

ADJUSTMENT OF GNSS PERMANENT STATIONS NETWORK MOLDPOS

Iuliana CONSTANTINOV, student – Technical University of Moldova,
iulianaconstantinov18@gmail.com

Vasile CHIRIAC, conf. univ. dr – Technical University of Moldova, V_Chiriac@hotmail.com

Abstract: *The aim of this work is to analyze the GNSS measurements results at different periods of time in order to estimate the accuracy of GNSS network monitoring in Republic of Moldova and to describe the national position system MOLDPOS. The goals of this paper are: the analyze of position systems; analyze of GNSS bases processing methods; the study of GNSS measures processing software and the adjustment of permanent stations network and the comparative analysis of the results. The most important part of the work was achieved by using Leica Geo Office Software that allowed to calculate the GNSS permanent stations coordinates for 4 different periods of time with the help of which was possible to determinate the smallest average deviation from initial coordinates and to determinate the average square error both in altitude and plan, in this way it's possible to find out which accuracy is the best from all periods of time. The achievements of this paper are: for 30 minutes with ± 1 cm in plan and ± 2.6 cm for altitude and is the best accuracy and the rest of the results are represented in the next way:*

- 24 hours: in plan : ± 0.9 cm and for altitude is ± 3.4 cm;
- 60 minutes: in plan: ± 1 cm and for altitude is ± 2.7 cm;
- 15 minutes: in plan: ± 1.6 cm and for altitude is ± 3.5 cm;

Keywords: *GNSS, permanent stations, coordinates adjustment, MOLDPOS, Leica Geo Office.*

1. Introduction

The National Positioning System was created for the purposes of the " National strategy of developing for 2008-2011 years" for to determining the objects positioning for Republic of Moldova in the real time, based on Global Navigation Satellite System, for to provide the state with necessary geodetic and cartographic dates for economical, social and scientific development.

The network comprises 10 stations that are located throughout country with the distance of 70-80 km between each station and in that mode for to have good connection with stations from neighboring countries Romaine and Ukraine. For a high precision of GNSS measurements the position of GNSS reference stations has to be monitored in real time mode.

The present work represents the determination aspects of permanent network stations coordinates, based on the GNSS technology. The most part of this subject is practical application using Leica Geo Office and Excel software that are used for post-processing positioning service.

