Steps on the way to UELN05 and Enhancements of the web-based Geodetic Information and Service System

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Abstract

Since the last UELN report in 2004 two new data sets were included in the UELN database. In May 2004 the Danish network block was substituted by a new version of the same epoch (1980-1995). In December 2004 the 5th Primary Levelling of the Netherlands was handed over. The data of the new levelling networks of Finland, Norway and Sweden are expected for the very next time.
The Information System for European Coordinate Reference Systems (CRS – EU) was refined. In this paper the available information about the different height systems in Europe will be introduced.

1. Status of the UELN Data Base

1.1. Replacement of the Danish Network

In May 2004 a new data set of the Danish Levelling Network (1980-1995) was handed over. The data derive from the same epoch of measurements as the data of the previous Danish UELN part from 1998, but they differ in some substantial points.
Instead of handing over all points and the observations between each benchmark, the measurements were summarized from node to node. Some corrections were applied and new weights were calculated by the Danish colleagues. Only the 25 major loops are included in the data. Small loops around the major nodal points were cancelled. So the number of measurements between the nodal points decreased considerably, and the a-posteriori accuracy from the adjustment is probably more realistic.

Table 1 Comparison of the Danish data sets

	Old data	New data
Number of nodal points	735	66
Number of measurements	1036	100
a-posteriori s_0 in kgal·mm	0.59	0.88

Table 1 shows that the a-posteriori standard deviations from the adjustments of the two Danish networks differ considerably. Two border connections between Denmark and Sweden were handed over. The new connection across the bridge between Copenhagen and Malmö cannot be used till the replacement of the whole Scandinavian block of UELN because the end point belongs to the new Swedish network. So the test of the new Danish data was performed with the only one connection between Helsingør and Helsingborg. Obviously the added corrections or the summarization of measurements caused changes in the height differences between some nodal points. After the replacement of the Danish network the height of the connection point to Sweden increased by almost 16 mm. Besides that, there are big positive height changes on the island Zealand. (Figure 1).

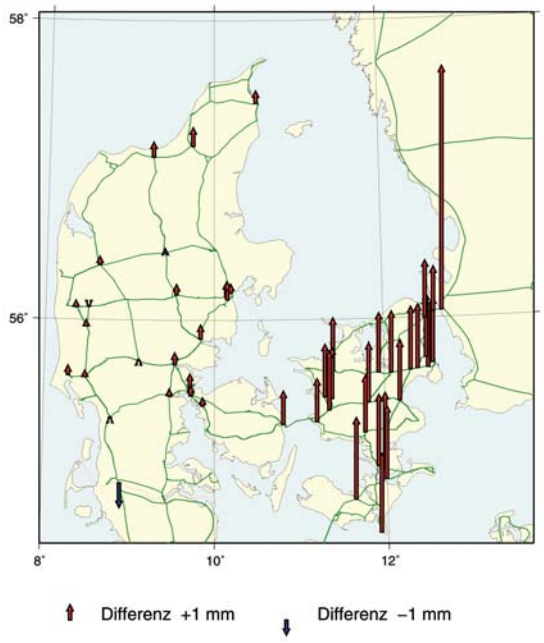

Figure 1: Height differences of the points after replacement of the Danish network block

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These differences are mainly caused by the two border connections to Germany. After discussions with the Danish colleagues and joint verification of the measurements, the data of the new set were appointed to use.

1.2. New Epoch of the Netherlands

The 5th Primary Levelling of the Netherlands was measured between 1996 and 1999. The data were handed over to the BKG data center in December 2004. The network consists on about 1100 nodal points and 1400 measurements between them. Only 242 of the nodal points are identically to points of the last epoch. In a first attempt, ann unconstraint adjustment of the Dutch network was performed. The datum of the network was realized by the geopotential numbers of the identical points of the last UELN adjustment. This adjustment gave height changes with respect to the 4th epoch between about –200 mm and +30 mm. The big negative velocities in the northern country are caused by the exploitation of natural gas (Figure 2).

