Study on the possibilities of the geodetic support network development by using the national traingulation netowk

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ABSTRACT

In Romania it is used in the work of geodetic, topographic and cadastral local projection system called "Stereographic 1970". And Romania were determined points belonging to continental geodetic networks of global reference systems (WGS84/ETRS89) being conducted in several stages National Geodetic Space Network - NGSN consists of coordinate points known European Reference System ETRS89 . Although permanent stations network in Romania is fully functional and permanent stations spread across the country has reached a suitable density , new networks of support through their specificity cannot always develop at a convenient distance to a permanent station in therefore solutions must be found to achieve them. In turn, a network of support geodetic GNSS can be compensated where appropriate, in a different way , as free network partially constrained or constricted . In this paper will be considered and addressed different positioning modes and some variants of calculation, clearing and transformation, presented and compared with each other , yielding interesting findings of interest to improve the positioning of GNSS support networks. The main cases analysed in this paper is Supporting the development of a point of National Geodetic Space Network (NGSN).

Keywords*: sateleitare observations , NGSN, reference systems , geodetic network, GPS, coordinate transformations*

1. Introduction

A thickening GNSS geodetic network [1], [2] can be positioned in the Stereo'70 projection system through situating it directly in the classical geodetic network, the state triangulation network. The core issue in this case is establishing the local transformation parameters between the geodetic datum of GNSS measurements and the national reference system locally seen as conditioned by:

- The existence in the area of at least four common points positioned in the two reference systems;
- The quality, namely the accuracy of determining the terminals and their stability's integrity given their age.

Making a geodetic support network through directly situating it in the state geodetic network, involves the following steps[4]::

- identification and verification of available triangulation points;
- achievement of a rigorous geometric network that contains both the points of the triangulation network and the new points of the support network;
- redetermination of these points using GPS technology;
- calculation of local Helmert parameters;
- transformation of all points' coordinates using the 7 Helmert parameters.

Consequently, first, the geodetic triangulation network will be verified by comparing the initial coordinates to the newly determined ones using GNSS technology.

Obtaining local transformation parameters is performed by satellite observations in the current triangulation network, so that the old points would have two sets of known coordinates – the WGS84 system and the Stereo’70 national projection system[5]. Through specific mathematical procedures based on the points known in both systems, the local transformation parameters (also called coefficients) can be determined between the two systems so that the points of the new system are “forced” to be closer to their position in the local (original) coordinate system.

Once these points determined, all the other newly determined points will reach the new coordinate system. If the position obtained for the known points meets some criteria of accuracy, the newly obtained coordinates can be adopted for all points.

The main stages of designing and implementing the support network are outlined above. The main concerns in this chapter refer to highlighting a proper way of work by describing the steps to be run and the conditions to be met in order to achieve uniformity and accuracy requirements in positioning the points by this method.

For achieving the research in this chapter, we used[6]:

- the data acquired by the static method using the four L1/L2 GPS receivers;
- the support network we designed and implemented, consisting of 40 points;
- the coordinates of the state geodetic triangulation network that frame the area.

2. Checking the points of the triangulation network existing in the area

The quality of the support network resulting this way will greatly depend on the quality of the triangulation network’s points. Therefore, checking on the existing points should be one important start stage. In this stage, the local Helmert transformation parameters will be also computed. In consequence, based on the observations made in the classic network, the triangulation points were repositioned by using the GPS technology, in the WGS84 reference system, through the calculations carried out in a free network, using the Pintic East point as a reference point whose geocentric coordinates in the WGS84 reference system resulted from absolute positioning. The observations made in these points have been selected, calculated and compensated separately from the rest of the network. Calculations assumed running all the knownen stages and aimed to determine the three-dimensional components dX, dY, dZ of all network’s vectors, relative to the Pinticu East point[6]: (Fig. 1).