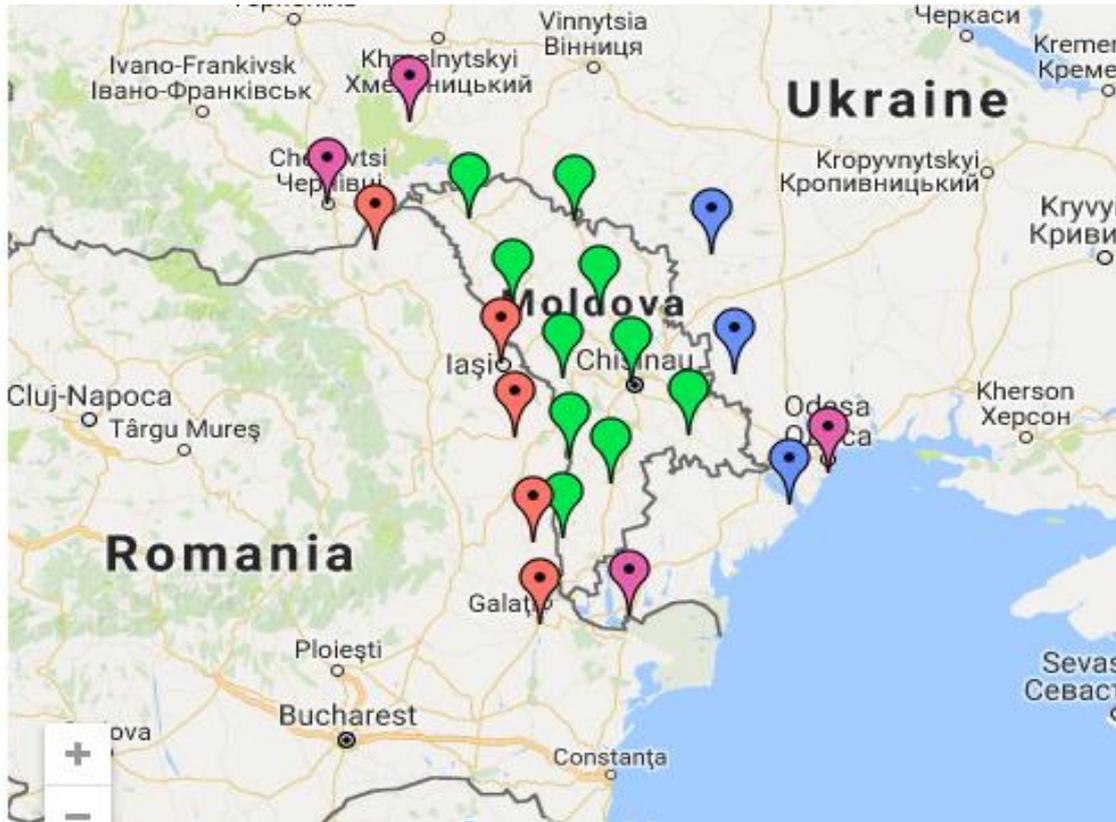


Figure. 1. The MOLDPOS GNSS Network [4]

The GNSS permanent reference stations of the national positioning system MOLDPOS are the initial reference points for execution of the geodetic, topographic and cadastral work.

The primary goal of this work is to realize the study of processing methods of permanent network stations in order to calculate their coordinates for different periods of time to determine the smallest average deviation from initial coordinates and the average square error both in altitude and plan

In this paper was made the analyze of permanent position systems; the analyze of GNSS bases processing methods; the study of GNSS measures processing software and the adjustment of permanent stations network and the comparative analysis of the results.

2. The analysis of GNSS processing methods

The determination of positions is possible by several methods like absolute positioning and relative positioning with the simple, double and triples difference. In this work the accent was put on the second method.

The principle of relative position is related by the coordinates determination of an unknown point relative to a known point. Here is determined the base vector between 2 points that is named the base.

In the case of relative position with the simple differences are eliminated the satellite clock errors:

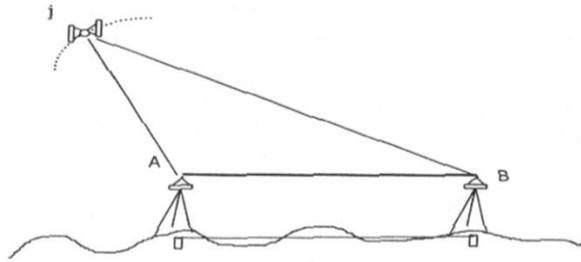


Figure. 2. The relative position with simple difference [1]

$$\Phi_A^j(t) - f^j \delta^j(t) = \frac{1}{\lambda} \rho_A^j(t) + N_A^j - f^j \delta_A(t)$$

$$\Phi_B^j(t) - f^j \delta^j(t) = \frac{1}{\lambda} \rho_B^j(t) + N_B^j - f^j \delta_B(t)$$

$$\Phi_{AB}^j(t) = \frac{1}{\lambda} \rho_{AB}^j(t) + N_{AB}^j - f^j \delta_{AB}(t)$$

(1)

In the case of equations of double differences are eliminated the receiver clock errors:

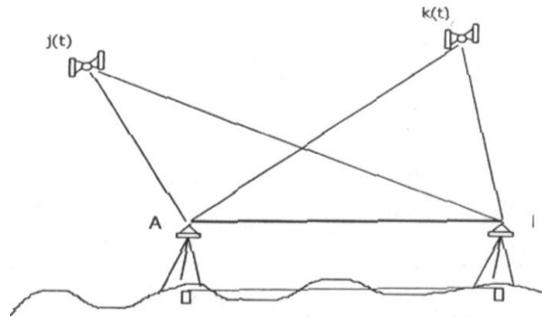


Figure. 3. Relative position with double difference [1]

$$\Phi_{AB}^j(t) = \frac{1}{\lambda} \rho_{AB}^j(t) + N_{AB}^j - f^j \delta_{AB}(t)$$

$$\Phi_{AB}^k(t) = \frac{1}{\lambda} \rho_{AB}^k(t) + N_{AB}^k - f^k \delta_{AB}(t)$$

$$\Phi_{AB}^{jk}(t) = \frac{1}{\lambda} \rho_{AB}^{jk}(t) + N_{AB}^{jk}$$

(2)

The equations with triple difference are necessary for to eliminate the time ambiguity:

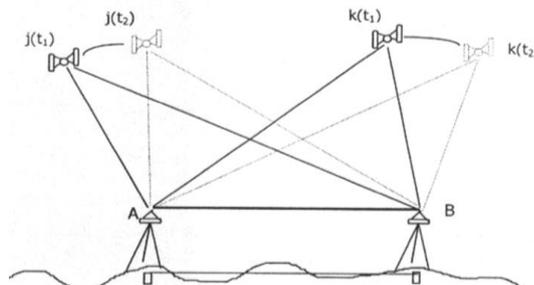


Figure. 4. Relative position with triple difference [1]

$$\begin{aligned} \Phi_{AB}^{jk}(t_1) &= \frac{1}{\lambda} \rho_{AB}^{jk}(t_1) + N_{AB}^{jk} \\ \Phi_{AB}^{jk}(t_2) &= \frac{1}{\lambda} \rho_{AB}^{jk}(t_2) + N_{AB}^{jk} \\ \Phi_{AB}^{jk}(t_2) - \Phi_{AB}^{jk}(t_1) &= \left[\frac{1}{\lambda} \rho_{AB}^{jk}(t_2) + N_{AB}^{jk} \right] - \left[\frac{1}{\lambda} \rho_{AB}^{jk}(t_1) + N_{AB}^{jk} \right] = \frac{1}{\lambda} [\rho_{AB}^{jk}(t_2) - \rho_{AB}^{jk}(t_1)] \end{aligned} \tag{3}$$

The general form of this equation is representing without receiver’s clock, satellite’s clock errors and time ambiguity, that is necessary for a good coordinates determination.

3. The calculation of permanent stations network coordinates

The software that was used in this work is Leica Geo Office (LGO). For to work with LGO is necessary to download the RINEX files (Receiver Independent Exchange Format) that is an international standard of post processing data exchange. The RINEX files have been downloaded from the moldpos.md site but they are archived, for to import RINEX files in LGO is necessary to unzip them, to create a job in LGO and to import the unzip RINEX files. The RINEX files were downloaded for 4 different time periods: 15, 30, 60 minutes and 24 hours.

After RINEX files import the network view is represented with all permanent stations from Republic of Moldova like in the next pictures:

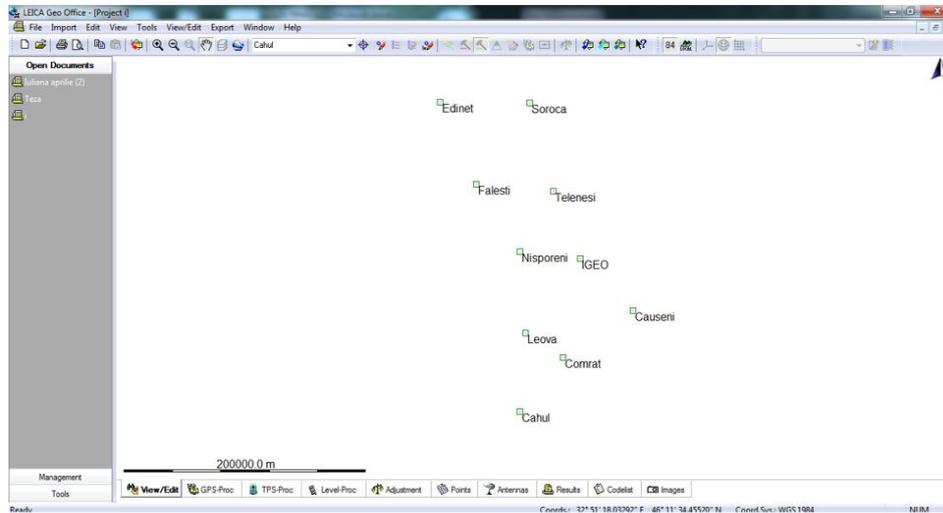


Figure. 5. The network representation after RINEX files import in to Leica Geo Office software

In the end of the downloaded RINEX files in Leica Geo Office was created the network permanent stations and with the help of two nearest stations with known coordinates it’s possible to process the coordinates of unknown station., by this way are processing all stations coordinates, and after all stations processing it’s obtained the network base vectors of permanent stations

The next image represents the base vectors of network stations processing

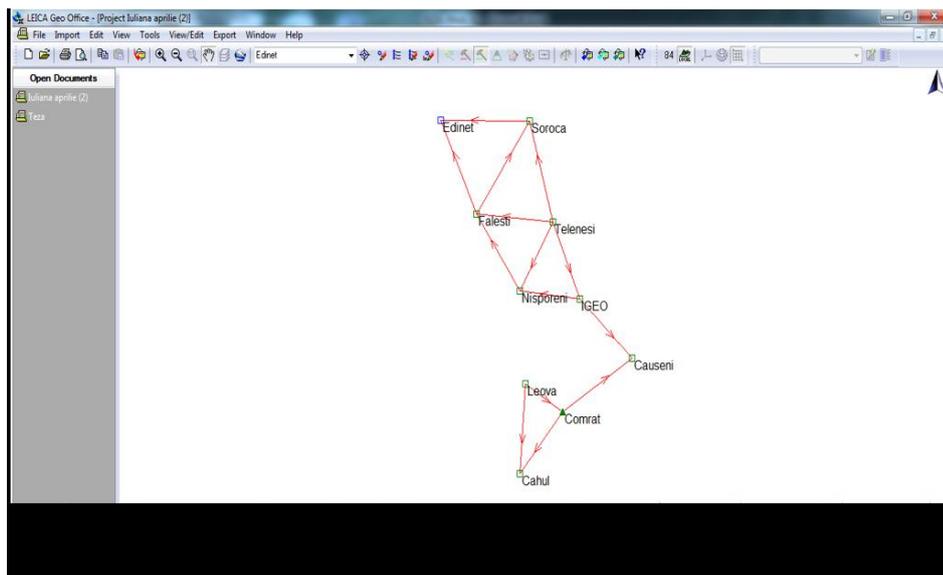


Figure. 6. The representation of the network processing and the base lines

The software that was used for to determine the stations coordinates was Leica Geo Office, but for to determine the average square error has been used Excel program in conformity with State Metrological Standard.

4. Analyze of results

The difference of coordinates that were obtained in the end shows a bigger difference for altitude's coordinates because of difference between geoid and quasigeoid model and are represented in next figures for each period of time:

The results of coordinate difference for the time period of 24 hours is represented in the next picture