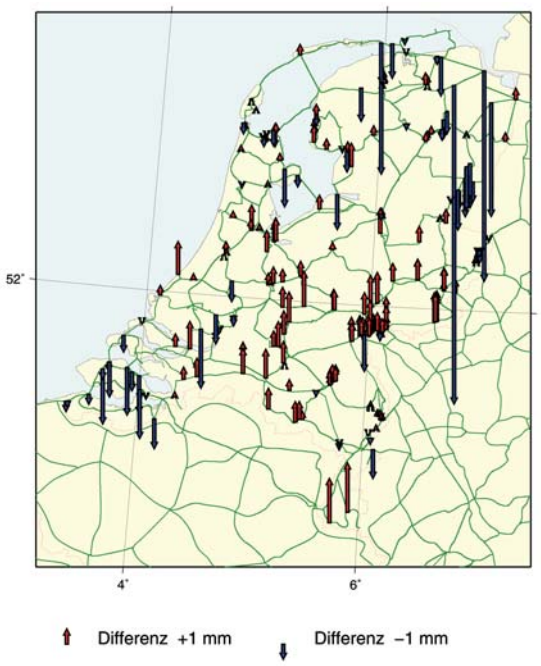

Figure 2: Height differences to the previous UELN heights after test adjustment of the new Dutch network

Table 2 shows a comparison of the a-posteriori standard deviations of the 2 epochs.

Table 2 Comparison of the Dutch data sets

	Old data	New data
Number of nodal points	771	1107
Number of measurements	935	1408
a-posteriori s_0 in kgal·mm	1.09	0.75

1.3. Current contents of the Database

Figure 3 shows the current contents of the UELN/EVRS database after including of the new data set of the Netherlands. First arrangements about the delivering of the new epochs of Finland, Norway and Sweden were made in June 2005. The data are expected for the next months.
The former datum point of the UELN 000A2530 is still missing in the delivered data set of the Netherlands. That why, adjustments of the UELN network were carried out with a substitute of that datum point. Furthermore, some border connections between the Netherlands and Belgium can be added after delivering of the junctions of the end points with the Belgian network block of UELN.

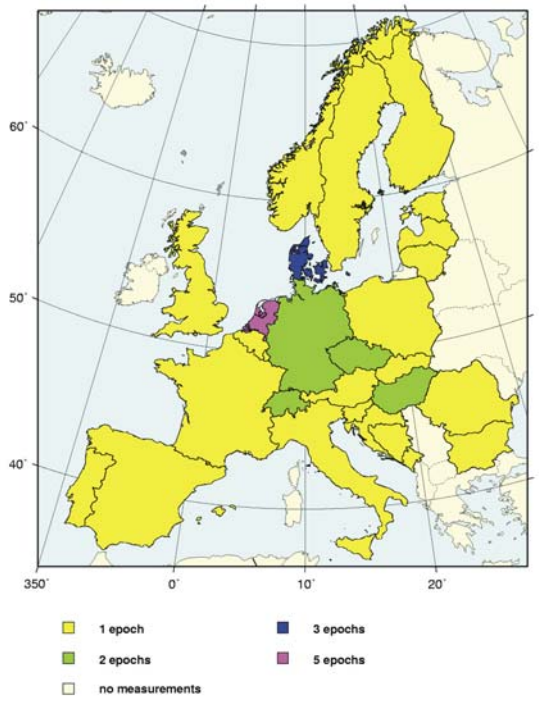

Figure 3: Number of epochs in the UELN/EVRS database (status May 2005)

1.4. Future Datum of UELN

The detected height changes in the levelling network of the Netherlands intensified the current discussion about the future datum of the UELN (Mäkkinen 2004). To study the effect of the vertical movement two alternatives of the UELN were computed. In the first variant one substitute datum point with a minimal height change was chosen. This point was fixed with the same height as in the adjustment version UELN-95/17. In the second variant an unconstraint adjustment with 23 datum points all over Europe was performed.
Figure 4 shows the results of the variant with one datum point. The height changes of the Dutch network are dispersed over the whole network and leads to height changes of about 7 mm also in Bulgaria. The increasing of the heights in

Scandinavia is caused by the change of the connection point to Denmark, which was described in paragraph 1.1.

