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# What does EUREF considers as a realisation of EVRS?

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# **Purpose of document**

The Inspire directive state that the reference systems to be used for exchange of geographic information should be ETRS89 and EVRS.

The purpose of this document is to find out what can be considered as acceptable realisations of EVRS in the context of data exchange within the Inspire community.

There are no legal body that have booth the competence to judge and the power to decide what should be accepted as valid realisations of EVRS. Therefore it may be considered that the national mapping authorities (NMAs) should decide by themselves if a specific national height system is a sufficient realisation of EVRS for activities related to Inspire. The purpose of this paper is therefore more precisely to come up with an opinion from the EUREF technical working group (TWG) on what can be an acceptable realisation of EVRS in the context of Inspire, as an assistance to the NMAs in their evaluation.

#### Limitations

Useful realisations of EVRS for scientific applications like finding common points with EVRS and ETRS89 values for evaluation of European geoid, or construction work between countries, are beyond the scope of this document.

# Short review on activities towards a common height system for spatial information in Europe

The adoption of a common European Vertical Reference System is a necessary condition for a future simplification in data harmonisation and interoperability.

#### **Defining European needs**

At the 9th EC GI-GIS conference on 24-26 June 2003 in La Coruña (EC GI-GIS, 2003), the need for the harmonisation of the vertical reference of spatial coordinates was raised. It is driven by the fact that exact knowledge, understanding, management, and subsequent processing of the spatial coordinates of any European GI dataset is one of the central aspects of cross-border GI interoperability.

At a workshop on "Vertical Reference Systems for Europe", 2004 in Frankfurt am Main, the needs, requirements, and problems in establishing a pan-European Vertical Reference System were debated to fulfil scientific and practical requirements for vertical georeferencing of the next decades. This workshop was jointly organised by the Joint Research Centre (JRC) of the European Commission and by EuroGeographics, Expert Group Geodesy with support from the IAG Sub-Commission for Europe EUREF.

#### Work within EUREF

The IAG Sub-Commission for Europe EUREF took up the gauntlet and in Resolution No. 3 of the EUREF Symposium in Vienna, 2005, all European NMAs are requested to provide any new levelling data for UELN2006 and information on national height reference and ECGN points for the new EVRS realisation.

Two years later EUREF considered the urgent request of the European Commission for the definition and realisation of a pan-European vertical reference system for the referencing of geographic information. At the same time the definition of the European Vertical Reference System (EVRS), as accepted at the EUREF 2000 Symposium, is considered not to comply with this request. However, the progress in national levelling data information makes it possible to improve the realisation of the EVRS and in Resolution No. 3 of the EUREF Symposium in London, 2007, the TWG was requested to prepare the technical specifications for a new EVRS and its realisation (EVRF2007).

Following year in Resolution No. 3 of the EUREF Symposium in Brusseles, 2008, the European Commission is proposed to adopt the new realisation of the EVRS under the name EVRF2007 as the vertical reference for pan-European geo-information.

## The INSPIRE directive

The INSPIRE directive came into force on 15 May 2007 and will be implemented in various stages, with full implementation required by 2019.

The INSPIRE directive aims to create a European Union (EU) spatial data infrastructure. This will enable the sharing of environmental spatial information among public sector organisations and better facilitate public access to spatial information across Europe.

A European Spatial Data Infrastructure will assist in policy-making across boundaries. Therefore the spatial information considered under the directive is extensive and includes a great variety of topical and technical themes.

# **Implementing Rules**

To ensure that the spatial data infrastructures of the Member States are compatible and usable in a community and transboundary context, the Directive requires that common Implementing Rules (IR) are adopted in a number of specific areas (Metadata, Data Specifications, Network Services, Data and Service Sharing and Monitoring and Reporting). These IRs are adopted as Commission Regulations/Decisions.

Now the regulatory committee has adopted IR for the area of Data Specifications in which "Coordinate Reference Systems" is a Theme.

Below the part from these IR that touches on the vertical component is quoted:



#### Guidelines

There are also published Guidelines for the spatial data themes referred to in Annex I of the INSPIRE Directive. They will supplement the Implementing Rule for interoperability of spatial data sets and services and allow for preparation for implementation. Together with the relevant materials, they will support the implementation and provide a better understanding of the requirements of the Implementing Rule.