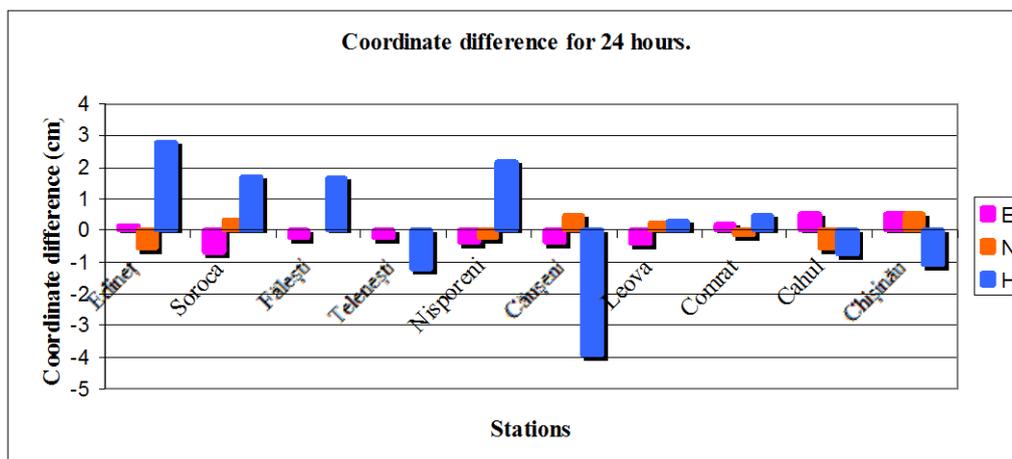


Figure 7. The difference of the calculated coordinates and initial coordinates for 24 hours

The results of coordinate difference for the time period of one hour is represented in the next picture

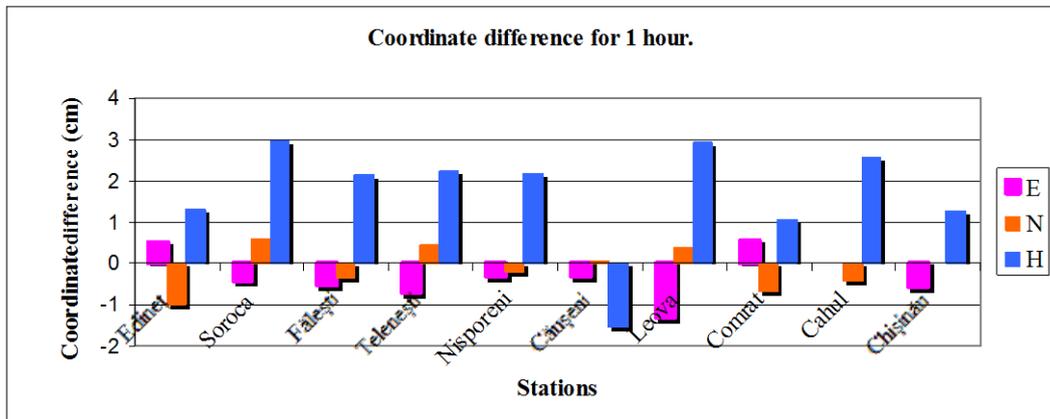


Figure. 8. The difference of the calculated coordinates and initial coordinates for 1 hour

The results of coordinate difference for the time period of 30 minutes is represented in the next image

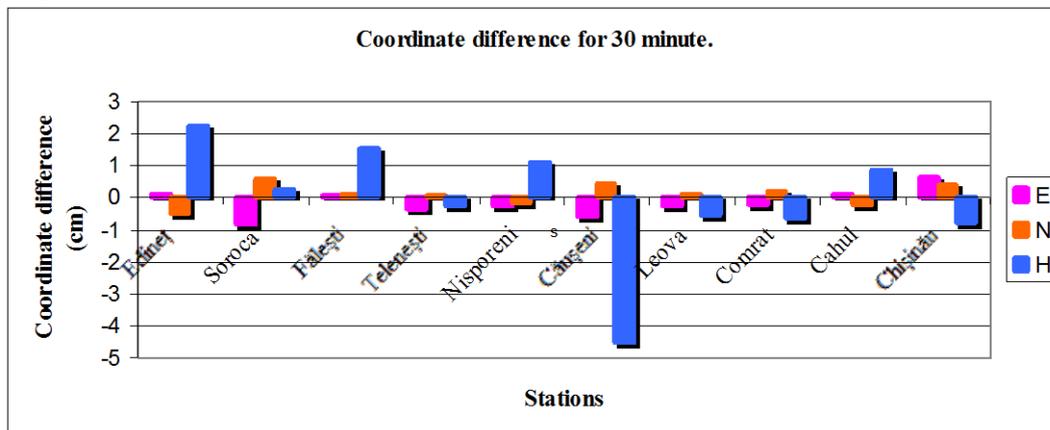


Figure. 9. The difference of the calculated coordinates and initial coordinates for 30 minutes

