ISSUES RELATING TO THE PROCESSING OF GPS VECTOR AS A NETWORK TRILATERATION USING COMPUTER SYSTEMS TRIMBLE TOTAL CONTROL AND TOPOSYS

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Abstract:*Using modern technology dense works currently trigonometrical control network, offers several advantages, because data collection methods and respectively their processing systems. The work explores the possibility of GPS vector processing, register with the network trilateration GNSS technology, thus representing an alternative process, verification of those registration and the results obtained by other methods of calculation. Working methods are based on the use of GNSS technology for registration data and systems Trimble Total Control and TopoSys for processing those in order to simulate two variants of determining the points spacial positioned. Getting the final details in the national reference system for the processed points as trilateration network is realised through indirect measurements method. To analyze the differences of coordinates corresponding processed points as trilateration network and respectively as vector network was used a statistical test Dwass Steel. Using two different types of data processing registered with GNSS technology offers the possibility to optimize work process and respectively checking the solutions obtained. Processing data recorded as network trilateration needs a minimum of four control points from the trigonometrical control network related work area, determined in both reference systems, which will be used to produce elements of transformation and implicitly to obtain the final coordinates, in the national reference system. As a practical importance, this method does not require advance knowledge of national transformation parameters, area or local issue that has direct implications on the positioning accuracy spatial determinated points. The accuracy of determining the vectors and implicitly the points position can be analyzed efficiently if the GPS vector processing trilateration network of data processing report where they are presented in detail. Data processing computer systems specialist, offers the opportunity to efficiency the work process, the results obtained by different variants of calculation can be compared, some processing errors in this situation can be detected relatively easy. Because this calculation possibility involves the existence of efficient logistics, there is currently a restraint regarding the use in parallel of some computing system performance to ensure verification solutions obtained.*

Key words**:** *triangulation, calcul systems, primary coordinate, final coordinate, coordinate transformation, transformation parameters, coordinate differences*

INTRODUCTION

Trilateration supose accurate determination of chain length of the sides of triangles, something that can be achieved with the high precision with the aparition of apparatus of distance measuring through the wave (SABĂU N.C., 2010), respectively the performance of total stations.

Although GNSS technology fundamentally functions different from conventional technology works (total station) can be used to position various points that belong to the trigonometrical control network, network performance monitoring over time of hydraulic constructions (ILIES A., VASILCA D., 2005) data processing can be achieved as the network of trilangulation, trought the indirect measurement method (NEUNER J., SAVULESCU C., MOLDOVEANU C., 2002).

In support of this background it can be said that measurements of the distances are always enough (technical regulations in force stipulate that each item be placed with GNSS technology derived from the three vectors), obtained after processing inclined distances are determined with high precision, provisional coordinates in stereographic projection 1970 are knowed in relatively precisely (from a 3D processing) and altitudes of points necessary to reduce the distances at the plane projection are known wiyh the enough accurately (NEUNER J., SAVULESCU C., MOLDOVEANU C., 2002).

As a result, we plan to process the data registered with the GNSS technology by the static method rapidly from the phase I dense of the trigonometrical control network (...), to triangulation network.

MATERIAL AND METHODS

In general, to realised the processing of data registrated by the GNSS technology as a triangulation network, are necessary at least four points of known coordinates (common points), which will be used to achieve the transformation necessary to obtain the final coordinates. Points used in this case study are: 7, 11, 41 and 16 401 - Fig. 1.

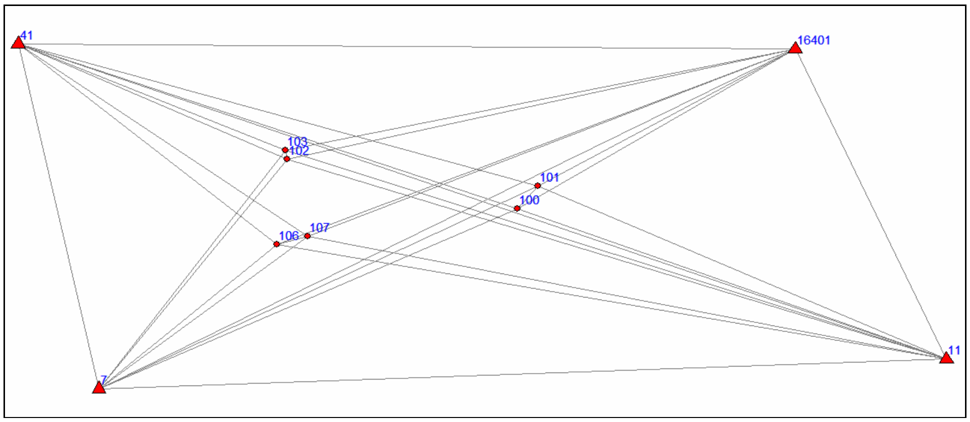

Figure 1: Sketch triangulation network proposed for the study and analysis

For the realisation of the study case were used GNSS seven receivers TRIMBLE R3 model for data collection. A relative working method was used to register traditional static data using the Trimble Digital Fieldbook (TDF) program for this purpose.