Citation from the guidelines:

The European Vertical Reference System (EVRS) [EUREF] is the vertical reference system recommended for Europe on land to express gravity-related heights. The most recent realisation of the EVRS is labelled European Vertical Reference Frame 2007 (EVRF2007). The definition of EVRS is described in the EVRS Conventions 2007.

The vertical reference systems for land existing in the MS can be expressed in the EVRS in their continental territories through their own realisations that are linked to the EVRF2007 solution. Future solutions of the EVRF will constitute an improvement and are considered realisations of the EVRS. The European continental territories of the MS constitute the geographical scope of the EVRS.

Since not all the vertical datums in use can be connected to the European vertical datum, it is necessary that the rules concerning the vertical datum also take into account areas that are not in the European continental territories. In this case, a locally or globally defined vertical reference system related to the Earth gravity field will be used to express gravity-related heights.

Requirement 1	For the vertical component on land, the European Vertical Reference System (EVRS) shall be used to express gravity-related heights for the areas within the geographical scope of EVRS.
Requirement 2	Other vertical reference systems related to the Earth gravity field shall be used to express gravity-related heights in areas that are outside the geographical scope of EVRS.

# The present situation

Now, with the ongoing implementation of the INSPIRE Directive in the legal framework of the EU member states (MS), we will have a situation where EVRS is identified as the vertical reference system for Europe on land to express gravity-related heights in. All data providers are, according to Inspire, mandated to deliver heights in EVRS. Sooner or later someone will put up the question whether these height values are given in EVRS or not? Maybe it is clear to everyone whether the height system in a certain MS is an EVRS realisation or at least can be considered as such. In that case there is no problem. But otherwise the GI community will ask for help and these people may not be helped with the EVRS definition.

#### **Definition of EVRS**

At the EUREF Symposium 2007 in London the Technical Working Group (TWG) of EUREF was asked to prepare the technical specifications (conventions) for a new EVRS and its realisation EVRF2007.

From Ihde et al (2008) we have following:

The European Vertical Reference System (EVRS) is a kinematical height reference system. The EVRS definitions fulfil the following four conventions:

(1) The vertical datum is defined as the equipotential surface for which the Earth gravity field potential is constant:

 $W_0 = W_{0E} = const.$ 

and which is in the level of the Normaal Amsterdams Peil.

- (2) The unit of length of the EVRS is the meter (SI). The unit of time is second (SI). This scale is consistent with the TCG time coordinate for a geocentric local frame, in agreement with International Astronomical Union (IAU) and International Union of Geodesy and Geophysics (IUGG) resolutions (1991). This is obtained by appropriate relativistic modelling.
- (3) The height components are the differences between the potential ΔW<sub>P</sub> of the Earth gravity field through the considered points *P*, and the potential W<sub>P</sub> of the EVRS conventional zero level. The potential difference -ΔW<sub>P</sub> is also designated as the geopotential number c<sub>P</sub>

 $-\Delta W_{\rm P} = c_{\rm P} = W_{0\rm E} - W_{\rm P}$ 

Normal heights are equivalent with geopotential numbers, provided that the reference gravity field is specified.

(4) The EVRS is a zero tidal system, in agreement with the IAG Resolutions No. 9 and 16 adopted in Hamburg in 1983.

The enhancing of the EVRS needs a revision of EVRF2000 conventions and parameters, and a new realisation EVRF2007. From practical point of view, the tendency is not to change height values if not necessary. The EUREF community prefers to tie the height values to the height level of EVRF2000 and to keep normal heights.

Now we have two realisations of EVRS, EVRF2000 and EVRF2007, among other things representing different epochs and in the future when we will have more (and better) data new realisations will be available. However, for the moment the EVRF2007 is the preferred realisation:

#### Resolution no. 3 (Brussels 2008)

The IAG Reference Frame Sub-commission for Europe (EUREF)

*recognising* the requirement of the European Commission for harmonisation of the vertical reference system for geo-information

noting the availability of a new realisation of the European Vertical Reference System (EVRS) in agreement with the EVRS2007 conventions

*recommends* to adopt this new realisation of the EVRS under the name EVRF2007 and to exchange the results between all participating countries and

*proposes* to the European Commission that this solution is adopted as the vertical reference for pan-European geo-information.