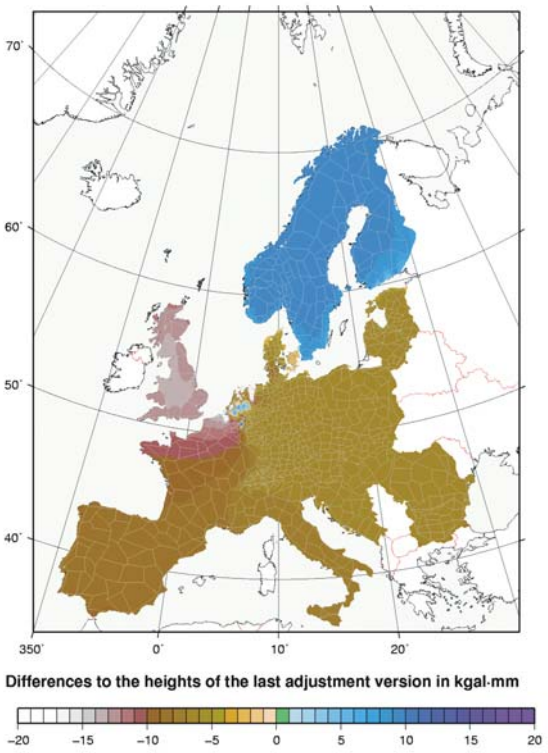

Figure 4: Version with 1 reference point in NL

In the adjustment variant with 23 datum points all over Europe the height changes farther from the Dutch network are lower (Figure 5).

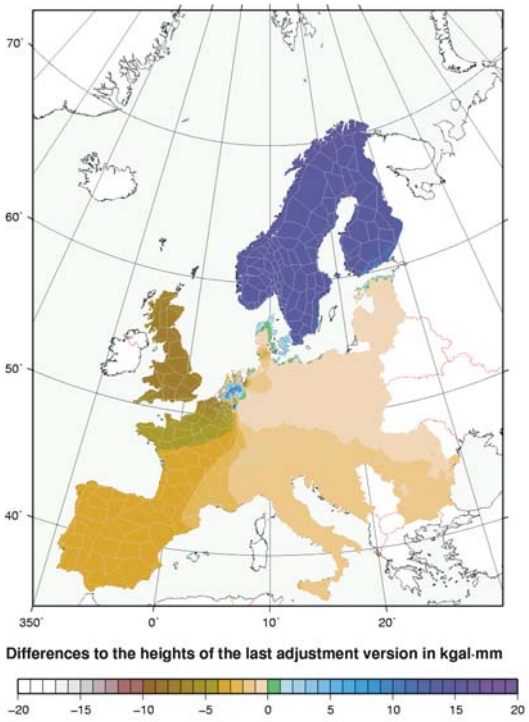

Figure 5: Version with 23 datum points all over Europe

One datum point in each country of UELN was chosen more or less highhandedly for this computation – in the most cases without consideration of stability. The error propagation depends not only on the distribution of the datum points but also on the number and distribution of the border connections.
These examples illustrate the importance of the chose of the network datum. Irrespective of a new definition of the EVRS datum a new realization is necessary. The realization of the datum by only one benchmark is neither contemporary nor advant-ageous.

2. Information System for European Coordinate Systems (CRS-EU) – part Height

2.1. Overview

The web-based information system about coordinate reference systems (CRS) was generated at the BKG in cooperation with EUREF and EuroGeographics. The information system consists mainly on two parts:

- Descriptions of the different geodetic coordinate reference systems which are used in Europe
- Transformation parameters from the different national systems to pan-European systems for position and height

The information is available at the web-address

http://crs.bkg.bund.de/crs-eu

The former existing address http://crs.ifag.de will be forwarded to the new address for some time via an information website. Figure 6 gives an overview about the structure of the information system.
In every case the published information has been agreed with the National mapping Agencies, in many cases they even delivered the information themselves. The descriptions were unified and prepared regarding the ISO standard for spatial referencing by coordinates 19111:2003.