Data were registred in the working sessions of two hours registering epochs of 15 seconds. Primary data processing was done with the program Trimble Total Control (TTC), making the final details and getting the transformation accomplished with TopoSys computer system in two different variants of primary processing of data (a possibility with a control and one variant with four control points).

For one variant of calculation, all stages of processing were performed with TTC program to achieve meaningful comparisons between results.

As research methods were used experimentation, stationary observation, observation of itinerary, simulation, comparison and statistical analysis.

To analyze the differences of coordinates related to points determined by the method of GNSS technology and that the traditional static network triangulation, we propose using Steel-Dwass statistical test, given that the particular methods of registering and data processing.

Study case was realised from the Bihor County Forest Administration, Săcuieni Forest District, Management Unit (U.P.) I Sîniob .

RESULTS AND DISCUSSIONS

After processing the registred data were obtained some results which are presented in tabular and graphical form, below. In Fig. 2 is presented the base network (vectors) primary process and the planimetric and altimetric elements precision involved.

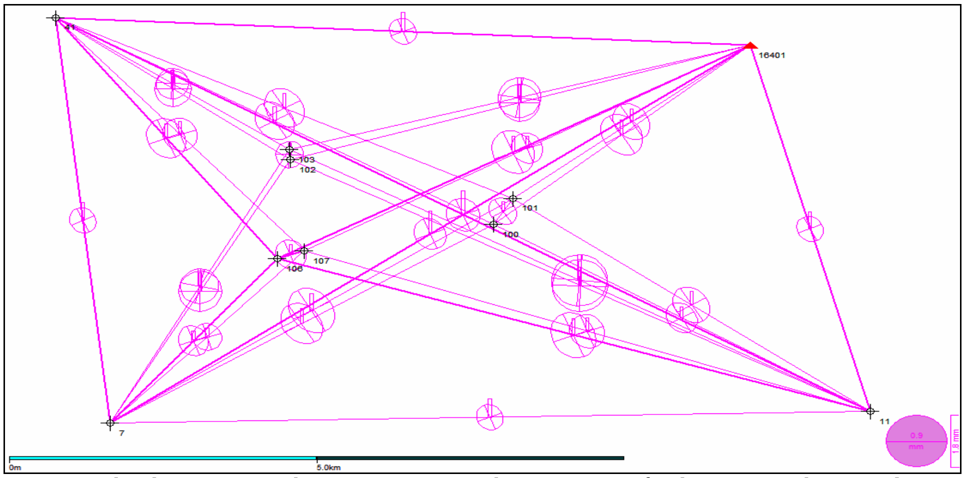

Figure 2: Sketch vector network primary process with TTC program for the variant with a control point

Table 1

Inventory of common points coordinates from the trigonometrical control support in the geocentric coordinate system WGS84 ellipsoid wich are used for the space transformation with program TopoSys

No. point	**X(m)**	**Y(m)**	**Z(m)**	**Observation**
7	4022080.269	1627582.127	4659390.965	Common points used for the space transformation
11	4016997.393	1638839.045	4659866.580	
41	4017227.959	1624350.434	4664669.252	
16401	4013124.326	1634882.839	4664668.344	

Table 2

Ellipsoidal initial coordinates inventory and coordinates corrections ellipsoidal WGS84

No. point	**X0(m)**	**dX(mm)**	**Y0(m)**	**dY(mm)**	**Z0(m)**	**dZ(mm)**
100	4017031.064	-12.1	1632105.481	14.5	4662152.556	14.2
101	4016569.925	-16.9	1632245.107	15.2	4662500.238	12.5
102	4017539.045	-5.7	1628700.063	12.9	4662918.807	-5.1
103	4017424.400	-2.5	1628625.169	11.6	4663067.192	-6.7
106	4018930.811	4.0	1629108.518	22.8	4661655.364	-6.7
107	4018652.577	-0.6	1629468.050	23.6	4661772.604	-7.4

Analyzing the data in Tab. 2 is found that the X-axis coordinate corrections vary between -16.9 and 4.0 mm, Y axis between 11.6 and 23.6 mm and Y axis between -7.4 and 14.2 mm.

