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Study of the Behaviour of the Rover and Assessment of the Overall Quality of the Results from RTK Measurements, Conducted in open-Field - Influenced by Active Disturber

Gintcho Petkov Kostov, “GEO ZEMIA” Ltd.

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Изследване поведението на подвижния приемник и оценка на общото качество на резултатите от RTK измерванията, извършени в открито поле – повлияно от активен смутител

Гинчо Петков Костов, “ГЕО ЗЕМЯ“ ООД

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ABSTRACT

Recently the open-field environment is strongly populated with radio signals from number of sources and frequencies. Some of the emissions could disturb the normal propagation of the radio waves coming from GPS and GLONASS satellites. The active disturbers exist at various regions and could cause great difficulties when conducting the geodetic measurements.

This experiment studies the behaviour of the rover - operating in RTK mode within a region, influenced by active disturber. The results from the geodetic measurements were also analysed. Based on the satellites’ status and calculated results, conclusions and recommendations are done.

РЕЗЮМЕ

Напоследък околната среда е наситена с радио вълни от голям брой източници и честоти. Някои от емисиите биха могли да смутят нормалното разпостранение на радио вълните от GPS и GLONASS спътниците. Активните смутители съществуват в различни райони и могат да причинят сериозни затруднения при извършване на геодезическите измервания.

Този експеримент изследва поведението на подвижния приемник - работещ в RTK режим в район, повлиян от активен смутител. Извършен е анализ на резултатите от геодезическите измервания. На база на статуса на спътниците и изчислените резултати са направени заключения и препоръки.

1. Introduction

Currently the open-field environment is “polluted” with various radio signals. The reason for this fact is the increased possible applications of hardware, working with radio waves. The ultra-rapid development of the IT nowadays, also its usage in the life of humans also contributes to the “high density” of the radio signals in the open-field.

In the process of radio emission from the satellites, the waves may interfere each other with another already existing signal from unknown source. The so called jamming happens near the earth surface, where the geodetic measurements are conducted. The disturbance may cause various technical problems when implementing the satellite measurements. Also, in some cases – even impossibility to complete the survey job.

The practice shows that the hardware, which could cause the interference, may be, but is not limited to: military, security, communicational, etc. Here are listed examples about the possible jammings for different operating mode of the GNSS equipment.

a) (fast) static mode – very slow initialization of the receiver, also it may occur complete loss of lock;

b) RTK mode – the data link between the reference station and the rover may be impossible to be set up.

There are several papers available, dealing with the effect of the disturbance by the various sources, caused to the normal propagation of GNSS radio signals, e.g.: [Tiwari et al., 2009], [Tiwari et al., 2012] and [http://waas.stanford.edu/~wwu/papers/gps/PDF/IWG/sbas_iono_scintillations_white_paper.pdf].

In this study the focus is set on experimenting how the disturber affects GNSS equipment and the relevant influence on the results from the satellite measurements in RTK mode. Another important detail of the experiment is the usage of specific settings in the system, see [Kostov, 2010].

2. Sources of Errors, Influencing the Quality of GNSS Measurements

When conducting GNSS determinations, then several factors concerning the quality of the satellite measurements should be considered. Taking in mind [Minchev et al, 2005], the main sources of errors in satellite measurements and data processing are: errors from synchronizing of the clocks in the satellites and the receiver, satellite orbit, troposphere refraction, ionosphere refraction, variations in the phase centre of the antenna, multipath.

Details, concerning the sources of errors in GNSS measurements and the possible ways for their mitigation are given in [Wellenhof et al., 2002].

As it is known, see [MRDPW, 2011] the geodetic measurements should be conducted in areas, away from radio sources or other devices, which perform emission of radio waves, as the last may interfere and also degrade the quality of the final results from the satellite measurements.

Unfortunately, it’s not possible to be aware in advance for the existence of active disturber in the area, subject of geodetic measurements. This makes necessary to do a test and study the influence of the active disturber on the results from the satellite measurements.

