Status of the UELN/EVS Data Base and Results of the Last UELN Adjustment

by

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1. Introduction

In January 1999 the adjustment version of UELN-95/13 was handed over to the participating countries as the UELN-95/98 solution. At the last EUREF Symposium 1999 in Prague it was reported about these results and about the adjustment of the levelling networks of Estonia and Latvia. Since these activities the extension of UELN continued and one request of the resolution No. 4 of the EUREF Symposium 1998 in Bad Neuenahr-Ahrweiler has been fulfilled the extension to the Black Sea.

2. Status of the UELN/EVS Data Base

Since the last EUREF Symposium 1999 in Prague the UELN data centre has got some data of several countries. A complete new data set is the network block of Romania which is extending the UELN to the Black Sea. These data will be described in the next paragraph. On the other hand the data of additional levelling epochs of countries which are already included in UELN have been sent to the data centre. At the moment there are the following countries with more than one levelling epoch (see figure 1):

- *Czech Republic*

  Additionally to the first order levelling network of the epoch 1973-1992, which is contained in the UELN-95/98, we got the second order levelling network of this epoch as well as the first and second order levelling network of a preliminary epoch of 1939-1959. The data editing is going on.

- *Denmark*

  Additionally to the last epoch from 1982-1994, which is included in the last UELN adjustment version, there are two preliminary epochs:

  1885-1905,
  1943-1961.

  The data editing is completed and first test computations have been carried out.

- *Germany*

  In Germany there are different conditions in the Eastern and the Western part. In the Eastern part, there exists the epoch from 1974-1976, which was included in the common first order network after the unification of the two German states and which is also part of the UELN. Additionally, there exists a preliminary epoch from 1953-1959 with nearly the same configuration. The editing of these data is completed.
  In the Western part the situation is more difficult. The current network was measured in the eighties. There also exists a preliminary epoch with measurements between 1948-1964 completed by some measurements from 1934-1943, but the identities of the points are not be clear in all cases and there are no coordinates and no gravity corrections for the measurements.

- *The Netherlands*

  The data centre got the following levelling epochs

  1926 – 1940 (2. Primary levelling)
  1950 – 1964 (3. Primary levelling)
  1965 – 1978 (4. Primary levelling)
  1986 – 1996 (Secondary levelling)

  The number of points of all epochs was reduced by the Survey Department (Dr. Molendijk) of the Netherlands. The data editing is completed and first test computations have been carried out.
  Table 1 gives an overview about the contents of the UELN data base.

