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Study on the Quality of the GNSS Measurements in Static mode if Applying Certain Values of the Parameters, Following the Current Regulatory Requirements

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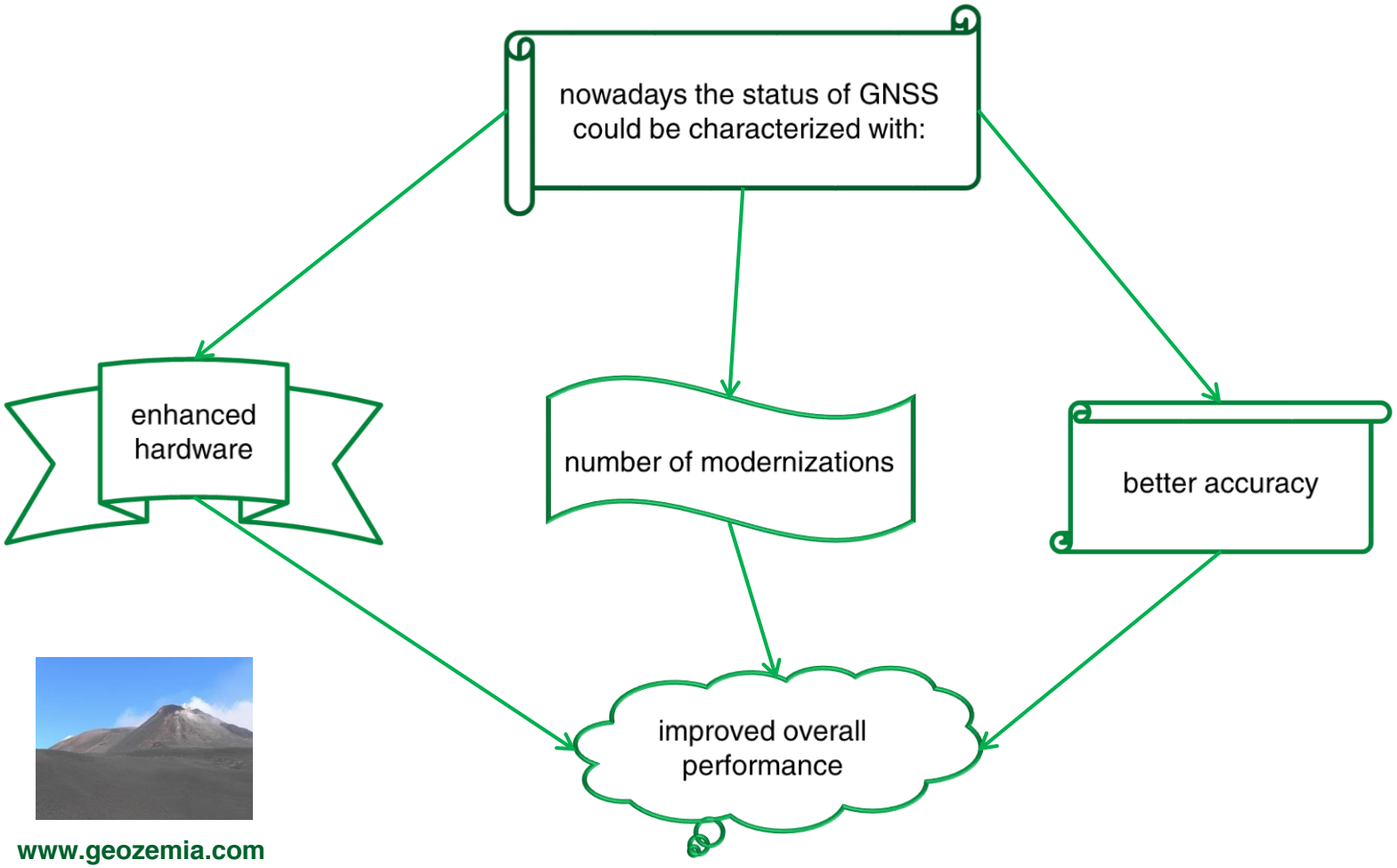
1. INTRODUCTION



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2. AIMS OF THE EXPERIMENT

– to conduct GNSS measurements in static mode in an open field environment, *as stated in the regulatory requirements*

- to process the results with specialized own geodetic software and analyse them

(*its important advantage is the capability to analyse various sets of data*)

- to link the current study with the conclusions from *previous author's work*

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3. PRACTICAL IMPLEMENTATION OF THE EXPERIMENT

Study details

Static mode for GNSS measurements was used

All points were situated in an open field environment with clear horizon, out of the urban areas

Three baselines were subject of geodetic measurements and overall quality assessment

the experiment used certain values for:

-cut-off angle;
-length of the session;
-record rate.