3. Conducted Geodetic Measurements in the open-Field - Influenced by Active Disturber. Study and Specifics of the Behaviour of the Rover

For this paper the following experiment was done. It is known, see [MRDPW, 2011] that GNSS measurements should be conducted in open-field, away from trees, buildings and other passive disturbers. Based on these conditions, a region with working active disturber was chosen. The reference GNSS station was set up in proximity to the area under study. The geodetic measurements in RTK mode were conducted inside the disturbed region and the behaviour of the rover was carefully examined. The spatial length between the reference station and each measured point was less than 1 km. All new-determined points were situated in open-field environment, without obstructions around them.

3.1 Behaviour of the rover

The unit, operating in RTK mode and the on-screen notifications of the firmware in the controller were carefully studied in the terms of:
a) Time, needed for acquiring of the satellites;
b) Number of the visible/used satellites;
c) Changes/variations in the number of used satellites.

3.2. Ascertained facts during the measurements

In the process of conduction of the measurements in RTK mode, the following technical details were noticed:
a) the receiver acquired the satellites slower than usual, according to the light indicator;
b) the number of the used satellites was unstable, i.e. a moving of the receiver in small distances caused a change (lowering) of their amount;
c) the visible satellites were less than expected, according to the results from the prediction tool of the software;
d) there was a significant number of thrown away satellites – between 2 and 10 in the open-field under study.

4. Used Criteria for Assessment of the Overall Quality of the Measured points

In this study the following quality criteria were applied:
1. Diagonal elements of the co-variance matrix of each measured point: Q11, Q22 and Q33;
2. Position quality - Mp;
3. Height quality - Mh;
4. Position and height quality - M3D;

5. Results and Analysis from the Measurements in RTK mode. Conclusion

The calculated values of the quality criteria (see chapter 4) are listed in table 1. The overall quality, i.e the rating of each measured point is given in the last column.

point N	**Q11**	**Q22**	**Q33**	**Mp [mm]**	**Mh [mm]**	**M3D [mm]**	**rating**
335	0.00001915	0.00001231	0.00009714	6	11	12	0.63
336	0.00001916	0.00001281	0.00010978	6	11	12	0.63

350	0.00001914	0.00001280	0.00010994	5	10	11	0.63
351	0.00001933	0.00001282	0.00011988	5	10	11	0.64
352	0.00001583	0.00001265	0.00010010	5	10	11	0.64
353	0.00001903	0.00001269	0.00010491	6	11	12	0.63
354	**0.00002263**	**0.00002574**	**0.00029561**	**7**	**17**	**18**	**0.47**
355	0.00001560	0.00001254	0.00009616	5	10	11	0.64
370	0.00001918	0.00001320	0.00010867	5	10	11	0.63
371	0.00001535	0.00001268	0.00010175	5	10	12	0.64
				0			
372	0.00001928	0.00001314	0.00012432	6	11	13	0.63
373	0.00001529	0.00001235	0.00010590	6	11	13	0.64
374	0.00001527	0.00001234	0.00010611	5	11	12	0.64
375	0.00001519	0.00001228	0.00009874	6	12	14	0.63
376	0.00001512	0.00001151	0.00009519	6	11	12	0.64
377	0.00001406	0.00001151	0.00010383	6	11	13	0.65
378	0.00001199	0.00001039	0.00009535	5	11	12	0.68
383	0.00001188	0.00001097	0.00011269	6	13	15	0.63
384	0.00001159	0.00001037	0.00009499	6	12	13	0.66
385	0.00001155	0.00001037	0.00009547	6	12	13	0.66
390	0.00001558	0.00001339	0.00020323	6	16	17	0.55
391	0.00001143	0.00001036	0.00009719	4	9	10	0.69
394	0.00001443	0.00001110	0.00012543	6	13	15	0.63
395	0.00001176	0.00001111	0.00012155	5	13	14	0.68
396	**0.00001133**	**0.00001036**	**0.00010028**	**4**	**9**	**10**	**0.70**
397	0.00001439	0.00001105	0.00011995	4	9	10	0.65
398	**0.00001137**	**0.00001119**	**0.00011799**	**5**	**11**	**12**	**0.69**
399	**0.00000432**	**0.00000408**	**0.00004336**	**10**	**22**	**24**	**0.56**
400	0.00001135	0.00001070	0.00010613	5	11	12	0.69
401	0.00001174	0.00001180	0.00014581	5	13	14	0.68
402	0.00001173	0.00001129	0.00013052	5	12	13	0.68
403	0.00001196	0.00001178	0.00015797	5	12	13	0.68
404	**0.00001195**	**0.00001119**	**0.00013835**	**6**	**16**	**17**	**0.55**
405	0.00001197	0.00001170	0.00015670	6	15	16	0.58
406	0.00001185	0.00001119	0.00013371	6	15	16	0.58
416	0.00001212	0.00001086	0.00010845	5	11	12	0.68
417	0.00001237	0.00001107	0.00012259	6	13	15	0.63
418	0.00001241	0.00001106	0.00012153	6	13	14	0.65

