

## Charter Draft v2.0\_2024-05-17

# EUREF working group on “European Unified Height Reference”

## Goals

- Complement EVRS with an official height reference surface (hybrid quasigeoid model).
- Improve information about national height coordinate frames and their transformations to the EVRS.
- Enhance the usability of the unified European height reference.

An official height reference surface will be an essential element to promote the EVRS for scientific and practical applications in the future. This is in line with the EUREF activities and tasks (e.g., EUREF “Mission & Objectives”, Resolutions 2009/5, 2011/4, 2015/4, 2018/2, 79<sup>th</sup> GB). In particular, the “Mission & Objectives” of EUREF explicitly mentions

*“[...] to [...] implement the necessary projects for the long-term maintenance of the ETRS89 [...] and the EVRS [...], as well as for the **improvement of the coherence between both systems**, and this in close cooperation with other IAG components; [...]”*,

and Resolution 2009/5

*“[...] asks the TWG to contact the European Geoid Project in order to **develop a combined European geoid to link ETRS89 and the EVRS.**”*

## Background, current situation, goals and actions

ETRS89 is the European standard for spatial reference systems and is realized across national borders by means of global measurement techniques (GNSS). ETRS89 is stipulated in the national geodetic standards in all countries and is implemented by means of the different ETRF realizations. Every country provides respective satellite positioning services that enable to determine coordinates with centimeter accuracy in real-time. By that, the incompatibility of the national coordinate reference frames that lasted until the 1990ies could be practically resolved.

To date, this function is still not fulfilled by the European Height Reference System (EVRS). National height reference frames are computed based on the national leveling networks applying different standards. Likewise, national mapping agencies provide official models of the height reference surface that establish the transformation between ellipsoidal heights and heights in these national height reference frames with centimeter accuracy. At the borders, height coordinates of adjacent national leveling networks differ by more or less large amounts. The EVRS realizations are based on the common adjustment of the national networks (UELN) in terms of geopotential numbers and normal heights, latest 2019 (EVRF2019). Most of the European countries have not adopted EVRF solutions for their national height reference frames directly, they are rather used to derive transformation parameters for individual cross-border applications.

The CRS-EU is an information system summarizing descriptions of the national and pan-European reference frame realizations and of the transformation parameters between them. However, information about the associated official height reference surfaces resp. geoid models is not yet included.

The International Service for the Geoid (ISG, [Link](#)) hosts a repository of regional geoid models, both gravimetric and hybrid. Metadata are however limited to a very short verbal description of the general method and data, and a citation. In particular, there is no indicator whether a model is the official height reference surface of a country. Relevant information about the realization of the vertical datum (reference frames, ellipsoid, zero level, permanent tide) are incomplete or missing. Furthermore, the information may be outdated, since the repository seems to be updated “by chance” but not actively by the mapping agencies.

A number of initiatives exists to compute geoid models on a regional scale, mainly with scientific focus on gravimetric geoid models and regional height system unification:

- Scandinavia: NKG geoid ([Link](#)) by the Nordic Geodetic Commission (NKG)
- Mediterranean Sea: GEOMED / GEOMED 2 ([Link](#))
- Baltic Sea: Baltic Sea Chart Datum BSCD2000 ([Link](#))
- European Alps: European Alps Geoid Project ([Link](#))

For all of Europe, Heiner Denker (IfE Hannover, Germany) has developed gravimetric quasigeoid (EGG) models for more than two decades under the framework of the IAG SC 2.4a (Gravity and Geoid in Europe). The latest release is EGG2015 ([Link](#)). These models are linked to EVRS (NAP) by means of a one-parameter fit over whole Europe (EUVN-DA dataset excluding problematic countries). No hybrid quasigeoid models were derived by means of a corrector surface to GNSS/leveling benchmarks. Consequently, EGG does not qualify to serve as official height reference surface to convert heights between ETRS and EVRS realizations. Differences to leveling heights can reach one decimeter or more on the continental scale.

