**Hochschule Karlsruhe (HSKA) – University of Applied Sciences**

**Geomatics Master (MSc.)** **Faculty of Information Management and Media (IMM)**


## Candidate

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## Master Thesis (Year 2013)

Further development of DFHRS Concept and Software (C++) under Visual Studio 2012 and Computation of the Geoid for Albania.


## Referee

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## Key Words

DFHRS, C++-Software-Development, Visual Studio 2012, Physical Geodesy, Geoid, Albania


## Summary


The worldwide ongoing process of the establishment of highly precise regional GNSS (Global Navigation Satellite Systems) positioning services (e.g. ALBPOS in Albania), which are consistent with ITRF-related frames, leads to the new age of GNSS-positioning. The process is further promoted by an increasing number of GNSS orbital segments as well as high precision global GNSS services. Therefore GNSS becomes an interdisciplinary tool with a broad spectrum related to precise positioning, precise navigation, robotics, mobile GIS and mobile IT applications. The determination of physical heights via the direct transformation of the ellipsoidal GNSS heights to the Geoid or quasi-Geoid (QGeoid) height reference surface N - as the 2$^{nd}$ component of the geodetic infrastructure for GNSS positioning services requires (GIPS), see www.moldpos.eu) - requires the computation of Geoid-/QGeoid-models and RTCM-capable databases as a sustainable geodetic task in the establishment of GIPS. The DFHBF (engl. DFHRS = Digital FEM Height-Reference-Surface) and –software are developed within the research and development project DFHBF (www.dfhbf.de) at IAF. DFHBF aims at the computation of so-called DFHBF databases. These contain in the so-called geometrical DFHBF concept, and DFHBF-software, versions 4.x, a continuous FEM representation NFEM of the HRS to transform by H=h-NFEM(**p**|B,L,h) ellipsoidal GNSS heights h into physical heights H. A geoid or quasi-geoid as HRS is modelled in an arbitrary large area as a continuous surface by bivariate polynomials **p** over a FEM mesh grid. Geometric observations e.g. existing geoid heights N and vertical deflections (ξ,η) from geoid- or Q-geoid grids or global gravity models (GPM) and identical points (B,L,h|H) are directly to be related to NFEM(**p**|B,L,h). N or (ξ,η) grid or GPM-related information may be parted into different "patches" with individual patch-wise datum-parameters **d**, in order to reduce the effect of existing medium- and long-waved systematic errors.


A first main task of the masterthesis was the reimplementation of the C++ DHHBF-software 4.2 (Visual Studio 6.0) on Visual Studio 2012, as DFHBF-software version 4.3 (fig.). Here a redesign and reimplementation of the functional model of the DFHBF-software, as a $(N,\xi,\eta)_{Model}$-DLL), which evaluates the above components $(N,\xi,\eta)_{Model}$ from existing geopotential models like EGM2008 and others was required. The observation components $(N,\xi,\eta)_{Model}$ should optionally to be related either to a classical Geoid model (for countries with orthometric height systems $H_{Orth}$) or to a Q-Geoid model (following Molodenski's theory, for countries like n Europe with a normal height system $H_N$). It was enabled to set options concerning the use of $(N,\xi,\eta)_{Model}$ on "only N" or "both". In the latter case, the accuracies of $N_{Model}$ and $(\xi,\eta)_{Model}$ were fitted to each other following the law of error propagation. Further the implementation of a dialogue, which enables to choose in between different model sources (EGG97, EGM-2008, EIGEN, EGM96) and types (Geoid, QGeoid) was part of the software development. In addition, the implementation of the feature to visualize the area- or country borders with a symbol and colour of free choice, based on a given closed polygon (B,L), was implemented. The implementation of vertical deflection observations $(\xi,\eta)_{Obs}$ , as a new observation type to be taken with modern GNSS/zenith camera equipment, was a further task of the masterthesis' first part. The new observation type $(\xi,\eta)_{Obs}$ should be implemented in terms of groups of observations with individual accuracy settings, and optionally each with, or without, individual datum parameters, and including observation testing based and variance component estimation. The testing of the DFHBF-software was due to existing projects and the former version 4.2. It could be carried out also in the frame of the new project of the Geoid computation for Albania (see below). The documentation (short manual) of the new DFHBF software was done as final part in the frame of the software developments of the masterthesis.