Table 3

Inventory adjust ellipsoidal coordinates and average errors on the WGS84 ellipsoid

No. point	X(m)	mX(mm)	Y(m)	mY(mm)	Z(m)	mZ(mm)
100	4017031.052	15.3	1632105.496	16.7	4662152.570	20.1
101	4016569.908	14.7	1632245.122	16.1	4662500.251	19.6
102	4017539.039	14.9	1628700.076	13,1	4662918.802	12.8
103	4017424.398	14.8	1628625.181	13.2	4663067.185	12.7
106	4018930.815	16.7	1629108.541	14.7	4661655.357	17.7
107	4018652.576	20.1	1629468.074	18.0	4661772.597	19.7

The analysis of the information contained in the Tab. 3 note that the standard deviations for the X axis varies between 14.7 and 20.1 mm, Y axis between 13.1 and 18.0 mm and Z axis between 12.7 and 20.1 mm.

Table 4

Coordinates inventory adjust and average errors of coordinates, in the system topocentric locally on WGS84 ellipsoid (variant with one control point)

No. point	X(m)	mX[mm]	Y(m)	mY[mm]	He	mHe[mm]
100	144929.774	1.0	218480.761	8.6	5243.212	29.0
101	145429.485	0.9	218159.328	8.4	5242.445	28.1
102	146166.132	4.8	221781.804	5.5	5371.962	22.5
103	146366.717	4.8	221801.232	5.7	5359.387	22.3
106	144256.935	3.0	221999.799	6.3	5284.666	27.6
107	144410.472	4.9	221556.363	7.8	5269.953	32.1

Analyzing the information contained in the Tab. 4 X-axis is found that standard deviations vary between 0.9 and 4.9 mm, Y axis between 5.5 and 8.6 mm and Z axis between 22.3 and 32.1 mm.

Table 5

Inventory ellipsoidal coordinates on the WGS84 ellipsoid (variant with one control point)

No. point	Fi	La	He
7	47.1354	22.0153	137.706
11	47.1416	22.1139	166.693
41	47.1806	22.0057	139.919
100	47.1605	22.0642	143.141
101	47.1622	22.0657	144.314
102	47.1642	22.0403	156.472
103	47.1648	22.0402	174.317
106	47.1539	22.0356	207.739
107	47.1545	22.0417	210.528
16401	47.1802	22.0955	246.761

Table 6

Inventory vectors processed as triangulation (calculation variant of a control point)

GPS vectors		DX(m)	DY(m)	DZ(m)
From the	To			
102	103	74.895	114.642	148.383
107	106	359.533	278.239	117.239
100	101	139.627	461.144	347.680
103	7	1043.054	4655.871	3676.220
7	106	1526.414	3149.454	2264.392
7	101	4662.995	5510.361	3109.286
7	102	1117.949	4541.230	3527.837
7	107	1885.947	3427.693	2381.632
7	100	4523.369	5049.217	2761.605
103	41	4274.747	196.439	1602.067
41	106	4758.107	1702.856	3013.895
41	102	4349.642	311.080	1750.450

GPS vectors		DX(m)	DY(m)	DZ(m)
From the	To			
41	107	5117.640	1424.617	2896.655
41	7	3231.693	4852.310	5278.287
41	101	7894.688	658.051	2169.001
41	100	7755.062	196.907	2516.682
16401	103	6257.658	4300.072	1601.159
16401	106	5774.298	5806.489	3012.987
16401	102	6182.763	4414.713	1749.542
16401	107	5414.765	5528.250	2895.747
16401	7	7300.712	8955.943	5277.379
16401	41	10532.405	4103.633	0.908
16401	101	2637.717	3445.582	2168.093
16401	100	2777.343	3906.726	2515.774
103	11	10213.864	427.005	3200.605
11	106	9730.504	1933.422	1788.777
11	101	6593.923	427.485	2633.671
11	102	10138.969	541.646	3052.222
11	107	9370.971	1655.183	1906.017
11	100	6733.549	33.659	2285.990
11	7	11256.918	5082.876	475.615
11	41	14488.611	230.566	4802.672
16401	11	3956.206	3873.067	4801.764
103	102	74.895	114.642	148.383
106	107	359.533	278.239	117.239
101	100	139.627	461.144	347.680
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41	11	14488.611	230.566	4802.672
11	16401	3956.206	3873.067	4801.764

The analysis of data from Tab. 8 is found that the standard deviation obtained in the transformation space coordinates for the X axis is set to 0.015 m, 0.008 m and the Y-axis Z-axis 0.097 m. It is noted that planimetric, standard deviation of transformation has the tolerance recommended by the technical rules for the dense works of the trigonometric control network, for the height the standard deviation is not within tolerances.