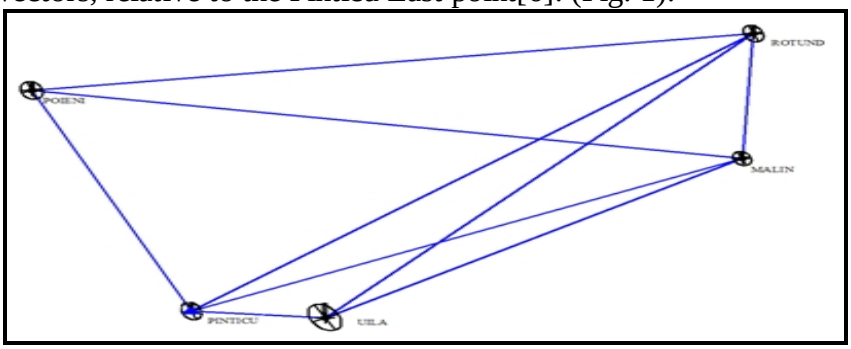

Figura 1. Adjusted baselines în the triangulation network

The network was balanced and it resulted into the geocentric coordinates in the WGS84 reference system of the existing network points. There was special determination accuracy. Therefore, as it can be noted, the total deviation for each geocentric coordinate, for each point, does not exceed 1.5 mm (Fig. 2). Note that the accuracy obtained refers to the relative positioning of points calculated in the network, with the Pintic East point considered fixed.

5.Adjusted Points in WGS84 (Cart. Coordinates and Std.Dev.)

Point	X [m]	Y [m]	Z [m]	sX [mm]	sY [mm]	sZ [mm]
MALIN	3960397.4220	1822285.5109	4641161.9999	1.0	0.8	1.0
PINTICU	3968505.5446	1813593.3332	4637474.2775	0.0	0.0	0.0
POIENI	3964737.8110	1808270.9063	4642536.2329	1.1	0.8	1.1
ROTUND	3957493.3789	1821199.0185	4644129.9735	1.1	0.9	1.1
UILA	3967514.1630	1816146.6439	4637313.1285	1.5	1.3	1.4

Figura 2. The result of network adjustment of the

The Cartesian coordinates of the old triangulation points, determined in the WGS84 reference system, were meant to serve in calculating the local parameters used in the spatial Helmert transformation. The results obtained by the 2D plan metric transformation are also presented as a choice for work.

2.1 The 3D spatial transformation of the triangulation points' coordinates

The calculation steps taken in transforming the coordinates of the WGS84 reference system points into the Stereo'70 projection system were:

a. The plane coordinates known in Stereo'70 were converted into B, L geodetic ellipsoid coordinates on Krasovsky ellipsoid.
b. These geodetic coordinates were transformed into three-dimensional Cartesian coordinates corresponding to a three-dimensional coordinate system attached to the Krasovsky ellipsoid.
c. The three-dimensional Cartesian coordinates of the points known in the two three-dimensional Cartesian systems, help determine the seven Helmert transformation parameters – three translations, three rotations and a scale factor.
d. The parameters thus obtained will help transform the geocentric coordinates of the old points of the WGS84 reference system into three-dimensional Cartesian coordinates within the three-dimensional Cartesian system corresponding to the Krasovsky ellipsoid.
e. The coordinates thus obtained will be further converted into ellipsoidal coordinates and finally into plane Stereo'70 coordinates.

In the end, the points of the current network will have two coordinate sets – a first set of known coordinates and a set of coordinates determined from the GNSS observations.

The transformation parameters determined through the TopoSys program using first all the five points of triangulation are:

$$\Delta X = 144.963\ m \qquad r_X = -0.27170''$$
$$\Delta Y = -132.459\ m \qquad r_Y = -0.13586''$$
$$\Delta Z = 120.577\ m \qquad r_Z = 0.36492''$$
$$k = 0.999989205$$

The differences between the known coordinates of the triangulation points and those obtained through GPS positioning, both projected in the Stereo'70, are relatively low (Table 1).