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3. PRACTICAL IMPLEMENTATION OF THE EXPERIMENT

The points of the spatial chords were chosen very carefully, according to the following requirements:

1. **Reference station**

One and the same reference point was used in the experiment.

2. **Remote stations**

They were chosen to be points from the national geodetic network.

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3. PRACTICAL IMPLEMENTATION OF THE EXPERIMENT

3. **Lengths of the baselines**

-up to 10 km;
-from 10 km up to 20 km;
-over 20 km.

4. **Regulatory requirements**

strictly were applied the conditions for:
-lengths of the baselines;
-surrounding environment;
-cut-off angle;
-occupation time;
-record rate.

5. **Previous author's work**

the study used the conclusions from other experiments

in this paper were also applied:
-cut-off angle 0 degrees;
-length of the session 10 min.

4. CONDUCTED EXPERIMENTAL GNSS MEASUREMENTS IN STATIC MODE, APPLYING BOTH THE REQUIRED AND PROPOSED VALUES OF THE PARAMETERS IN THE SYSTEM

Used methodology in the experiment

names of the baselines:

"up to 10 km"
"from 10 up to 20 km"
"over 20 km"

Three sessions "a", "b" and "c" were used and conducted consecutively

the cut-off angle was set to 0 degrees

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4. CONDUCTED EXPERIMENTAL GNSS MEASUREMENTS IN STATIC MODE, APPLYING BOTH THE REQUIRED AND PROPOSED VALUES OF THE PARAMETERS IN THE SYSTEM

Used methodology in the experiment

Procedure for the baseline "up to 10 km"

4.1 The first session "a" was set to 15 min., according to the regulatory requirements

4.2 The second session "b" was performed right after the first one, with occupation time, which was doubled (as required) - set to **30 min.**

4.3 The third session "c" was conducted for **10 min.**, based on previous authors' experiments.

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4. CONDUCTED EXPERIMENTAL GNSS MEASUREMENTS IN STATIC MODE, APPLYING BOTH THE REQUIRED AND PROPOSED VALUES OF THE PARAMETERS IN THE SYSTEM

Used methodology in the experiment

Procedure for the baseline "from 10 up to 20 km"

4.4 The length of the first "a" session was set to 40 min., as required.

4.5 The second session "b" was started consecutively after the first. The occupation time (set as required) was doubled from 40 to **80 min.**

4.6 The third session "c" was conducted for **10 min.**

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4. CONDUCTED EXPERIMENTAL GNSS MEASUREMENTS IN STATIC MODE, APPLYING BOTH THE REQUIRED AND PROPOSED VALUES OF THE PARAMETERS IN THE SYSTEM

Used methodology in the experiment

Procedure for baseline "over 20 km"

4.7 The occupation time for the first session "a" was set to **60 min.**, according to the regulatory requirements.

4.8 The next session "b" was conducted consecutively after the first one.

The length of the session was set to **120 min.,** based on the requirements

4.9 The third session "c" was done for **10 min.**

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5. USED CRITERIA FOR OVERALL QUALITY ASSESSMENT OF THE PERFORMED GEODETIC MEASUREMENTS

Within this study, the following criteria were applied:

1. Quality in the position M_P

2. Quality in the height M_h

3. Elements of the co-variance matrix for the chord: Q_{xx} Q_{yy} Q_{zz}

4. The numbers: $Gdop(\max)$, $Pdop(\max)$, $Hdop(\max)$ and $Vdop(\max)$.

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6. NUMERICAL RESULTS FROM THE EXPERIMENTAL GEODETIC MEASUREMENTS

occupation time	**length of the baseline - up to 10 km,** ***cut-off angle 0 degrees***								
	criteria								
	Mp [mm]	Mh [mm]	Q11	Q22	Q33	GDOP max	PDOP max	HDOP max	VDOP max
10 min.	0.7	0.9	0.00000078	0.00000049	0.00000107	1.4	1.3	0.8	1.0
15 min.	0.5	0.7	0.00000066	0.00000034	0.00000045	1.6	1.4	0.7	1.2
30 min.	0.4	0.5	0.00000027	0.00000017	0.00000027	1.6	1.4	0.8	1.2

