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

nowadays the status of GNSS could be characterized with:

- enhanced hardware
- number of modernizations
- better accuracy
- improved overall performance
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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

3. PRACTICAL IMPLEMENTATION OF THE EXPERIMENT

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

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.

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.
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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

Three sessions “a”, “b” and “c” were used and conducted consecutively

the cut-off angle was set to 0 degrees

names of the baselines:
“up to 10 km”
“from 10 up to 20 km”
“over 20 km”

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

Procedure for the baseline “up to 10 km”

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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Conducted Experimental GNSS Measurements in Static Mode, Applying Both the Required and Proposed Values of the Parameters in the System

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

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

4.3 The third session "c" was conducted for 10 min.

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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: $GDOP_{\text{max}}$, $PDOP_{\text{max}}$, $HDOP_{\text{max}}$ and $VDOP_{\text{max}}$.

### Table 1

<table>
<thead>
<tr>
<th>occupation time</th>
<th>length of the baseline - up to 10 km, cut-off angle 0 degrees</th>
<th>$M_p$ [mm]</th>
<th>$M_h$ [mm]</th>
<th>$Q_{11}$</th>
<th>$Q_{22}$</th>
<th>$Q_{33}$</th>
<th>$GDOP_{\text{max}}$</th>
<th>$PDOP_{\text{max}}$</th>
<th>$HDOP_{\text{max}}$</th>
<th>$VDOP_{\text{max}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 min</td>
<td></td>
<td>0.7</td>
<td>0.9</td>
<td>0.00000076</td>
<td>0.00000049</td>
<td>0.00000107</td>
<td>1.4</td>
<td>1.3</td>
<td>0.8</td>
<td>1.0</td>
</tr>
<tr>
<td>15 min</td>
<td></td>
<td>0.5</td>
<td>0.7</td>
<td>0.00000066</td>
<td>0.00000034</td>
<td>0.00000045</td>
<td>1.6</td>
<td>1.4</td>
<td>0.7</td>
<td>1.2</td>
</tr>
<tr>
<td>30 min</td>
<td></td>
<td>0.4</td>
<td>0.5</td>
<td>0.00000027</td>
<td>0.00000017</td>
<td>0.00000027</td>
<td>1.6</td>
<td>1.4</td>
<td>0.8</td>
<td>1.2</td>
</tr>
</tbody>
</table>

- no substantial quality improvement
- increased accuracy - step 0.2 mm

Ideal, excellent values

Tables NN 1, 4
### 6. NUMERICAL RESULTS FROM THE EXPERIMENTAL GEODETIC MEASUREMENTS

#### Table 2

<table>
<thead>
<tr>
<th>occupation time</th>
<th>criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mp [mm]</td>
</tr>
<tr>
<td>10 min.</td>
<td>0.5</td>
</tr>
<tr>
<td>40 min.</td>
<td>0.3</td>
</tr>
<tr>
<td>80 min.</td>
<td>0.2</td>
</tr>
</tbody>
</table>

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- Improvements in: 
  - \( M_p \) up to 0.3 mm / 
  - \( M_h \) up to 0.6 mm / 
  - if the session is prolonged

- excellent DOP values

#### Table 3

<table>
<thead>
<tr>
<th>occupation time</th>
<th>criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mp [mm]</td>
</tr>
<tr>
<td>10 min.</td>
<td>0.5</td>
</tr>
<tr>
<td>60 min.</td>
<td>0.3</td>
</tr>
<tr>
<td>120 min.</td>
<td>0.2</td>
</tr>
</tbody>
</table>

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- increased quality especially for \( M_h \)

- excellent values of DOP factor
### Study on the Quality of the GNSS Measurements in Static mode if Applying Certain Values of the Parameters, Following the Current Regulatory Requirements

#### 6. NUMERICAL RESULTS FROM THE EXPERIMENTAL GEODETiC MEASUREMENTS

#### Table 4

<table>
<thead>
<tr>
<th>occupation time</th>
<th>length of the baseline - up to 10 km, cut-off angle 15 degrees</th>
<th>criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M_p [mm]</td>
</tr>
<tr>
<td>10 min.</td>
<td></td>
<td>0.6</td>
</tr>
<tr>
<td>15 min.</td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>30 min.</td>
<td></td>
<td>0.4</td>
</tr>
</tbody>
</table>