Difference on the 3D transformation based on all old points *Tabel 1*

Denumire punct	**Diferenţe de coord. în punctele comune**			**Eroarea medie a coord. (cm)**		
	Dif. X[cm]	**Dif. Y[cm]**	**Dif. Z[cm]**	$\mathbf{m_X}$	$\mathbf{m_Y}$	$\mathbf{m_Z}$
Măliniş	-0.2	5.7	11.0	±4.4	±11.5	±11.5
Pinticu	3.8	5.2	13.0			
Dl. Poieni	5.0	7.3	-7.4			
Dl. Rotund	-5.3	2.1	-3.5			
Uila Vest	-3.4	-20.3	-13.1			

It is noted that the Uila West point is over 20 cm deviated on the Y-axis, and therefore, after its exclusion, a new spatial transformation was run, resulting in a different set of transformation parameters, namely:

$\Delta X = 54.568\ m$ $r_X = -0.39875"$
$\Delta Y = -188.817\ m$ $r_Y = 0.3781"$
$\Delta Z = 204.154\ m$ $r_Z = 0.35002"$
$k = 0.999990991$

By this transformation, results have improved on each of the three axes, being below ± 5 cm. This finding may be accepted in order to achieve a support network (Table 2).

The 3D transformation using four of the points *Tabel 2*

Denumire punct	Diferenţe de coord. în punctele comune			Eroarea medie a coord.		
	Dif. X[cm]	Dif. Y[cm]	Dif. Z[cm]	m_X	m_Y	m_Z
Măliniş	-0.8	1.8	4.3	±3.7	±4.1	±4.0
Pinticu	-3.1	-6.1	2.6			
Dl. Poieni	5.4	2.1	-3.6			
Dl. Rotund	-1.4	2.2	-3.2			

2.2. Coordinates' 2D transformation

In order to have a complete view on the processing result and on any differences, we also studied the case of the plan metric transformation[6]:. The steps were:

a. The geocentric coordinates of the old points previously obtained within the WGS84 reference system will be converted into B, L geodetic coordinates related to the WGS84 ellipsoid.
b. These coordinates will be further converted into plane coordinates corresponding to a plane projections attached to this ellipsoid, but with the projection parameters corresponding to the Stereo'70 projection. This system will be called in calculations "the particular coordinate system".
c. The two sets of coordinates corresponding to the old points will help calculate the corresponding plan metric transformation parameters.
d. The parameters so determined, will help convert the coordinates of the old points within the particular system into the Stereo'70 projection system.

In the end, the same as in the 3D transformation, the points of the triangulation network will have two coordinate sets – a first set of known coordinates and a set of coordinates determined from the GNSS observations.

The transformation parameters were also determined through the TopoSys program:

$X_0 = 31.700$ $m_0 = 0.109$ $m_x = 0.064$
$Y_0 = 124.390$ $m_y = 0.096$
$k_x = 0.9999955084$
$k_y = 0.9999955084$

All the five points were used at the beginning (Table 3).

Coordinates difference on the 2D transformation using all old points *Tabel 3*

Nr. pct.	Coordonate iniţiale		Transformare plana		Diferenţe	
	x	y	x	y	dx[cm]	dy[cm]
Măliniş	609452.507	477940.435	609452.565	477940.487	5.8	5.2
Pinticu	604250.728	466638.889	604250.777	466638.920	4.6	3.1
Dl. Poieni	611843.269	463407.048	611843.164	463407.096	-10.5	4.8
Dl. Rotund	613736.106	478183.039	613736.112	478183.079	0.6	4.0
Uila Vest	604009.012	469371.371	604009.006	469371.200	-0.6	-17.1

It is noted that in this case too, the Uila West point registers the greatest deviation. Therefore, it will be removed and new transformation parameters will be determined:

$X_0 = 32.650$ $m_0 = 0.085$ $m_x = 0.054$
$Y_0 = 120.861$ $m_y = 0.032$
$k_x = 0.9999972979$
$k_y = 0.9999972979$

It is noted that in this case too, by eliminating the Uila West point, results were improved (Table 4).

Elements of 2D transformation using four points *Tabel 4*

Den. Pct.	Coord. iniţiale		Transformare plană		Δx [cm]	Δy [cm]
	x	y	x	y		
Maliniş	609452.507	477940.435	609452.536	477940.455	2.9	2.0
Pinticu	604250.728	466638.889	604250.784	466638.844	5.6	-4.5
Dl. Poieni	611843.269	463407.048	611843.202	463407.047	-6.7	-0.1
Dl. Rotund	613736.106	478183.039	613736.089	478183.065	-1.7	2.6

By grouping the results, we may note that differences in plane (Δx, Δy) between the two sets of coordinates taken from the geodesic triangulation and repositioned through GPS technology are low, up to 6 cm in both transformations (Table 5, table 6). The differences in height are also acceptable, although normal rates and ellipsoid heights have different references, namely on the glob and on the ellipsoid (Table 5).