no substantial quality improvement

increased accuracy - step 0.2 mm

Table 1

ideal, excellent values Tables NN 1, 4

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6. NUMERICAL RESULTS FROM THE EXPERIMENTAL GEODETIC MEASUREMENTS

occupation time	length of the baseline - from 10 up to 20 km, *cut-off angle 0 degrees*								
	criteria								
	Mp [mm]	Mh [mm]	Q11	Q22	Q33	GDOP max	PDOP max	HDOP max	VDOP max
10 min.	0.5	0.9	0.00001679	0.00000843	0.00001345	1.7	1.5	0.8	1.2
40 min.	0.3	0.5	0.00000346	0.0000021	0.00000336	1.7	1.5	0.7	1.3
80 min.	0.2	0.3	0.00000204	0.00000113	0.00000218	1.5	1.4	0.9	1.1

Table 2

improvements in:
Mp /up to 0.3 mm/
Mh /up to 0.6 mm/
if the session is prolonged

excellent DOP values

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6. NUMERICAL RESULTS FROM THE EXPERIMENTAL GEODETIC MEASUREMENTS

occupation time	**length of the baseline - over 20 km, *cut-off angle 0 degrees***								
	criteria								
	Mp [mm]	Mh [mm]	Q11	Q22	Q33	GDOP max	PDOP max	HDOP max	VDOP max
10 min.	0.5	1.0	0.00002364	0.00000842	0.00001752	1.7	1.5	0.8	1.2
60 min.	0.3	0.5	0.00000352	0.00000152	0.00000291	1.7	1.5	0.8	1.3
120 min.	0.2	0.3	0.00000181	0.00000059	0.00000136	1.7	1.5	0.8	1.3

Table 3

increased quality especially for Mh

excellent values of DOP factor

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6. NUMERICAL RESULTS FROM THE EXPERIMENTAL GEODETIC MEASUREMENTS

occupation time	length of the baseline - up to 10 km, cut-off angle 15 degrees								
	criteria								
	Mp [mm]	Mh [mm]	Q11	Q22	Q33	GDOP max	PDOP max	HDOP max	VDOP max
10 min.	0.6	0.8	0.0000008	0.00000049	0.00000126	1.9	1.6	1.0	1.3
15 min.	0.5	0.7	0.00000067	0.00000034	0.00000047	1.8	1.5	0.8	1.3
30 min.	0.4	0.5	0.00000029	0.00000018	0.00000028	1.8	1.5	0.8	1.3

Table 4

very slight improvement for Mp /compared to 0 deg/

ideal, excellent DOP values

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6. NUMERICAL RESULTS FROM THE EXPERIMENTAL GEODETIC MEASUREMENTS

occupation time	length of the baseline - from 10 up to 20 km, cut-off angle 15 degrees								
	criteria								
	Mp [mm]	Mh [mm]	Q11	Q22	Q33	GDOP max	PDOP max	HDOP max	VDOP max
10 min.	0.6	0.9	0.00002351	0.00000891	0.00001545	2.1	1.8	0.9	1.5
40 min.	0.3	0.5	0.00000374	0.0000023	0.00000358	1.9	1.6	0.8	1.4
80 min.	0.2	0.3	0.00000263	0.00000127	0.00000259	4.3	3.6	2.4	2.6

Table 5

same quality as 0 deg

slight increase, lowest rating

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6. NUMERICAL RESULTS FROM THE EXPERIMENTAL GEODETIC MEASUREMENTS

occupation time	length of the baseline - over 20 km, cut-off angle 15 degrees								
	criteria								
	Mp [mm]	Mh [mm]	Q11	Q22	Q33	GDOP max	PDOP max	HDOP max	VDOP max
10 min.	0.5	1.1	0.00002751	0.00001049	0.00002095	1.9	1.6	0.8	1.4
60 min.	0.2	0.4	0.00000382	0.00000165	0.00000311	2.3	1.9	0.9	1.7
120 min.	0.2	0.3	0.00000212	0.00000065	0.00000157	2.4	2.1	0.9	1.9

Table 6

improved quality (sessions 10-60 min.)
no change (sessions 60-120 min.)