To conclude, despite the demands acknowledged by Resolution 2009/5, to date there is still not available

- an official model of the height reference surface associated with a respective EVRS realization that readily enables GNSS-based height determination across borders,
- a complete and maintained list of national height reference surfaces (i.e., hybrid geoid or quasigeoid models) and their metadata in Europe.

The national implementation of unified European standards for height determination is a process that is not yet foreseeable. Information about transformations should be improved in order to facilitate working with the unified European height reference system, and, by that, to conform to the growing demands of surveyors and to better promote the EVRS.

To achieve these goals, the following actions are proposed:

- a) CRS-EU should be complemented and continuously updated with national (quasi)geoid models (descriptions, metadata, transformation tools).

- b) Since the heights of leveling benchmarks being practically not publicly available or usable in a meaningful way, the height reference surface of EVRS should be explicitly realized by an official hybrid quasigeoid model (“EVRS geoid”).
- c) GNSS/leveling benchmark data should be continuously renewed or updated for this purpose.

### Objectives / Purpose(s) of the working group

- 1) Collect, update and provide information about national height reference frames, height reference surfaces and height transformation grids.
- 2) Initiate, coordinate, support and promote collaborative works to
  - a. create, update and/or extend datasets of benchmarks with consistent coordinates in the most recent ETRS and EVRS realizations (“GNSS/leveling data”) on a continental scale,
  - b. develop a hybrid European quasigeoid model consistent with current ETRS and EVRS realizations.
- 3) Complement existing initiatives within EUREF (e.g. UELN, modernization of CRS-EU, ...)
- 4) Exchange with scientific working groups and commissions (e.g. IAG SC 2.2, 2.4a).

### Tasks

- 1) Develop, distribute and evaluate a **questionnaire** about the current national (quasi)geoid models in order to build up the inventory (as in task 2).
- 2) Establish a continuously updated **inventory of official national height reference surfaces** (and national reference frames for positions and heights including transformation parameters to ETRS89 or ITRS realizations) in order to facilitate, first, comparisons and consistent use of the height reference surfaces along borders and, second, unification of height systems in general.
  - a. It should include the most relevant metadata (e.g., defining geodetic parameters, method summary, quality indicators, points of contact, licensing, ...), thus enhancing the existing list of models from ISG.
  - b. We suggest this inventory to be **integrated in the CRS-EU database** in order to complement the national height reference frames, including their transformation surfaces to the UELN/EVRS realizations.
  - c. The height transformations should be defined and described according to the **ISO 19111:2019** standard, which was extended amongst others by the possibility to describe geoid-based vertical coordinate reference systems. The procedures for establishing, maintaining and publishing the registry are specified in ISO 19135-1:2015. CRS-EU does not conform to this standard yet.
- 3) Replace **EUVN\_DA GNSS/leveling dataset**. The EUVN\_DA project started in 2003 and was preliminary finished in 2009. In the meantime a new realization of EVRS has been

computed, which includes additional countries, especially in Eastern Europe. On the other hand, new sets of GNSS/leveling have become available in several countries. In the EUVN\_DA project, the EVRF2007 heights of some countries (Spain, Italy, Latvia) were determined by transformation only. With the updated leveling data set of EVRF2019, it may be possible to link the GNSS heights of these countries with the leveling heights directly.

- 4) Compute a European quasigeoid model as an **official height reference surface for the EVRS**, which is consistent with the latest EVRS and ETRS89 realizations (currently EVRF2019 and ETRF2020). Consequently, this model shall have the name **European Height Reference Surface (EHR)**.

## Co-operations

- “European Alps Geoid” project (formerly “D-A-CH Geoid” project)
- BSHC Chart Datum, Water Level and Currents Working Group (CDWCWG) for the Baltic Sea Chart Datum 2000 (BSCD2000)
- NKG geoid group
- Geomed-2 project

## Membership of this WG

*The WG will be open to scientists interested in the topic*

Joachim Schwabe (BKG, Germany, chair)

Martina Sacher (BKG, Germany, GB member, chair of UELN)

Martin Lidberg (Lantmäteriet, chair of EUREF)

Heiner Denker (IfE Hannover, Germany, observer, advisor)

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