Coordinates difference of the old points with a 3D transformation *Tabel 5*

Den. Pct.	Coord. iniţiale			Transformare spaţială			Δx [cm]	Δy [cm]	Δz [cm]
	x	y	z	x	y	z			
Măliniş	609452.507	477940.435	777.880	609452.537	477940.452	777.911	3.0	1.7	3.1
Pinticu	604250.728	466638.889	640.210	604250.787	466638.844	640.193	5.9	4.5	1.7
Dl. Poieni	611843.269	463407.048	493.689	611843.204	463407.041	493.702	6.5	0.7	1.3
Dl. Rotund	613736.106	478183.039	839.980	613736.088	478183.062	839.954	1.8	2.3	2.6
Uila Vest	604009.012	469371.371	632.269	604009.008	469371.127	631.933	0.4	24.4	33.6

Coordinates difference of the old points between 3D and 2D transformations *Tabel 6*

Den. Pct.	Transformare spaţială		Transformare plană		Δx	Δy
Măliniş	609452.537	477940.452	609452.536	477940.455	-0.2	0.2
Pinticu	604250.787	466638.844	604250.784	466638.844	-0.3	0.0
Dl. Poieni	611843.204	463407.041	611843.202	463407.047	-0.2	0.6
Dl. Rotund	613736.088	478183.062	613736.089	478183.065	0.1	0.3
Uila Vest	604009.008	469371.127	604009.004	469371.129	-0.4	0.2

3. Data processing in the support network

Once old points were checked and the results were considered satisfactory, we started to calculate the support network. This network's processing was achieved through taking into consideration an available network. The observations' duration was the greatest within the Pinticu point, so that the program had automatically chosen this reference.

The data files obtained from observations were processed daily. They aimed at identifying possible errors produced by either operators or equipment, or at identifying errors in the

satellite signals. The vectors characterized by insufficient observation periods, by small number of satellites, or by large processing errors, had been re-observed.
At the end it resulted a design of all the vectors projected (Fig. 3). Since all errors have been eliminated by checking data every day, all the solutions obtained in the final processing were above expectations.

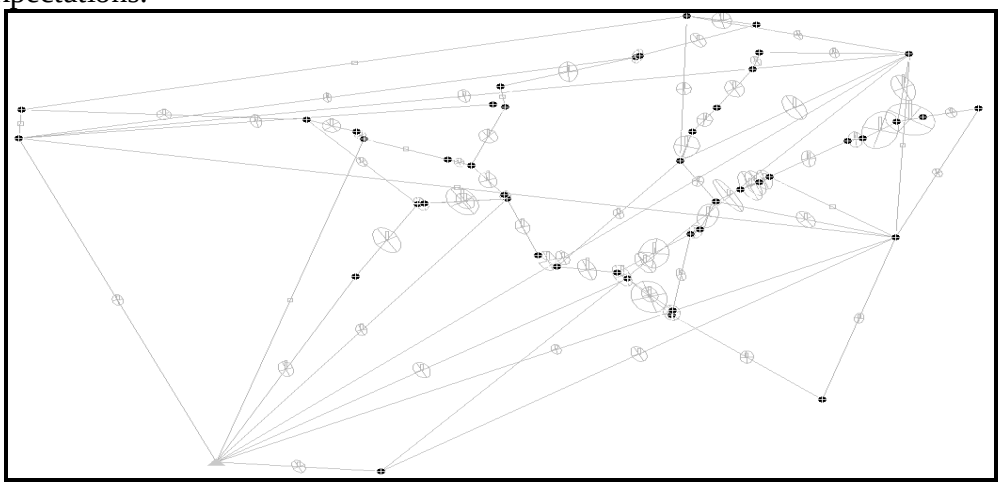

Figura 3. The final support network

The network has also been freely balanced so that to allow checking the network's internal geometry. The relative determination accuracy of each vector in the WGS84 reference system (and thus the coordinate system) was millimetric (Table 7). The compensation's result can also be regarded in numbers in different tables. The program calculates and expresses the average squared errors for the quantities determined at various stages of processing. We can thus follow the average squared errors for the components of each vector, the average squared errors for the geocentric coordinates and the average squared errors for the geodetic coordinates on the WGS84 ellipsoid (Table 8). We recall here that these indicators are in the free network. As the absolute precision is not influenced by the absolute precision of the coordinates of the reference point, we are interested in the result of compensation in this case only in terms of the relative accuracy obtained.