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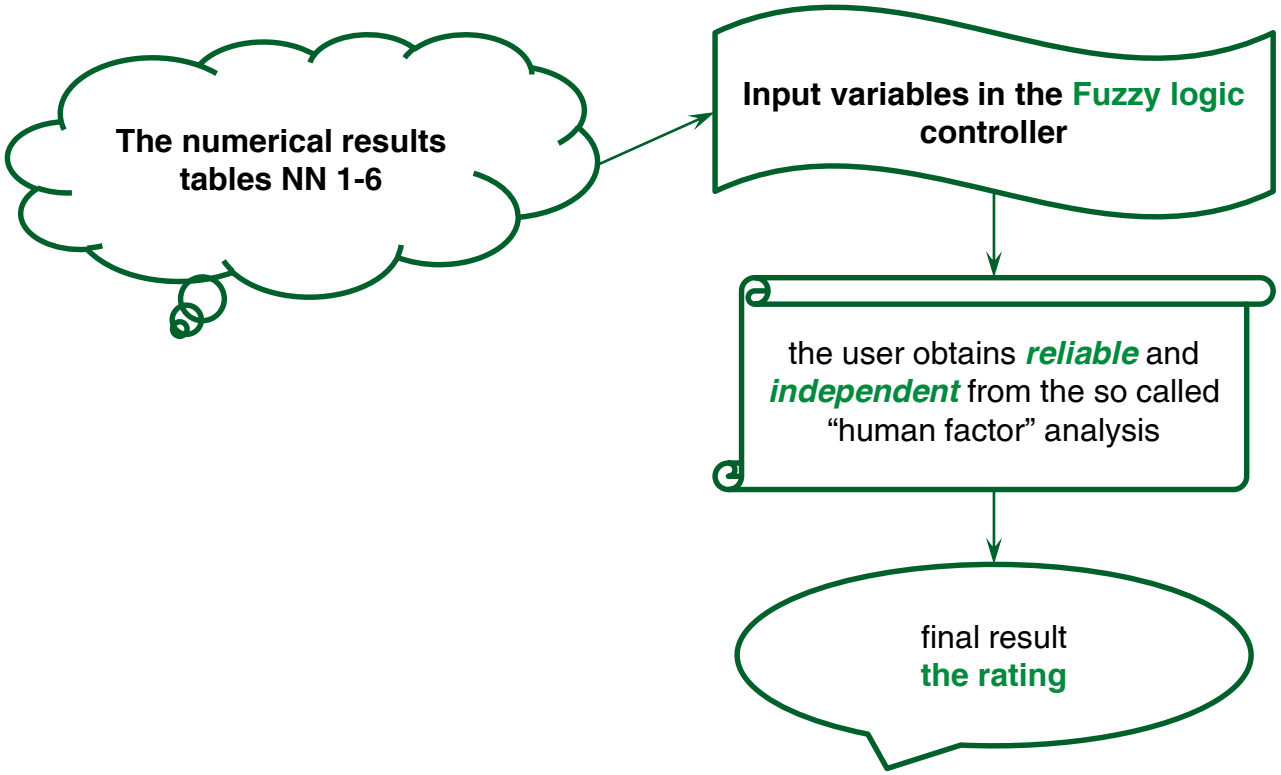
7. ANALYSIS OF THE RESULTS



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7. ANALYSIS OF THE RESULTS

length of the baseline - up to 10 km, *cut-off angle 0 degrees*	
occupation time	**rating**
10 min.	0.53
15 min.	0.52
30 min.	0.52

Table 7

the same values of rating for various occupation time

length of the baseline - up to 10 km, cut-off angle 15 degrees	
occupation time	**rating**
10 min.	0.33
15 min.	0.49
30 min.	0.51

Table 8

a change in the cut-off angle quality - decreased

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7. ANALYSIS OF THE RESULTS

length of the baseline - from 10 up to 20 km, *cut-off angle 0 degrees*	
occupation time	**rating**
10 min.	0.58
40 min.	0.68
80 min.	0.78

Table 9

highest overall quality

if occupation time doubled @0 deg. cut-off angle

length of the baseline - from 10 up to 20 km, cut-off angle 15 degrees	
occupation time	**rating**
10 min.	0.58
40 min.	0.68
80 min.	0.56

Table 10

decreased overall quality

@80min. and 15 deg. cut-off angle

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7. ANALYSIS OF THE RESULTS

length of the baseline - over 20 km, *cut-off angle 0 degrees*	
occupation time	**rating**
10 min.	0.57
60 min.	0.67
120 min.	0.76

Table 11

significant improvement in the rating

length of the baseline - over 20 km, cut-off angle 15 degrees	
occupation time	**rating**
10 min.	0.57
60 min.	0.50
120 min.	0.50

Table 12

the change in the cut-off angle possible reason for low overall quality

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8. CONCLUSION. RECOMMENDATIONS. FUTURE WORK

This experiment studied the results from the post-processing and the rating of three baselines with various lengths, following the current regulatory requirements, also using certain values of the parameters from previous work of the author.