Similar was calculated the coordonates of the dense points processed as a network triangulation and tranformed spacialy on common points with the computer program TopoSys, in the national reference system for version with one control point - Tab. 11 .

Table 7

Elements transformation ellipsoidal coordinates in rectangular coordinates in projection Stereo70 on the ellipsoid WGS84 (variant with one control point)

No. point	Linial deformation	Convergence of meridian
7	1.000182598	2.092823038
11	1.000149785	2.022201262
41	1.000198964	2.101343918
16401	1.000167470	2.034201308
100	1.000172354	2.060000000
101	1.000172383	2.054980324
102	1.000183503	2.075641811
103	1.000183915	2.075744362
106	1.000180681	2.080031406
107	1.000179744	2.074527041
Average	**1.000177140**	**2.067149447**

Table 8

Elements transformation ellipsoidal coordinates in rectangular coordinates in projection Stereo70 on the ellipsoid WGS84

The coordinate diferences in common points			
No. point	**dX(m)**	**dY(m)**	**dZ(m)**
7	0.001	-0.001	0.075
11	0.012	0.011	-0.083
41	0.008	-0.005	-0.084
16401	-0.021	-0.006	0.092

Average error of the coordonates		
m_X	**m_Y**	**m_Z**
0.015	0.008	0.097

Transformation parameters						
X_0	**Y_0**	**Z_0**	**r_X**	**r_Y**	**r_Z**	**k**
21.705	119.902	-23.999	-0.000020442	-0.000002357	-0.000001610	1.000005468

Table 9

Geocentric coordinates of the points of trigonometrical control network in the WGS84 ellipsoidal in projection system STEREO 70 (variant with one control point)

No. point	X(m)	Y(m)	Z(m)
7	641117.497	275249.718	137.706
11	641334.216	287609.966	166.693
41	648933.638	274367.730	139.919
100	644951.552	281486.591	143.141
101	645451.317	281808.104	144.314
102	646189.422	278183.048	156.472
103	646389.687	278164.145	174.317
106	644278.351	277967.427	207.739
107	644431.712	278411.233	210.528
16401	648399.171	285659.912	246.761

Processing the data registrated as triangulation network led to obtain adequate results, considering the precision indicators obtained from the spatial transformation of common points in the final stage precede to obtaining the coordinates in the national reference system - Tab. 8. Also, the differences in spatial coordinates obtained in the I dense stage of the trigonometrical control network through traditional static method and obtained as triangulation network (in both variants of calculation), in absolute value are in the range 0.8 to 2.9 cm - Tab. 12 and Fig.

3 and 4. It found that these differences are imposed by the lower tolerance technical work force for the dense work in the trigonometrical control network.

Table 10

Inventory details of the dense point processed as network triangulation and transformed spacialy on the common points with computer programTopoSys, in the national reference system (variant with one control point)

No. point	X(m)	Y(m)	Z(m)
100	644977.237	281606.996	114.909
101	645477.005	281928.511	116.077
102	646215.108	278303.434	128.310
103	646415.375	278284.531	146.156
106	644304.026	278087.816	179.578
107	644457.389	278531.624	182.358

Table 11

Inventory coordonates of the dense points processed as a network triangulation and tranformed spacialy on common points with the computer program TopoSys, in the national reference system (version with four control point)

No. point	X(m)	Y(m)	Z(m)	N(m)
100	644977.237	281606.996	114.909	28.232
101	645477.005	281928.511	116.077	28.237
102	646215.108	278303.434	128.310	28.162
103	646415.375	278284.530	146.154	28.161
106	644304.030	278087.811	179.580	28.161
107	644457.390	278531.623	182.358	28.170

Table 12

Differences of coordinates related to points of dense stage I, positioned GNSS technology by static method and that the network triangulation (through the two variant of calcul)

Point	Coordinate differences								
	Variant GNSS - Variant 1			Variant GNSS - Variant 2			Variant 1 – Variant 2		
	DX(m)	DY(m)	DZ(m)	DX(m)	DY(m)	DZ(m)	DX(m)	DY(m)	DZ(m)
100	-0.017	-0.008	0.020	-0.017	-0.008	0.020	0.000	0.000	0.000
101	-0.014	-0.010	0.021	-0.014	-0.010	0.021	0.000	0.000	0.000
102	0.011	0.024	0.008	0.011	0.024	0.008	0.000	0.000	0.000
103	0.013	0.029	0.029	0.013	0.028	0.027	0.000	-0.001	-0.002
106	0.020	0.013	-0.027	0.024	0.008	-0.025	0.004	-0.005	0.002
107	0.017	0.008	-0.029	0.018	0.007	-0.029	0.001	-0.001	0.000