Base line adjustment în the support network (WGS84) (partially) Tabel 7

Baseline	DX [m]	DY [m]	DZ [m]	sDX [mm]	sDY [mm]	sDZ [mm]
01-02	-1783.5466	4375.8271	-140.7199	4.5	3.9	5.3
01-03	-1934.1715	5227.2740	-321.1932	4.8	4.0	5.6
MALIN-780	-2619.1454	314.7720	1995.4955	4.9	3.4	4.6
MALIN-PINTICU	8108.1155	-8692.1803	-3687.7264	2.4	1.8	2.4
MALIN-POIENI	4340.3836	-14014.6058	1374.2277	2.3	1.6	2.3
POIENI-01	-548.4740	-201.4087	356.7099	2.3	1.8	2.4
POIENI-10	-5526.9767	8720.0593	1287.5954	4.1	2.8	4.0
ROTUND-20	3084.6774	-2767.7515	-1901.3912	4.2	3.1	4.1
ROTUND-PINTICU	11012.1583	-7605.6874	-6655.7007	2.9	2.2	2.7
ROTUND-POIENI	7244.4264	-12928.1130	-1593.7466	2.9	2.0	2.6
UILA-PINTICU	991.3783	-2553.3112	161.1468	4.0	3.5	3.8
UILA-ROTUND	-10020.7800	5052.3762	6816.8475	4.2	3.6	3.9

Adjusted points în the support network (WGS84 geodetic coordinates) (partially) *Tabel 8*

Point	Lat [Deg]	Lon [Deg]	ell.H [m]	sN [mm]	sE [mm]	sH [mm]
01	N 47° 00' 39.91765"	E 24° 31' 03.93150"	394.8330	2.4	1.8	3.9
11	N 47° 01' 20.65466"	E 24° 39' 08.97090"	522.8638	3.8	2.7	6.9
16	N 46° 58' 36.47919"	E 24° 38' 51.60867"	491.5529	5.1	3.6	10.5
17	N 46° 58' 31.66581"	E 24° 38' 59.20930"	492.5210	4.3	3.2	7.3
18	N 46° 57' 00.07764"	E 24° 41' 32.31485"	491.7777	3.2	2.3	5.4
19	N 46° 59' 29.99320"	E 24° 40' 08.85450"	534.8570	3.3	2.5	6.1
20	N 47° 00' 00.90356"	E 24° 39' 41.05459"	609.8744	2.7	2.0	5.3
PINTICU	N 46° 56' 12.95211"	E 24° 33' 36.84270"	677.9694	1.8	1.4	3.1
POIENI	N 47° 00' 18.24296"	E 24° 31' 01.83200"	531.1893	1.8	1.3	2.9
ROTUND	N 47° 01' 21.88568"	E 24° 42' 41.08740"	877.8477	1.8	1.3	2.9
UILA	N 46° 56' 05.59349"	E 24° 35' 46.09943"	669.7993	3.0	2.3	5.2

However, using the geocentric coordinates of the new points, along with the transformation parameters determined in the previous chapter, the coordinates of these points would be converted into plane coordinates in the Stereo'70 national projection plan. Processing operations were performed through the TopoSys program (Table 9).

Coordinates differences of the network's points between 3D transformation and the 2D transformation *Tabel 9*