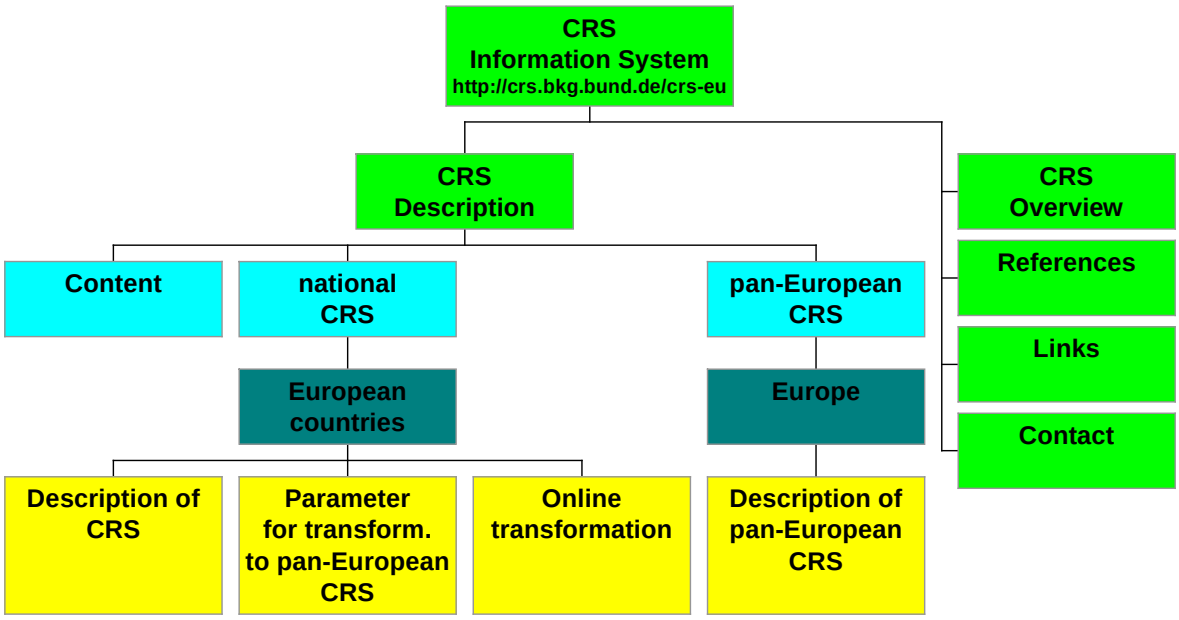

Figure 6: Structure of the information system

2.2. Contents for gravity related heights

Opening the information system the user can choice between national or pan-European CRS. After selecting a country in the rubric national CRS a list appears, which contains the available CRS descriptions and if possible their transformation parameters to the corresponding pan-European CRS. The user can find descriptions and transformation parameters of several CRS for the same country.

This paper is especially focussed on the part of the information system dealing with gravity related heights. The part contains the descriptions of national height reference systems, the description of the pan-European CRS for height – EVRF2000 – and the transformation parameters from the respective national system to the EVRF2000.

Figure 7 shows the reference tide gauges of the national height systems in Europe and their transformation parameters to EVRF2000. It was updated regarding the current status of the information system. Transformation parameters are only available for such countries, which are part of UELN. For gravity related heights a 3-parameter-transformation is used. The parameters are a vertical translation and the slopes in the direction of the meridian and perpendicular to the direction of the meridian. Selecting the button "Quality of the transformation" the user will find information about the accuracy of the transformation parameters and the minimum and maximum deviations. The residual deviations are in the most cases less than 5 cm.

In Figure 7 only the value of the vertical translation is displayed.

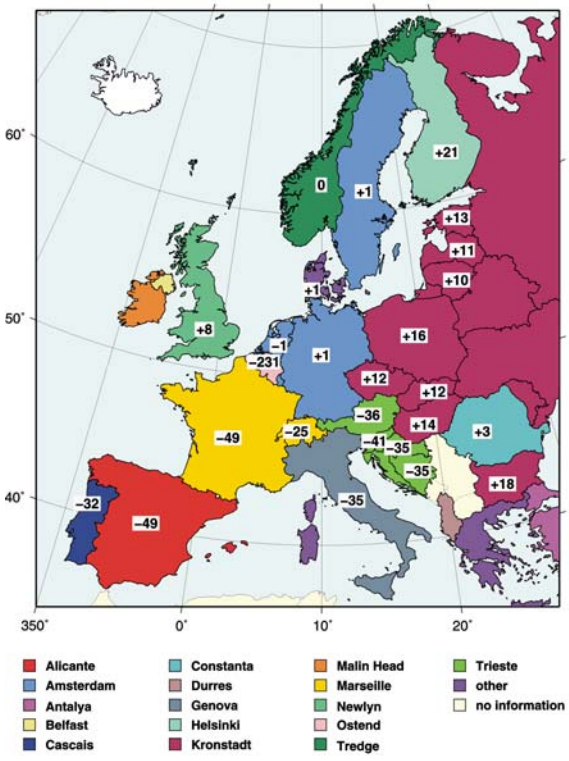

Figure 7: Reference tide gauges in Europe and height differences between the national height systems and the EVRF2000 in cm

Description of CRS - DE_AMST / NH

Country	Germany
Country identifier	DE
CRS identifier	DE_AMST / NH
CRS alias	DHHN92
CRS valid area	Germany
CRS scope	
CRS remarks	mean geoid
Datum identifier	Amsterdam
Datum alias	NHN
Datum type	vertical
Datum anchor point	Wallenhorst 3614/00005
Datum realization epoch	1992; sea level 1684 MHT
Datum valid area	Germany
Datum scope	
Datum remarks	geopotential number of point No.110 from the UELN-73/86 adjustment was fixed
Coordinate system identifier	normal heights
Coordinate system type	gravity related
Coordinate system dimension	1
Coordinate system remarks	
Coordinate system axis name	height
Coordinate system axis direction	up
Coordinate system axis unit identifier	metre