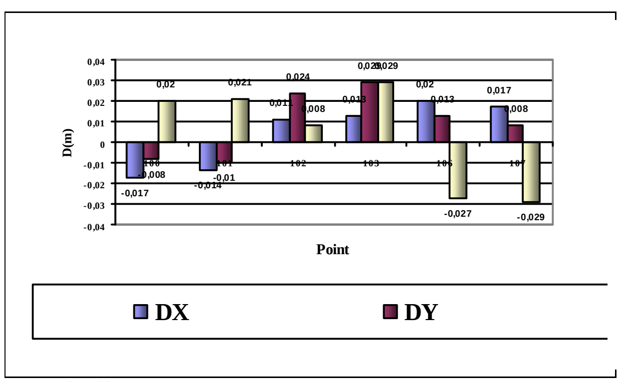

Figure 3: Histograms of differences related coordinate points dense positioned with GNSS technology through the traditional static method and respectively as an network triangulation variant 1

Table 13

The results obtained by applying the test Steel Dwass to analyze differences corresponding coordinate points in the dense stage I positioned trigonometrical control network with GNSS technology and traditional static method and respectively network triangulation (two variant)

X	**Var. 1**	**Var. 2**	**Var. 3**
Var. 1	-	0.16126 N.S. (P>0.05)	-0.16013 N.S. (P>0.05)
Var. 2	1	-	-0.16013 N.S. (P>0.05)
Var. 3	1	1	-
Y	**Var. 1**	**Var. 2**	**Var. 3**
Var. 1	-	-0.24146 N.S. (P>0.05)	-0.16013 N.S. (P>0.05)
Var. 2	1	-	-0.16013 N.S. (P>0.05)
Var. 3	1	1	-
Z	**Var. 1**	**Var. 2**	**Var. 3**
Var. 1	-	0 N.S. (P>0.05)	-0.16013 N.S. (P>0.05)
Var. 2	1	-	-0.16013 N.S. (P>0.05)
Var. 3	1	1	-

The analysis results presented in the Tab. 13 is found that the differences are not significant, because any analysis of working methods are feasible and can be applied successfully.

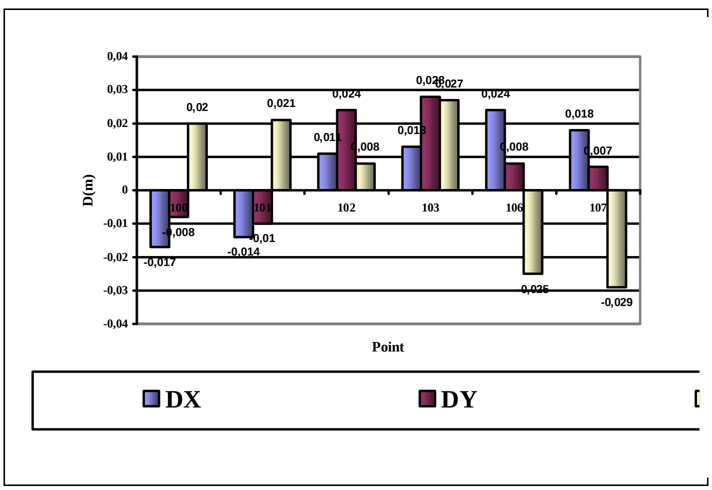

Figure 4: Histograms of differences related coordinate points dense positioned with GNSS technology through the traditional static method and respectively as an network triangulation variant 2

CONCLUSIONS

Coordinates the network of primary processing triangulation,with TopoSys computing system is an effective alternative for determining the final coordinates, thus obtaining the elements of transformation and respectively final details of the national reference system.

It appears that the variations between data processing computer system TopoSys no differences between the variant and the processing performed by the computer program with

TopoSys realised TTC and maximum coordinate differences, in absolute value does not exceed 0.029 m.

In both variants of calculation, data processing reports obtained by the two computer system have that detail steps of calculation and results obtained.

If it has a unit, is preferable to obtain data processing and coordinates with two different computers to compare results, in the event of large differences between these unjustified and can be relatively simple to identify and reveal the correct version calculation errors occurred.

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