The results show, that at short distances, if using **cut-off angle of 0 degrees** and **length of the session 10 min.,** the final results would have **similar** overall quality, regardless to the occupation time. A change of the cut-off angle to 15 degrees would decrease the quality of the results.

For the middle range distances, it could be summarized that results with highest possible overall quality could be obtained, if **doubled observation time** was applied, as required and **cut-off angle of 0 degrees** was used.

The analysis for the long-range distances show, that maximum overall quality was obtained for occupation time **120 min.** at **0 degree cut-off angle**. The change of the cut-off angle to 15 degrees was the possible reason for the low value of the rating.

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8. CONCLUSION. RECOMMENDATIONS. FUTURE WORK

Based on the calculated numeric values of the used quality criteria, also the rating of each measured baseline it could be concluded with the following **recommendations**:

a) if cut-off angle of **0 degrees** is applied, with the usage of nowadays GNSS status, the results from the post-processing of the baselines would have highest overall quality;

b) the extension of the session's length **does not necessarily leads** to significant improvement in the accuracy of the determination of the baseline, see tables NN 7 and 12;

c) a prolongation of the occupation time would cause **significantly decrease of the productivity**, which is essential for the geodetic practice;

d) the improved quality (e.g. in the position of the new-determined point) of all baselines under assessment was **maximum 0.3 mm** (derived experimentally, see tables NN 1, 2 and 3), which might not be of significance for the geodetic applications.

Future work - this study and its experimental results could be used for an **update of the current regulatory requirements**, according to the technical possibilities nowadays and the continuous improvement of the GNSS status.

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REFERENCES:

1. Kostov, G. 2009, Using of Fuzzy Logic for Some Studies over GNSS Determination in fast Static mode. University of Architecture, Civil Engineering and Geodesy. International Scientific-Applied Conference. pp6, 7, Sofia, UACEG 29-31-st of October 2009. ISSN 1310-814X.

2. Kostov, G., 2010, Some Studies on the Quality of GNSS Determinations Under Specific Conditions. FS 1H - GNSS CORS Networks - Positioning Infrastructure, Analysis and Applications I. pp9-10, Sydney, FIG Congress 2010 Facing the Challenges – Building the Capacity Sydney, Australia, 11-16 April 2010. ISBN 978-87-90907-87-7.

3. Kostov, G., 2010, Assessing of the Overall Quality of GNSS Determinations, Using Specific Values of Parameters. pp7, Nessebar, Third International Conference on Cartography and GIS. June, 15-20, 2010 Nessebar, Bulgaria.

4. Ministry of regional development. 2011, Instruction N RD-02-20-25/20.09.2011 for determination of geodetic points using GNSS. Sofia, 11.10.2011.

5. Wellenhof, B., Herbert Lichtenegger, James Collins, 2002, GPS Theory and practice, Springer-Verlag/Wien, pp183, Wien, Austria (in Bulgarian).

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REFERENCES:

WEB:

http://en.wikipedia.org/wiki/Dilution_of_precision_(GPS)
http://gpsworld.com/category/gnss-system/gps-modernization/
http://www.af.mil/News/ArticleDisplay/tabid/223/Article/109195/gps-iif-4-successfully-launched-from-cape-canaveral.aspx
http://www.examiner.com/article/next-generation-gps-system-advancing-fast
http://www.gps.gov/systems/gps/modernization/
http://www.space.com/21192-gps-satellite-launch-atlas-5.html

Documents on the WEB:

http://www.geoconnexion.com/uploads/publication_pdfs/int-v13i2-A-better-place.pdf
http://www.glonass-center.ru/aboutIAC/GLONASS%20STATUS%20and%20PROGRESS.pdf
http://www.gps.gov/multimedia/presentations/2013/11/USTTI/kim.pdf

Used Geodetic Software:

1. Geomax Geo Office;
2. GNSSTransformations;
3. Vienna_Fuzzy.

Thank you for your attention!

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