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STUDY OF THE PERFORMANCE OF A GNSS EQUIPMENT AND ASSESSMENT OF THE QUALITY OF THE RESULTS FROM THE GEODETIC MEASUREMENTS IN AN OPEN FIELD ENVIRONMENT WITH ACTIVE DISTURBER

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Research area**:** *geodesy*

ABSTRACT

Nowadays the environment is being populated with radio signals from number of sources on various frequencies. Some of the emissions could disturb the normal propagation of the radio waves coming from GPS and/or GLONASS satellites. The so-called active disturbers exist in various regions and cause difficulties when conducting the geodetic measurements.

This study focuses on: measurements performed both in regions with existing disturbers and also in area close to, but outside of the disturbed place. The results from the satellite measurements from the disturbed and not-disturbed region were analysed. Based on the current satellites' status and calculated results, conclusions and recommendations are done.

1. Introduction

Nowadays the open field environment is heavily populated with various radio signals. This is due to the increased usage of the modern devices and in fact to the fast development of the IT and its application in our everyday life.

As the satellites emit radio waves, the last could interfere with already existing signals (which in general come from various unknown sources) near the earth surface (where the geodetic measurements are conducted). The disturbance often causes difficulties in the implementation of the geodetic measurements and in some specific cases also impossibility to complete the survey task.

Several examples about the possible jammings are given below. Military, security equipment devices, etc. with their emissions can cause:

a) In fast static mode – very slow (difficult) initialization of the receiver or complete loss of lock;

b) In RTK mode – impossibility to establish the data link or to emit differential corrections.

Some studies exist, dealing with the influence caused by the various sources of disturbance of GNSS radio signals, see: [5], [6] and [10].

In this paper the attention is focused on tests, which examine how the disturber affects GNSS equipment and the relevant influence on the results from the satellite measurements in fast static mode. The key moment in this study is the use of specific values of the parameters in the GNSS system, see [1] and [2].

2. Sources of Errors, Affecting the Overall Quality of GNSS Measurements

If using GNSS technology, then several factors concerning the quality of the satellite determinations should be considered. According to [3], the main sources of errors in satellite measurements and data processing are: errors from synchronizing of clocks in satellites and receiver, satellite orbit, troposphere refraction, ionosphere refraction, variations in the phase centre of the antenna, multipath.

Information about the sources of errors in GNSS measurements and possible ways for their mitigation can be found also in [7].

It is well known, see [4] that the points from the geodetic networks should be positioned away from radio sources or other emitting devices, as the last could interfere and degrade the quality of the results from the satellite measurements. From practical point of view it is almost impossible to know in advance the existence of active disturber/s/. This imposes a study on the influence of the last on the results from the geodetic measurements.

3. Conducted Geodetic Measurements. Study of the Performance of GNSS equipment

For the needs of this experiment the following test was done. As it is known, see [4] that GNSS measurements should be conducted in open field environment, away from trees and buildings. According to these conditions, a suitable open-field region was chosen. The place, subject of test was with active disturber in operation. A reference GNSS station out of and in close proximity to the disturbed area was installed. New-determined points were placed and coordinated out and inside of the region under study. The length of each measured spatial chord was less than 1 km in order to maximize the accuracy of the results. All new-determined points were placed in the open field, without any obstructions. The distance between the points in the disturbed area was from 50 up to 100 m.

In this specific case the raw satellite data were collected both with and without the influence of the active disturber, operating in the area under study. Fast static GNSS measurements were conducted and post-processed with specific values of the parameters, see [1] and [2]. In order to have enough data for analysis, two cycles of geodetic measurements were done. The results from their post-processing are summarized and given in Tab. 1, 2 and 3.

The behaviour of the geodetic equipment when collecting data was carefully examined in the means of:

a) Initialisation time of the rover;

b) Time to calculate a position;

c) Number of visible/used satellites.

During the measurements *in fast static mode*, the following experimental facts were tested and ascertained:

-the initialisation time was the same as it is in normal, not-disturbed area;

-the determination of the current position did not meet difficulties;

-the number of the used GLONASS satellites was very unstable, while the total number of the visible ones was constant and not changed during each session. The amount of the used GPS satellites was much more stable, according to the on-screen information on the controller.

4. Used Criteria for Assessment of the Overall Quality of the Measured Spatial Chords

In this paper the following quality criteria were involved:

1. Position quality;
2. Position and height quality;
3. Diagonal elements of the co-variance matrix of each measured chord: Q11, Q22 and Q33;
4. DOP factor for assessing the geometry of the visible satellites, including $GDOP(max), PDOP(max), HDOP(max), VDOP(max)$.

Further information about the dilution of precision can be found in: [7] and [8].

