	586857.9723	96.5133	0.0153	0.0064	0.0139
2	Balotești	10.04.2021	09:40	Fixed RTK	343774.5583	586857.9935	96.5220	0.0179	0.0111	0.0140
3	Balotești	13.04.2021	08:59	Fixed RTK	343774.5387	586857.9798	96.53442	0.0118	0.0072	0.0094
4	Balotești	13.04.2021	12:46	Fixed RTK	343774.5599	586857.9783	96.53486	0.0141	0.0076	0.0118
	Average				**343774.5516**	**586857.9810**	**96.5262**	**0.0084**	**0.0066**	**0.0052**
1	Sinteşti	09.04.2021	12:20	Fixed RTK	313636.8352	588252.1543	67.8732	0.0297	0.0178	0.0238
2	Sinteşti	13.04.2021	09:38	Fixed RTK	313636.8370	588252.1525	67.8635	0.0235	0.0127	0.0198
3	Sinteşti	13.04.2021	12:07	Fixed RTK	313636.8190	588252.1640	67.8835	0.0295	0.0153	0.0253
	Average				**313636.8304**	**588252.1569**	**67.8734**	**0.0089**	**0.0067**	**0.0058**
1	Baniţa	11.04.2021	15:58	Fixed RTK	439751.9717	371097.6880	637.1423	0.0190	0.0119	0.0148
2	Baniţa	12.04.2021	11:32	Fixed RTK	439751.9644	371097.6802	637.1422	0.0178	0.0093	0.0152
3	Baniţa	13.04.2021	07:56	Fixed RTK	439751.9566	371097.6910	637.1540	0.0169	0.0083	0.0148
4	Baniţa	13.04.2021	13:17	Fixed RTK	439751.9694	371097.6882	637.1624	0.0203	0.0133	0.0154
	Average				**439751.9655**	**371097.6869**	**637.1502**	**0.0064**	**0.0041**	**0.0049**
1	Bretea	11.04.2021	18:01	Fixed RTK	463387.0337	344004.7317	276.4257	0.0278	0.0163	0.0225
2	Bretea	13.04.2021	09.26	Fixed RTK	463387.0358	344004.7272	276.4110	0.0443	0.0206	0.0392
3	Bretea	13.04.2021	12:11	Fixed RTK	463387.0300	344004.7412	276.4418	0.0220	0.0136	0.0174
	Average				**463387.0332**	**344004.7334**	**276.4262**	**0.0099**	**0.0044**	**0.00889**

Appendix 2

Rompos RTK Determining							Altitude MN75_IGF [m]	Altitude MN75_DTM [m]
		Nr. crt.	Item Name	X [m]	Y [m]	H [m]		
Medium Values Rompos RTK		1	Băniţa	439751.97	371097.69	637.15	637.18	
		2	Bretea	463387.03	344004.73	276.43	276.32	276.36
		3	Balotești	343774.55	586857.98	96.53	96.50	96.52
		4	Herăstrău	331057.40	586797.73	80.99		
		5	Sinești	313636.83	588252.16	67.87		
		6	Băneasa	332236.21	585568.03	87.02		
Static Determination	**TOPOEXIM**	1	Băniţa	439751.95	371097.69	637.13	637.18	
		2	Bretea	463387.04	344004.73	276.37	276.32	276.36
		3	Balotești	343774.56	586857.98	96.52	96.50	96.52
		4	Herăstrău	331057.40	586797.74	80.98		
		5	Sinești	313636.84	588252.14	67.82		
		6	Băneasa	332236.21	585568.03	87.02		
Static Determination	**HEVECO**	1	Băniţa	439751.95	371097.69	637.14	637.18	276.36
		2	Bretea	463387.04	344004.74	276.34	276.32	96.52
		3	Balotești	343774.55	586857.98	96.58	96.50	
		4	Herăstrău	331057.39	586797.74	80.92		
		5	Sinești	313636.84	588252.14	67.88		
		6	Băneasa	332236.21	585568.01	87.00		
Static Determination	**TOPGEOCART**	1	Băniţa	439751.95	371097.69	637.12	637.18	
		2	Bretea	463387.04	344004.73	276.40	276.32	276.36
		3	Balotești	343774.55	586857.99	96.53	96.50	96.52
		4	Herăstrău	331057.40	586797.74	80.99		
		5	Sinești	313636.84	588252.14	67.86		
		6	Băneasa	332236.21	585568.03	87.03	637.18	
Static Determination	**EXPERT NEGRU SORIN**	1	Băniţa	439751.95	371097.69	637.12	276.32	276.36
		2	Bretea	463387.04	344004.74	276.37	96.50	96.52
		3	Balotești	343774.55	586857.98	96.60		
		4	Herăstrău	331057.40	586797.73	81.00		
		5	Sinești	313636.84	588252.15	67.86		
		6	Băneasa	332236.21	585568.02	87.12	637.18	
Static Determination	**GEODETIC UNION**	1	Băniţa	439751.95	371097.67	637.08	276.32	276.36
		2	Bretea	463387.05	344004.72	276.32	96.50	96.52
		3	Balotești	343774.55	586857.98	96.48		
		4	Herăstrău	331057.41	586797.73	80.93		
		5	Sinești	313636.85	588252.14	67.89		
		6	Băneasa	332236.21	585568.02	87.02		
Static Determination	**UTCB THE FACULTY OF GEODESY**	1	Băniţa	439751.97	371097.67	637.16	637.18	
		2	Bretea	463387.05	344004.75	276.42	276.32	276.36
		3	Balotești	343774.55	586857.99	96.51	96.50	96.52
		4	Herăstrău	331057.40	586797.74	81.01		
		5	Sinești	313636.84	588252.15	67.85		
		6	Băneasa	332236.21	585568.03	87.04		