419	**0.00001679**	**0.00001275**	**0.00012999**	**8**	**16**	**18**	**0.45**
420	0.00001245	0.00001099	0.00011075	6	13	14	0.65
421	0.00001246	0.00001099	0.00011050	6	12	14	0.66
422	0.00001254	0.00001099	0.00010936	5	11	12	0.67
425	**0.00001308**	**0.00001164**	**0.00012041**	**8**	**17**	**18**	**0.47**
426	0.00001312	0.00001165	0.00011957	7	15	16	0.54
434	**0.00001316**	**0.00001102**	**0.00009676**	**5**	**10**	**11**	**0.67**
435	**0.00001331**	**0.00001104**	**0.00009961**	**5**	**9**	**10**	**0.67**
436	0.00001378	0.00001130	0.00010815	5	10	11	0.66
437	0.00001363	0.00001107	0.00010058	6	13	14	0.64
438	0.00001415	0.00001240	0.00010750	6	12	13	0.64
439	0.00001417	0.00001241	0.00010731	6	12	14	0.64
440	0.00001381	0.00001126	0.00010326	6	13	14	0.64
441	0.00001383	0.00001126	0.00010304	6	13	14	0.64
442	0.00001386	0.00001127	0.00010265	7	14	15	0.56
443	0.00001392	0.00001129	0.00010199	6	13	14	0.64

Table 1. Values of the criteria and results for the overall quality assessment

As it was noted in chapter 3.2, point b, the number of the used satellites was changing frequently for some of the measured points. Due to this fact, these points in the region under study were occupied several times consecutively, without moving the rover. In table 1, the different points are separated with empty row - i.e. numbers from 436 up to 443 have one and the same coordinates. Lines, highlighted with red colour indicate large values for M3D.

According to the results for the overall quality assessment in table 1, it could be summarized:
1. the variations in the accuracy are very well visible for points NN: 354, 355, 390, 391, 399, 400, 402, 404, 419 and 422;
2. despite of the open-field environment (where 3D quality control generally has value at about 9-15 mm.), in this specific case it was observed degradation of the accuracy of the measured points up to 24 mm.
3. M3D quality criterion as standalone parameter was not sufficient for complete control of the accuracy, as it could be seen from points NN 397 and 398. If thorough and precise analysis is required, more criteria should be considered and used.

It must be noted that several years ago in the region under study GNSS measurements could not be conducted due to the strong influence of the active disturber. According to various reasons, one of them – the GNSS modernization nowadays the measurements were technically possible.

Based on the continuous improvement of the system, see: http://en.wikipedia.org/wiki/GPS_modernization, [http://www.ion.org/search/view_abstract.cfm?jp=p&idno=1292] and [http://en.wikipedia.org/wiki/GLONASS], considering the data given in table 1, it could be noted that geodetic measurements conducted with GNSS equipment nowadays are characterised with better overall quality and reliability in comparison with passed last years.

Taking in mind the performed geodetic measurements, also the current status of the system and GNSS modernizations it could be concluded:

1. Nowadays there are enough operational satellites, which can be used for geodetic determinations and be delivered good quality results, even in area with operating active disturber.
2. The future efforts for GNSS improvements are highly encouraged in order to be obtained: even better reliability in the determinations and higher overall quality of the results.

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