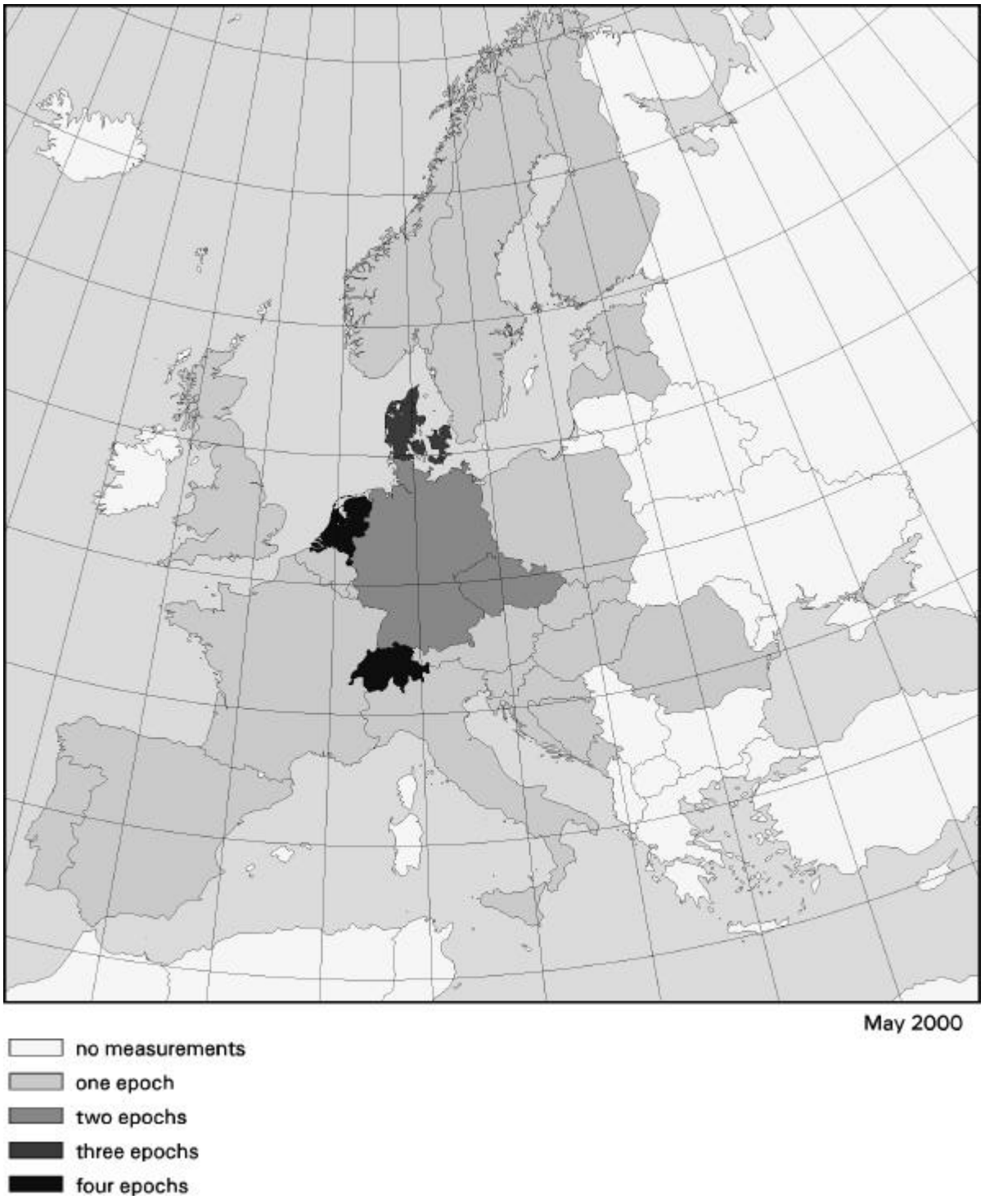

Figure 1 Number of epochs in the UELN/EVS Data Base

Table 1 Contents of the UELN/EVS - Data Base

Country	Number of Nodal Points	Number of Observati-ons	National Heights Available	Whole First Order Network	Epoch of Observation	Epoch of each Meas. known	Year of In-put in UELN	Kind of Ob-servations	Further E-pochs
Austria	96	145	X	X	1966-1992	X	1995	ΔC	
Belgium	35	54			1969-1975		1980		
Bosnia/Herz. + Croatia	46	64	X	X	1970-1973	X	1998	ΔC, Δh	
Czech Republic	53	82	X	X	1973-1992	X	1995	ΔC, Δh	1939-1959*
Denmark	738	1035	X	X	1982-1994	X	1998	ΔC	1885-1905, 1943-1961
Estonia	35	45	X	X	1959-1996	X	1999	ΔC, Δh	
Finland	67	89			1935-1972	X	1980	ΔC	
France	126	1785			1962-1969	X	1980	ΔC	
Germany	498	1508	X	X	1974-1992	X	1995	ΔC, Δh	1953-1959*
Hungary	43	51		X	1975-1978	X	1995	ΔC, Δh	
Italy	64	97			1942-1971	X	1980	ΔC, Δh	
Latvia	126	158	X	X	1968-1988		1999	ΔC, Δh	
Netherlands	842	932	X	X	1969-1975	X	1997	ΔC, Δh	1926-1940, 1950-1964, 1986-1996
Norway	120	194			1912-1978	X	1980	ΔC	
Poland	118	217	X		1973-1980		1996	ΔC	
Portugal	15	22			1943-1969	X	1980	ΔC, Δh	
Romania	65	89	X	X	1974-1986	X	1999	ΔC, Δh	
Slovakia	53	74		X	1973-1980		1996	ΔC	
Slovenia	11	15	X	X	1970-1973	X	1996	ΔC	
Spain	79	101			1925-1974	X	1980	ΔC, Δh	
Sweden	92	122			1950-1967		1980	ΔC	
Switzerland	10	13			1949-1976	X	1980	ΔC, Δh	2 epochs
United Kingdom	45	60			1951-1958		1980	ΔC	