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last change of site frame: 01-Jun-2004

Figure 8: Example for description of a CRS

Description of Transformation - DE_AMST / NH to EVRF2000	
Operation identifier	DE_AMST / NH to EVRF2000
Country	Germany
Country identifier	DE
Operation valid area	Germany
Operation scope	
Source coordinate reference system identifier	DE_AMST / NH
Target coordinate reference system identifier	EVRF_AMST / NH
Operation version	443 identical points
Operation method name	3 parameter height transformation
Operation method name alias	
Operation method formula	H(II)=H(I)+a1+a2·Mo·(LAT-LATo)+a3·No·(LON-LONo)·cos(LAT) H(I): height in the source system [m] H(II): height in the target system [m] Mo: radius of curvature in the meridian of GRS80 [m] in Po No: radius of curvature perpendicular to the meridian of GRS80 [m] in Po LAT: latitude in ETRS89 [radian] LON: longitude in ETRS89 [radian] Po(LATo,LONo): Reference point of the transformation a1...vertical translation [m] a2...slope in the direction of the meridian [radian] a3...slope in the direction perpendicular to the meridian [radian]
Operation method parameters number	3
Operation method remarks	coordinates of the reference point Po: Lat = 51° 3' N Lon = 10°13' E
Operation parameter name	vertical translation
Operation parameter value	+0.014 m
Operation parameter remarks	
Operation parameter name	slope in the direction of the meridian (positive when up northwards)
Operation parameter value	-0.001"
Operation parameter remarks	Equivalent to -0.0005 m height change at a distance of 100 km of Po. To be in agreement with formulas the slope parameter has to be converted to Radians.
Operation parameter name	slope in the direction perpendicular to the meridian (positive when up eastwards)
Operation parameter value	0.
Operation parameter remarks	

Figure 9: Example for description of transformation

Figures 8 and 9 exemplify the description of CRS and of the transformation parameters. The examples describe the official height system of Germany and its transformation to EVRF2000.
Table 3 shows the currently available information on the web site. The data of some countries exist but are not published yet because the respective country didn't verify the information up to now.

2.3. Improvements since the last Symposium and Outlook

Some improvements of the information system have been added since the last symposium:

- Improved layout and structure for better access to the information
- Verification data for transformation
- Starting of realization of single point online transformation for position.

The verification data for transformation in position and height were computed for a number of fictive points all over the respective country. For these points coordinates in both systems are available. The user can avail the data for testing own transformation programs or as an example for the possible size of the change of coordinates after transformation.

Further developments of the information system are intended:

- Completition of information about countries, whose data are unavailable up to now (depends on the assistance of these countries)
- Online transformation (including transformation) of single points for test and verification purposes – starting with CRS for position; currently a demo version is available
- Supply of general information about CRS, coordinates, map projections etc. selecting the button "Quality of the transformation

Table 3: Currently available data in the information system

Country	**Description of CRS**	**Transformation parameters**
Albania	**enquired**	
Austria	**published**	**published**
Belgium	**existing**	**existing**
Bulgaria	**published**	**published**
Switzerland	**published**	**published**
Cyprus		
Czech Republic	**existing**	**existing**
Germany	**published**	**published**
Denmark	**published**	**published**
Estonia	**published**	**published**
Spain	**published**	**published**
Finland	**existing**	**existing**
France	**published**	**published**
Great Britain	**published**	**published**
Gibraltar		
Greece	**existing**	*not part of UELN*
Croatia	**existing**	**existing**
Hungary	**published**	**published**
Ireland	**published**	*not part of UELN*
Iceland	no levelling network	
Italy	**existing**	**existing**
Lithuania	**existing**	**existing**
Luxembourg	**published**	*not part of UELN*
Latvia	**existing**	**existing**
Macedonia		
Malta	**enquired**	
Northern Ireland	**existing**	*not part of UELN*
Netherlands	**published**	**published**
Norway	**published**	**published**
Poland	**existing**	**existing**
Portugal	**published**	**published**
Romania	**existing**	**existing**
Russia	**existing**	*not part of UELN*
Sweden	**published**	**published**
Slovenia	**published**	**published**
Slovak Republic	**existing**	**existing**
Turkey	**published**	*not part of UELN*
Ukraine	**existing**	*not part of UELN*
Bosnia / Herzegovina	**existing**	**existing**

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