## User communities

These different realisations may be a challenge for academics within geodesy but for other users it can be a huge problem. As stated above in the framework of INSPIRE heights on land are mandated to be given in EVRS. How can such a user be sure that the height values in a data set are given in EVRS at a certain accuracy level? Of course he/she can discuss this with experts at the NMA but will different NMAs always come to the same judgement. We all know that there are different opinions in this matter.

# The EUREF responsibility

EUREF, as the Refrence Frame Sub-commission for Europe with following "Objectives and development of activities" (Terms of Reference, 2008),

"The long-term objective of EUREF is the definition, realisation and maintenance of the European Reference Systems, in close cooperation with the pertinent IAG components as well as EuroGeographics. EUREF must provide the best possible unique and homogeneous reference system and respective realisation, to be *used European-wide in all* scientific and *practical activities* related to precise geo-referencing and navigation, Earth Sciences research and multidisciplinary applications."

"The activities to be carried out to accomplish these objectives must result in a set of high quality products and services. For this, *EUREF must focus* on a continuous innovation and *on the changing user needs*, as well as on the maintenance of an active network of people and organizations."

In these citations we find two key phrases (in italic):

... used European-wide in all ... practical activities

and

... EUREF must focus ... on the changing user needs

this will call upon measures from EUREF.

Considering that the user needs to know if height values can be accepted as given in EVRS, EUREF has to give the NMAs some advice.

## The CRS and EVRS webpage

The webpage "Coordinate Reference Systems in Europe" is an "Information and Service System for European Coordinate Reference Systems" and is developed and maintained through a co-operation between BKG, EuroGeographics and EUREF. Information on pan-European coordinate reference systems (CRS) as well as national CRS is given, together with transformations between them and estimate of uncertainty in the transformation.

The CRS webpage is an important source of information for a first evaluation of the differences between a national vertical reference frame (VRF) and EVRF2007. For the moment (mid May 2010) the transformations are given between the national VRF and EVRF2000 and not to EVRF2007, but an update is foreseen in the close future.

Also the EVRS webpage at BKG (BKG, 2010) contains comprehensive information on EVRS, EVRF2007 and a map on national height datum relations (Figure 1).



**Figure 1.** The picture shows the reference tide gauges for European national height reference systems and the offsets to EVRF2007 in cm. From (BKG, 2010) – Related projects – height datum relations.

# **Conclusions (for discussion!)**

It seems necessary that EUREF-TWG have an opinion about what is a reasonable realisation of EVRS for the application of exchange of spatial information in the perspective of Inspire.

The purpose of this document is (for the moment) not to give the final opinion, but to describe the issue, and propose some options for an opinion. Possible directions could be:

- Only the realisations of EVRS developed at the UELN data center and recognised by EUREF are considered as valid realisations of EVRS. Based on Res. 3 from Bryssels, only EVRF2007 is the recommended realisations for the moment. Consequently, transformations should always be done when spatial information are being exchanged within the regulations of INSPIRE.
- 2. In principle only the EVRF2007 is a valid realisation for all kinds of applications. However, for data exchange in the context of Inspire and similar applications it is reasonable that transformations can be avoided if the national vertical frame in question is sufficiently close to EVRF2007. But to keep some control on this EUREF-TWG will develop a process for accepting national height frames as a realisation of EVRS at some level of uncertainty, or possibly just make a list of acceptable realisations.
- 3. EUREF-TWG has not the possibility and should not define the user needs within the European spatial data community for today and tomorrow. Therefore EUREF will not decide on what is a sufficient realisation of EVRS for applications in the framework of Inspire and similar. However, transformation relations between national height frames and EVRF2007 have been developed and published on the web. This information is available for everyone including the GI-community.

Considering the level of agreement between national height realisations and EVRF2007 (figure 1), some groups may be identified:

- Several meters: Belgium
- Few cm: D, NL, DK, N, SF, S
- 5-10 cm level: GB, Romania
- 2-3 dm: Kronstadt system

• 3-5 dm: most other

For the moment my own opinion (Martin Lidberg) is that alternative 3 may be a fruitful standpoint, given the information that actually have been made available on the web thanks to the work done by Johannes, Martina and others.

## References

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