The second main part of the masterthesis was dealing with the DFHBF database computation for Albania as a geoid-type, related to orthometric heights $H_{Orth}$. The fitting point information (B,L,h | $H_{orth}$) will be provided by the Albanian state via the cooperation partner, University Tirana. The main focus should be set on the use of $(N,\xi,\eta)_{Model}$ observations from EGG97 (grid) compared to the use of $(N,\xi,\eta)_{Model}$ from the spherical harmonics based GPM EGM2008. The computations based on GPM-2008 (and others EGM96, EIGEN) should be used for testing out the above $(N,\xi,\eta)_{Model}$-DLL in case of geoid-related model observations and EGM2008. The documentation of the databases computations (used / deleted erroneous points, computation of used of fitting points with DFHBF-tools and results documentation) was done.

The quality assessment and profound visualization (meshing and patching (see fig), identical points, residuals, difference surfaces were based on the $(N,\xi,\eta)_{Model}$ observations, both from EGG97 and EGM2008. Here the EGM2008 observations turned out to be better.

Finally a (1-5) cm Geoid for Albania could be achieved using a number of 109 fitting-points (B,L,h|H ) and the EGM2008 $(N,\xi,\eta)_{Model}$ observations (fig.)

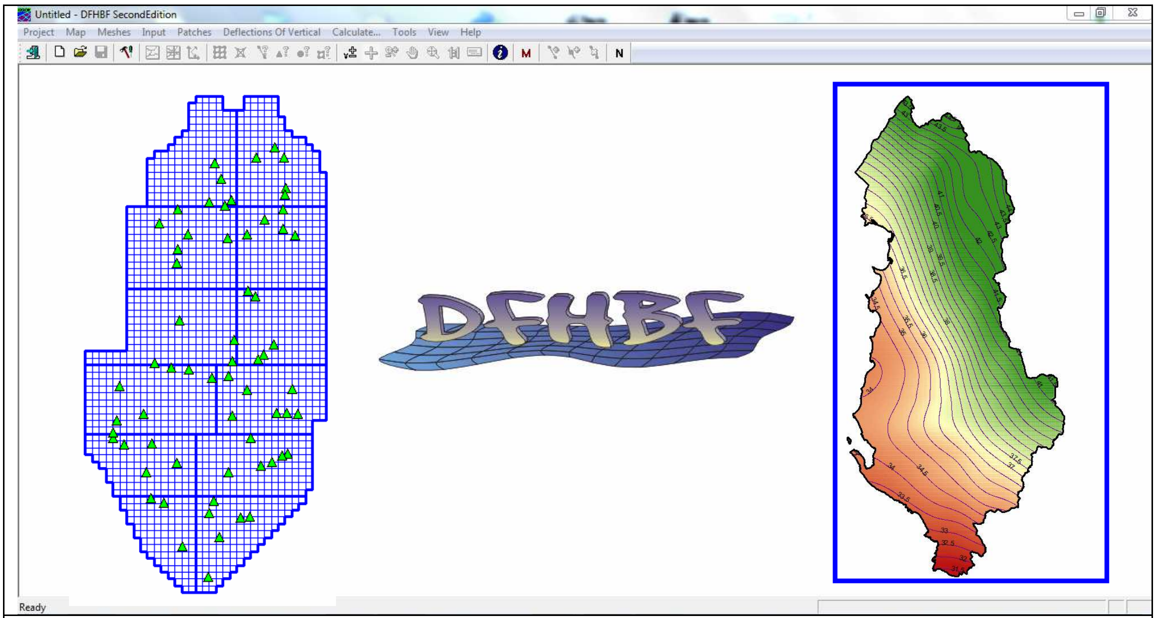


Fig.: GUI of DFHRS Software 4.3. Left: Patching and Meshing Design for Albania. Right, Contour-lines of the computed RTCM-compatible (1-5) cm Geoid for Albania