Results of the GNSS-Heighting Test-Measurements based on the country-wide Quasi-Geoid “DFHBF_V. 1.0 Baltic-Sea-1977 for Moldova”

1. Computation of the quasi-geoid “DFHBF_V.1.0 Baltic-Sea-1977 for Moldova”

The computation of the 1st version of the quasi-geoid was done within the MOLDPOS-project at HSKA using the DFHBF-approach and software (www.dfhbf.de, [1], [2], [3], [5]) by MSc. Ghadi Younis, scientific member of Moldpos staff at HSKA. For 1st version of the country-wide quasi-geoid for Moldova about 1200 identical points and related to the normal height H system Baltic Sea 1977 were used. The GNSS-fitting points (B,L,h) are related to the MOLD-REF1999 datum.

The computed DFHBF database is accordingly called “DFHBF_V. 1.0 Baltic-Sea-1977 for Moldova”.

Fig.1: Quasigeoid computation for Moldova using DFHBF-Software
Left: Mesh and Patch-Design in DFHBF-software.
Right: Difference surface between the use of EGG97 and EGM2008 observations
The so-called patch (thick blue lines) and FEM-mesh (thin blue lines) design of the DFHBF-computation are shown in fig. 1 left. Fig. 1, right shows, that there is no significant difference in the final Quasi-geoid computed by EGG97 and by EGM2008 observations, respectively.

The quality assessment led to an accuracy of (1-3) cm for “DFHBF_V. 1.0 Baltic-Sea-1977 for Moldova”.

2. GNSS-heighting test-measurements for the quasi-geoid “DFHBF_V. 1.0 Baltic-Sea-1977 for Moldova”

Fig. 2 shows the levelling control points H, which were not used for the computation of the “DFHBF_V. 1.0 Baltic-Sea-1977 for Moldova”. The point in the south, situated in Chisinau town, could not be used for the GNSS-heighting tests, because the Chisinau normal height system H is still related, in its main parts, to the old Baltic Sea system.

![Independent levelling control points with normal heights H (Baltic Sea 1977)](image)

**Fig. 2:**

Independent levelling control points with normal heights H (Baltic Sea 1977)

Fig. 3, up, shows the location of point 181010, and the pictures below show the situation of the RTK measurement with Trimble equipment. The GNSS reference station of Chisinau was used for all GNSS-heighting tests.

The tab. 1 gives an overview on the results of the GNSS-heighting test measurements by the comparison of $H_{\text{LEVELLED}}$ and $H_{\text{GNSS}}=h_{\text{GNSS}} - N_{\text{QG}}$, with $N_{\text{QG}}$ from the Trimble gridfile (“GGF”-file), which was derived from the “DFHBF_V.1.0 Baltic-Sea-1977 for Moldova” database by gridding-software. For Leica-Geosystem GNSS equipment a respective grid-file for country-wide “DFHBF_V.1.0 Baltic-Sea-1977 for Moldova” is also available. For Topcon GNSS-rovers a direct access to the DFHB-F database is possible. The DFHB_DB based gridfiles were prepared by Dipl.-Ing. (FH) S. Seiler (www.ib-seiler.de). Alternatively to the use of Qgeoid-
fridfiles for and on the different GNSS-controllers, the DFHBF-database may also be used to set up the new RTCM 3.1 height-transformation-messages ([4]).

**Fig. 3:**
Up: Location of Test-Point 181010 by GoogleEarth
Down: Pictures from the GNSS-heighting measurements at levelling point 181010
As Tab. 1 shows, the quality assessment of the DFHBF-computation of the quasi-geoid “DFHBF _V. 1.0 Baltic-Sea-1977 for Moldova” was more than confirmed by the GNSS-heighting test-measurements. All differences between $H_{\text{LEVELLED}}$ and the GNSS-based heighting determination – namely by $H_{\text{GNSS}} = h_{\text{GNSS}} - N_{\text{QG}}$ – are in a span-width of 0.7 cm to 2.8 cm. Considering an accuracy of 1-3 cm for $h_{\text{GNSS}}$, the “DFHBF _V. 1.0 Baltic-Sea-1977 for Moldova” turns out to be a (1-2) cm solution, more than a (1-3) cm.