The results of coordinate difference for the time period of 15 minutes is represented in the next image

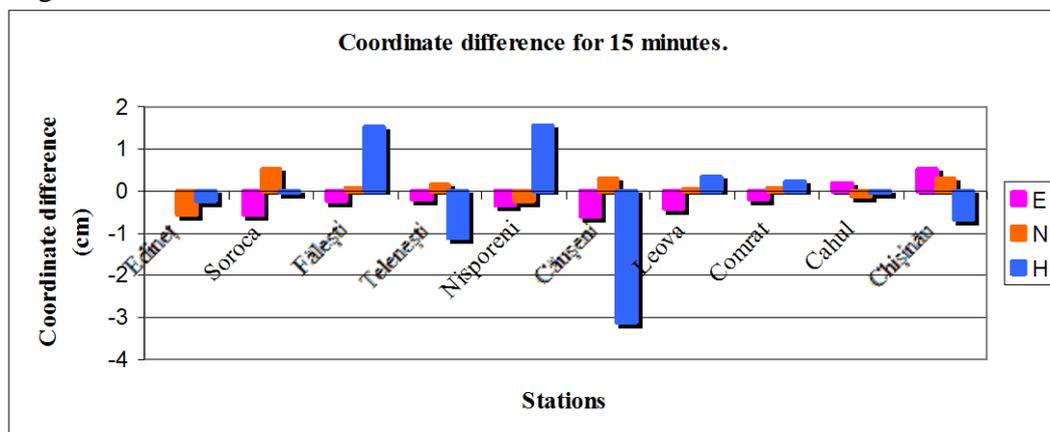


Figure. 10. The difference of the calculated coordinates and initial coordinates for 15 minutes

The results of average square deviation of processing GNSS measures for each period of time are represented by the next images:

The representation of accuracy in plan:

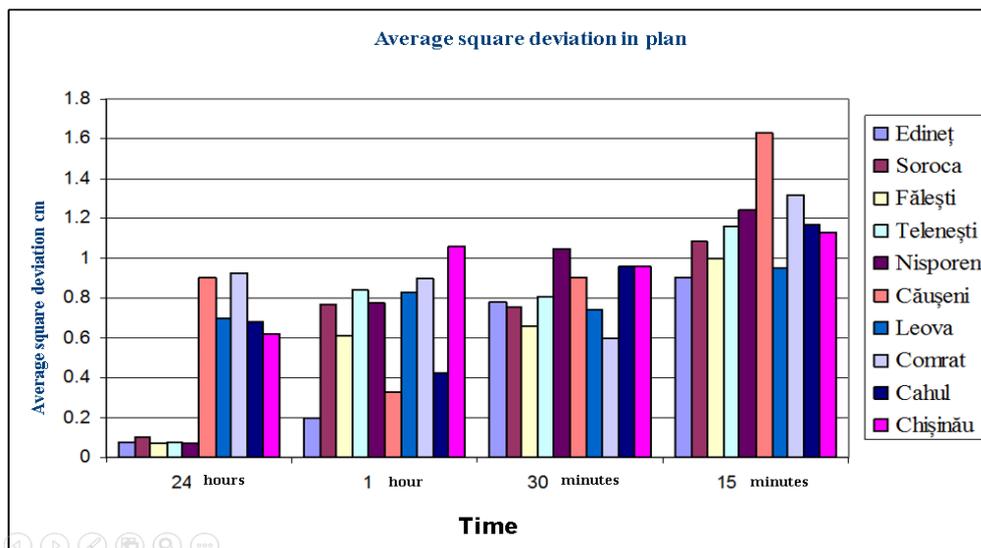


Figure. 11. The representation of average square deviation in plan

The representation of accuracy on altitude:

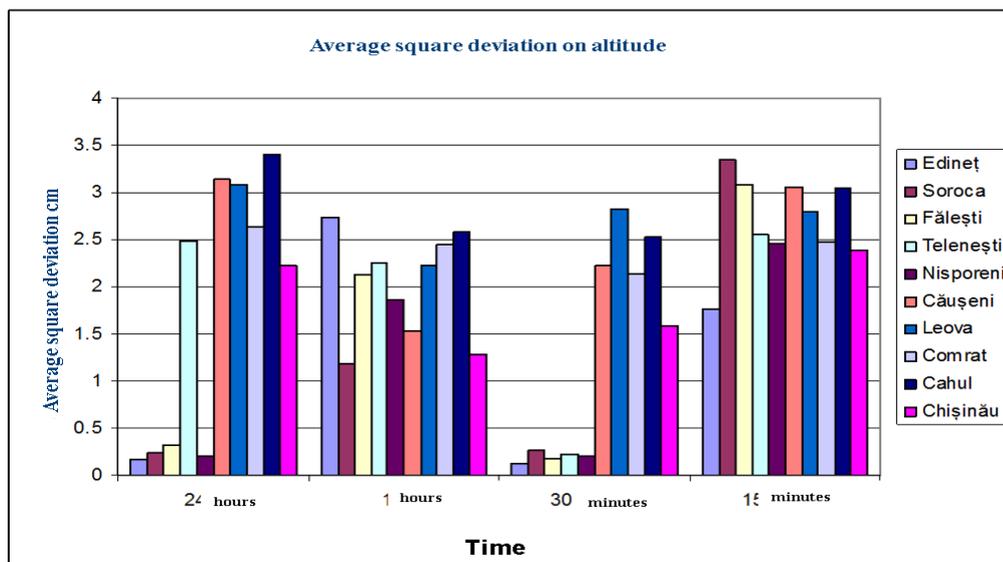


Figure. 12. The representation of average square deviation on altitude

The average results for 24 hours, 60, 30, 15 minutes are:

- 24 hours in plan : ± 0.9 cm and for altitude is ± 3.4 cm;
- 60 minutes in plan: ± 1 cm and for altitude is ± 2.7 cm;
- 30 minutes in plan: ± 1 cm and for altitude is ± 2.6 cm;
- 15 minutes in plan: ± 1.6 cm and for altitude is ± 3.5 cm;

5. Conclusions and recommendations

At the end of present work it's possible to conclude that from all GNSS positions methods the most important for this work is the relative method with triple difference, because only this type of position can eliminate all kind of ambiguity: satellite's clock errors, receiver's clock errors and the ambiguity independent of time.

The work was made in the base of RINEX files that was downloaded from moldpos.md site, for 4 different periods of time that can allow to determinate which period is necessary for to monitors a permanent station. The periods of time for the RINEX files was downloaded are 24 hours, 60, 30 and 15 minutes, and this files were processing with Leica Geo Office software, that is used for post-processing data.

The difference between initial coordinates and calculated coordinates can be explain because of difference geoid and quasigeoid models, and the accuracy results of processing GNSS measures concludes that the verification of reference permanent stations can be execute with the measures of 30 minutes with the reception interval of 5 seconds that provide the precision of ± 1 cm in the plan and ± 3 cm for altitude, but if it's necessary for a bigger precision can be used the measures of 24 hours.

Following the results of analyzes it's possible to conclude that the period of GNSS measurements could be around 30 minutes. So, every 30 minutes MOLDPOS control center will have the deviation of GNSS stations coordinates that allow organizing automated monitoring system.

6. References

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