Nr. Pct	Transformare Spaţială		Transformare 2D		Diferente	
	Nord	Est	Nord	Est	dN	dE
1	2	3	4	5	6	7
1	612512.144	463455.466	612512.139	463455.476	0.005	-0.010
2	612246.151	468174.220	612246.144	468174.231	0.006	-0.011
3	611959.841	469009.454	611959.835	469009.465	0.006	-0.011
4	611798.269	469131.231	611798.262	469131.242	0.007	-0.011
5	611304.122	470513.641	611304.115	470513.652	0.007	-0.011
6	611231.699	470707.581	611231.692	470707.593	0.007	-0.011
7	610482.216	471450.426	610482.208	471450.437	0.008	-0.011
8	612598.629	471274.013	612598.622	471274.025	0.007	-0.012
9	613010.639	471396.256	613010.633	471396.267	0.006	-0.011
10	613689.562	473643.316	613689.557	473643.327	0.006	-0.011
11	613716.118	473704.271	613716.112	473704.282	0.006	-0.011
12	614635.296	474501.092	614635.293	474501.101	0.003	-0.009
13	614436.506	475652.082	614436.502	475652.092	0.004	-0.010
14	608578.379	468976.263	608578.372	468976.272	0.007	-0.009
15	608785.712	472310.190	608785.704	472310.200	0.008	-0.010
16	608648.801	473315.080	608648.792	473315.090	0.008	-0.010
17	608499.474	473475.037	608499.465	473475.047	0.008	-0.010
18	605658.240	476699.519	605658.229	476699.529	0.011	-0.010
19	610293.990	474954.349	610293.982	474954.359	0.007	-0.010

20	611250.836	474371.138	611250.832	474371.146	0.005	-0.008
21	611927.130	474579.539	611927.125	474579.547	0.005	-0.008
22	612492.078	474976.816	612492.073	474976.824	0.005	-0.009
23	613776.220	475699.670	613776.216	475699.678	0.003	-0.008
24	611758.172	477408.904	611758.166	477408.913	0.006	-0.009
25	611709.808	477148.122	611709.802	477148.131	0.006	-0.009
26	610388.919	471486.692	610388.911	471486.703	0.008	-0.011
27	610741.016	475672.884	610741.009	475672.894	0.007	-0.010
28	610585.032	475367.918	610585.025	475367.928	0.007	-0.010
29	609062.629	472003.678	609062.621	472003.688	0.008	-0.010
707	607746.898	474218.141	607746.890	474218.150	0.008	-0.009
708	607644.677	474200.900	607644.668	474200.909	0.009	-0.009
720	613387.736	475576.244	613387.732	475576.252	0.004	-0.008
730	609647.688	474683.963	609647.681	474683.973	0.008	-0.010
734	610868.080	475852.220	610868.073	475852.230	0.007	-0.010
738	609534.071	474532.305	609534.063	474532.315	0.008	-0.010
757	610277.367	470113.845	610277.360	470113.854	0.007	-0.010
758	610266.985	470010.983	610266.978	470010.993	0.007	-0.010
780	612451.376	479331.884	612451.372	479331.890	0.003	-0.006
785	612149.756	477971.275	612149.752	477971.282	0.004	-0.007
786	612255.551	478406.471	612255.547	478406.478	0.004	-0.007

The coordinates obtained by plane transformation will be used as the unit of comparison towards the coordinates of the point calculated through development towards the permanent station (Table 10).

Coordinates differences of the network's points between ETRS89 processesing and the 2D transformation *Tabelul 10*

Nr. Pct.	**Staţia permanentă Utilitar TrasDatRO**		**Transformare 2D**		**Diferenţe**	
	Nord	**Est**	**Nord**	**Est**	**dN**	**dE**
1	**2**	**3**	**4**	**5**	**6**	**7**
1	612512.150	463455.512	612512.139	463455.476	**0.011**	**0.036**
2	612246.052	468174.293	612246.144	468174.231	**-0.092**	**0.062**
3	611959.723	469009.531	611959.835	469009.465	**-0.112**	**0.066**
4	611798.144	469131.309	611798.262	469131.242	**-0.118**	**0.067**
5	611303.962	470513.725	611304.115	470513.652	**-0.153**	**0.073**
6	611231.534	470707.669	611231.692	470707.593	**-0.158**	**0.076**
7	610482.015	471450.517	610482.208	471450.437	**-0.193**	**0.080**
8	612598.488	471274.109	612598.622	471274.025	**-0.134**	**0.084**
9	613010.506	471396.352	613010.633	471396.267	**-0.127**	**0.085**
10	613689.427	473643.422	613689.557	473643.327	**-0.130**	**0.095**
11	613715.981	473704.379	613716.112	473704.282	**-0.131**	**0.097**
12	614635.183	474501.213	614635.293	474501.101	**-0.110**	**0.112**
13	614436.395	475652.207	614436.502	475652.092	**-0.107**	**0.115**