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Surveyor: Nicolae Iacon
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Measurements made with reference station in Chisinau
RTK and postprocessed

Tab. 1:
Results for GNSS-heighting using the quasi-geoid “DFHBF _V. 1.0 Baltic-Sea-1977 for Moldova” on control points with given normal heights $H$ in the Baltic Sea 1977 datum. The differences show a (1-2) cm accuracy for the “DFHBF _V. 1.0 Baltic-Sea-1977 for Moldova”

3. Conclusion and further work within the MOLDPOS project
3.1 Further work

The further computation of the Q-geoid-models $N(B, L, h) = h - H$ as on part of modern geodetic infrastructures for GNSS-positioning services ([5]) shall be related in a second version to two Q-geoid models, namely a

2. A regional Chisinau town quasi-geoid model for the old Baltic Sea height system in Chisinau (“DFHBF _V.1.0/2.0 Old Baltic Sea for Chisinau-town”). Regional town-district related DFHBF-databases for the old Baltic Sea datum may of course also be computed for further towns¹.

The further computations on the HRS-database products 1. and on 2. are planned to be done in the following several steps:

¹ Like done by the state survey of Baden-Württemberg between old NN-heights and new European normal heights, a general transition-surface $dH(B, L)$ to transform the old Baltic heights to the new system Baltic Se 1997 could be evaluated by using also the DFHBF-software. See http://www.lv-bw.de/lvshop2/produktinfo/wir-ueber-uns/links/vortraege/DVW_Artikel_Normalhoehen_in_BW.pdf
Step 1, right now, as 2nd HRS-versions, to be computed again with version 4.0 of the DFHBF-software. These two 2nd versions will be computed - like the 1st version DFHBF_V.1.0 Baltic-Sea-1977 for Moldova” - above again with all available fitting-points points (B,L,h | H) and GPM-observations. In that way a precise the GNSS-heighting becomes operable country-wide and also in the Chisinau town-district on a 1-2 cm level, already before the end of 2010.

In spring 2011, the Chisinau town DFHBF Q-geoid version is planned to be computed using in addition the available gravity values, together with the fitting points (B,L,h|H) and GPM-information, in order to approach towards a 1 cm solution.

After finishing the gravity measurements country-wide, the country-wide Q-geoid version will be computed with the DFHBF-software, which is presently available at TUM, as a 1 cm solution, using again all available geometrical and physical data.

3.2 General Remarks on future regional Q-geoid computations

Presently we can still use identical points (B,L,h|H), even for precise Q-geoid-computations on 1 cm level (see www.dfhbf.de). The use of GNSS-heighting will however - automatically - lead to a thinning out of the levelling network H for economical reasons, saving time and money by applying GNSS-heighting instead of levelling.

E.g. in the country of Baden-Württemberg only 1st and 2nd order is kept by the state survey department, while country-wide 3rd and 4th order levelling points will not be continued. So 15.000 levelling-points remain, while 60.000 points H are given up in the country-wide levelling network. Levelling points in the town networks are mostly kept by the town survey authorities.

This trend is coming up by the installation of GNSS-positioning services world-wide. It means, that future Q-geoid computations will accordingly be related to

1. Fitting points (B,L,h | H) available for the 1st and 2nd order levelling networks country-wide, and the higher order levelling network fitting points (B,L,h|H) in the towns.
2. Gravity values. E.g. in the state survey gravity network of Baden-Württemberg (about the same size as Moldova) about 15.000 gravity values are available.
3. Vertical deflection measurements by digital zenith cameras and automatic processing (1 vertical deflection measurement replaces 10 gravity values – as proved by Austrian state survey by the country-wide geoid computation in Austria).
4. GPM-coefficient information from global models translated to regional carrier-functions.

In that context the use of the above 4 components arises the question of an optimum design:

- Number
- Accuracy and
- Position

of the “observation-types” 1., 2. and 3.

This “revival of geodetic network optimization” (1st, 2nd and 3rd order design) will become an interesting research topic in near future.

4 References


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