5. Analysis of the Results from the Geodetic Measurements. Conclusion. Outlook

After the post-processing of the raw data, the satellites' windows of the measured spatial chords were analysed. The availability of the satellites was also considered.

The study of the performance of the used GNSS equipment shows that:

-the active disturber in the region, subject of tests affects mainly GLONASS satellites;

-according to the information for the satellite availability and the recorded raw data, some of the GLONASS satellites which should be available, were "missing" in the satellites' windows of the rovers, placed in the area under study;

-significant number of satellites were "thrown away" and not used by the controller's software. The relative amount of the excluded satellites was at about 20-25%.

Taking in mind the numeric results calculated by the firmware and given in Tab. 1, it could be concluded:

-The points, subject of quality assessment, coordinated both inside and outside of the region under study have same position quality;

-Significant differences in the values were observed for the diagonal elements of the co-variance matrix of the chord for points N 13 and 14 (inside of the disturbed region) in comparison with points N 20 and 25 (outside of the area, subject of tests).

Maximum values for:

-Q11 was calculated for point N 13;
-Q22 and Q33 were produced for point N 14;
-Similar conclusion could be done for GDOP, PDOP and VDOP numbers.

Table 1. Results from the post-processing - I-st cycle

new-determined point ID	**11**	**12**	**13**	**14**	**20**	**25**
Position with respect to the disturbed region	inside the disturbed region				**outside of the disturbed region**	
Position quality [m]	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002
Position and height quality [m]	0.0002	0.0002	0.0002	0.0003	0.0002	0.0004
Q11	5.000E-07	5.500E-07	5.900E-07	5.700E-07	4.400E-07	4.000E-07
Q22	2.500E-07	2.700E-07	3.200E-07	3.300E-07	2.900E-07	2.600E-07
Q33	4.100E-07	4.800E-07	5.600E-07	5.700E-07	4.600E-07	4.000E-07
GDOP max	2.2	2.5	3.7	3.6	1.7	1.5
PDOP max	1.8	2.1	3	2.9	1.5	1.3
HDOP max	0.9	0.9	1.1	1.1	0.9	0.8
VDOP max	1.6	1.9	2.8	2.7	1.2	1.1

According to the data, listed in Tab. 2 and 3, the following facts could be summarized for the points inside the disturbed region:

-Point N 8 has high values for the parameters: Q33 and DOP factors in comparison with the points, situated outside of the disturbed region and in other places inside the area under study;

-Point N 9 has worst values for the parameters: position quality and position and height quality;

-Point N 10 has largest value for the element Q22;

Table 2. Results from the post-processing - II-nd cycle

new-determined point ID	**1**	**5**	**6**	**7**
Position with respect to the disturbed region	outside of the disturbed region	inside the disturbed region		
Position quality [m]	0.0001	0.0002	0.0003	0.0003
Position and height quality [m]	0.0002	0.0004	0.0005	0.0004
Q11	5.000E-07	4.200E-07	4.000E-07	4.100E-07
Q22	1.900E-07	1.900E-07	2.000E-07	2.100E-07
Q33	3.500E-07	3.700E-07	4.300E-07	5.600E-07
GDOP max	1.6	1.5	1.5	1.6
PDOP max	1.4	1.3	1.3	1.4
HDOP max	0.7	0.7	0.7	0.8
VDOP max	1.2	1.1	1.1	1.2

Table 3. Results from the post-processing - II-nd cycle

new-determined point ID	**8**	**9**	**10**
Position with respect to the disturbed region	inside the disturbed region		
Position quality [m]	0.0003	0.0004	0.0002
Position and height quality [m]	0.0005	0.0006	0.0004
Q11	4.200E-07	4.300E-07	4.200E-07
Q22	2.300E-07	2.500E-07	2.700E-07
Q33	6.100E-07	5.600E-07	5.200E-07
GDOP max	4.1	2.0	1.8
PDOP max	3.3	1.7	1.5
HDOP max	1.6	1.0	0.9
VDOP max	2.9	1.4	1.3

Taking in mind the continuous improvements of GPS, see [11] and GLONASS, see [9], the geodetic measurements conducted with GNSS equipment nowadays are characterised with better overall quality and reliability.

According to the conducted geodetic measurements (done with professional GNSS equipment in fast static mode and specific values of the parameters applied in the software) it could be summarised, that the active disturber (regardless of the overall improvement of the performance of GNSS) in this study:

- affects GLONASS satellites;
- the influence is very well noticeable in the values of: diagonal elements of the co-variance matrix and the DOP factor (see the results for points N 8 and 9 in Tab. 3).

As possible future work it could be noted, that the described experiment may be performed also for geodetic measurements in RTK mode.

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