14	608578.191	468976.350	608578.372	468976.272	**-0.181**	**0.078**
15	608785.465	472310.291	608785.704	472310.200	**-0.239**	**0.091**
16	608648.547	473315.189	608648.792	473315.090	**-0.245**	**0.099**
17	608499.223	473475.147	608499.465	473475.047	**-0.242**	**0.100**
18	605658.005	476699.640	605658.229	476699.529	**-0.224**	**0.111**
19	610293.771	474954.466	610293.982	474954.359	**-0.211**	**0.107**
20	611250.645	474371.249	611250.832	474371.146	**-0.187**	**0.103**
21	611926.951	474579.649	611927.125	474579.547	**-0.174**	**0.102**
22	612491.919	474976.940	612492.073	474976.824	**-0.154**	**0.116**
23	613776.093	475699.799	613776.216	475699.678	**-0.123**	**0.121**
24	611757.995	477409.031	611758.166	477408.913	**-0.171**	**0.118**
25	611709.636	477148.250	611709.802	477148.131	**-0.166**	**0.119**
26	610388.716	471486.783	610388.911	471486.703	**-0.195**	**0.080**
27	610740.822	475673.004	610741.009	475672.894	**-0.187**	**0.110**
28	610584.832	475368.033	610585.025	475367.928	**-0.193**	**0.105**
29	609062.389	472003.776	609062.621	472003.688	**-0.232**	**0.088**
707	607746.648	474218.257	607746.890	474218.150	**-0.242**	**0.107**
708	607644.421	474201.016	607644.668	474200.909	**-0.247**	**0.107**
720	613387.601	475576.372	613387.732	475576.252	**-0.131**	**0.120**
730	609647.435	474684.082	609647.681	474683.973	**-0.246**	**0.109**
734	610867.886	475852.344	610868.073	475852.230	**-0.187**	**0.114**
738	609533.819	474532.419	609534.063	474532.315	**-0.244**	**0.104**
757	610277.185	470113.929	610277.360	470113.854	**-0.175**	**0.075**
758	610266.805	470011.067	610266.978	470010.993	**-0.173**	**0.074**
780	612451.252	479332.020	612451.372	479331.890	**-0.120**	**0.130**
785	612149.611	477971.404	612149.752	477971.282	**-0.141**	**0.122**
786	612255.415	478406.603	612255.547	478406.478	**-0.132**	**0.125**

4. Conclusions

The results presented in the previous chapters lead to a series of aspects:

- The support network designed and developed by using GNSS technology was calculated as free network.
- The final accuracy of a geodesic support network positioning is given both by the absolute accuracy obtained from the processing and compensation into the WGS84 reference system, and by the accuracy of the coordinate transformation to the national reference system.
- Internal geometry of the network has a significant effect in achieving the requirements of accuracy, uniformity and safety.
- GNSS permanent stations have an important role both in the development of geodetic networks and in obtaining new points with known coordinates in the ETRS89 European reference system.
- In designing the vectors in the support networks, it is not necessary that each new point of the network to be connected to a known point.
- The number of fixed points used to calculate the support networks influences the accuracy of the network; in this case, a fixed point is recommended to 15-20 new points.

- Using several fixed points in balancing the networks is more than beneficial, thus providing information on networks security.
- In this case study, all the steps required by the process had been undergone: from positioning the old points in the WGS84 system to calculating the transformation coefficients and the plane coordinates in the Stereo'70 projection system.
- Transformation methods can radically influence the final accuracy of positioning in the national reference system.
- Given that Transdat Utility provides an accuracy of ± 15 cm when transforming the coordinates, the coordinate differences obtained fall within these limits, without taking into account the absolute accuracy of the network.
- Transdat Utility does not yet have the precision that the NACLRR (National Agency for Cadastre and Land Registration in Romania) argues to offer, but instead, it ensures uniformity in GPS networks processing throughout the country.
- In transforming coordinates by using local transformation parameters, it specifically counts the network's geometry and placement, as well as the new network points' integration in the triangulation network. An insufficient number of old points or injudiciously located, can lead to significant errors in the coordinate transformation.

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