- Table 4: ideal, excellent DOP values
- very slight improvement for M_p compared to 0 deg

#### Table 5

<table>
<thead>
<tr>
<th>occupation time</th>
<th>length of the baseline - from 10 up to 20 km, cut-off angle 15 degrees</th>
<th>criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M_p [mm]</td>
</tr>
<tr>
<td>10 min.</td>
<td></td>
<td>0.6</td>
</tr>
<tr>
<td>40 min.</td>
<td></td>
<td>0.3</td>
</tr>
<tr>
<td>80 min.</td>
<td></td>
<td>0.2</td>
</tr>
</tbody>
</table>

- Table 5: slight increase, lowest rating
- same quality as 0 deg

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6. NUMERICAL RESULTS FROM THE EXPERIMENTAL GEODETIC MEASUREMENTS

<table>
<thead>
<tr>
<th>occupation time</th>
<th>criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M_p [mm]</td>
</tr>
<tr>
<td>10 min.</td>
<td>0.5</td>
</tr>
<tr>
<td>60 min.</td>
<td>0.2</td>
</tr>
<tr>
<td>120 min.</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Table 6

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

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7. ANALYSIS OF THE RESULTS

The numerical results tables NN 1-6

The user obtains reliable and independent from the so called “human factor” analysis final result the rating

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7. ANALYSIS OF THE RESULTS

<table>
<thead>
<tr>
<th>Length of the Baseline - Up to 10 km, Cut-off Angle 0 Degrees</th>
<th>Length of the Baseline - Up to 10 km, Cut-off Angle 15 Degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupation Time</td>
<td>Rating</td>
</tr>
<tr>
<td>10 min.</td>
<td>0.53</td>
</tr>
<tr>
<td>15 min.</td>
<td>0.52</td>
</tr>
<tr>
<td>30 min.</td>
<td>0.52</td>
</tr>
</tbody>
</table>

Table 7: The same values of rating for various occupation time

Table 8: A change in the cut-off angle quality - decreased

<table>
<thead>
<tr>
<th>Length of the Baseline - From 10 up to 20 km, Cut-off Angle 0 Degrees</th>
<th>Length of the Baseline - From 10 up to 20 km, Cut-off Angle 15 Degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupation Time</td>
<td>Rating</td>
</tr>
<tr>
<td>10 min.</td>
<td>0.58</td>
</tr>
<tr>
<td>40 min.</td>
<td>0.58</td>
</tr>
<tr>
<td>80 min.</td>
<td>0.78</td>
</tr>
</tbody>
</table>

Table 9: Highest overall quality if occupation time doubled @0 deg. cut-off angle

Table 10: Decreased overall quality @80 min. and 15 deg. cut-off angle

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7. ANALYSIS OF THE RESULTS

<table>
<thead>
<tr>
<th>length of the baseline - over 20 km, cut-off angle 0 degrees</th>
<th>length of the baseline - over 20 km, cut-off angle 15 degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>occupation time</td>
<td>rating</td>
</tr>
<tr>
<td>10 min.</td>
<td>0.57</td>
</tr>
<tr>
<td>60 min.</td>
<td>0.67</td>
</tr>
<tr>
<td>120 min.</td>
<td>0.76</td>
</tr>
</tbody>
</table>

Table 11 Table 12

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

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 lead 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:


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REFERENCES:

WEB:
http://gpsworld.com/category/gnss-system/gps-modernization/
http://www.gps.gov/systems/gps/modernization/

Documents on the WEB:
http://www.glonass-center.ru/aboutIAC/GLONASS%20STATUS%20and%20PROGRESS.pdf

Used Geodetic Software:
1. Geomax Geo Office;
2. GNSS Transformations;
3. Vienna_Fuzzy.

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Thank you for your attention!

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