* Data are available at the BKG, but not yet in the data base

3. Current adjustment version UELN-95/14

Since the last EUREF Symposium 1999 in Prague the UELN has been extended to the Black Sea by integrating the First Order Levelling Network of Romania. A representative of Romania worked at the BKG in Leipzig and delivered the Romanian levelling data to the UELN data base.

The levelling data of Estonia and Latvia, which were delivered one year ago, have not been integrated in the UELN yet, because the data of Lithuania are not available yet.

3.1. The National Levelling Network of Romania

3.1.1 Description of the network

A ‚0'.order high accuracy levelling network of Romania has been created following the recommendations of the VIIth Conference of the Geodetic Services of the Eastern Countries (Sophia, 1968) which proposed to create some transcontinental lines, connecting the Black Sea tide gauges with the tide gauges of the Baltic Sea as well as creating an East European levelling network to study the actual vertical movements in Eastern Europe.

During the phase of design, the levelling lines overlapped those of the first order levelling network existing in Romania, which has been previously carried out by the Military Topographic Direction. The first order of the levelling Network has been completed by a number of 5 new lines, which provided smaller polygons and better values when classing the polygons with neighbouring countries.

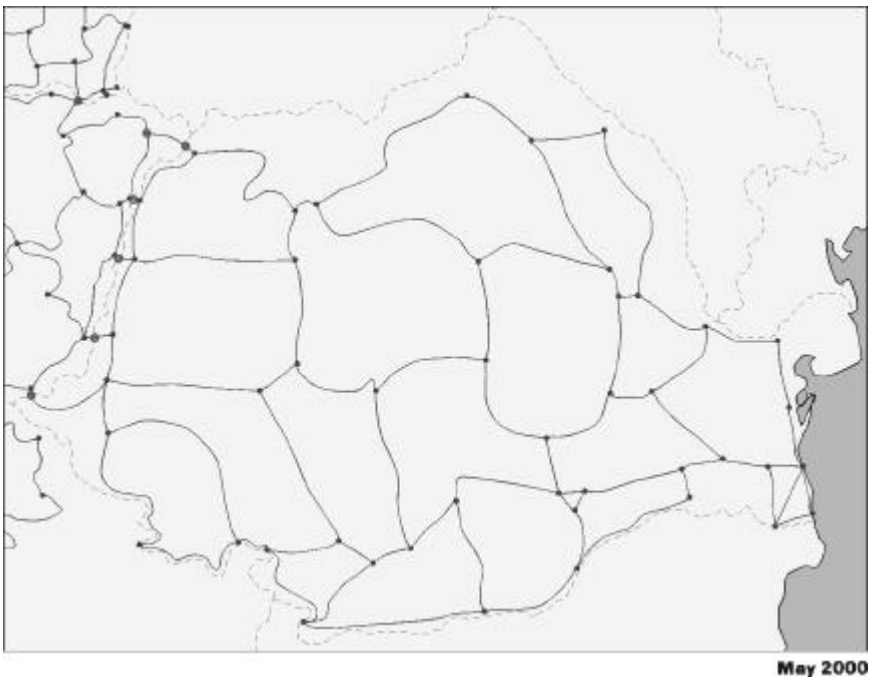

Figure 2 Levelling network of Romania

In 1972 the work on this network began with designing, reconnaissance and applying phases. The measurements began in 1974 and were finished in 1988.

The actual high accuracy levelling network of Romania consists of 19 polygons with an average circumference of 534 km. The main network is made up of 64 lines with an average length of 101 km plus 14 border connection lines to the neighbouring countries. Additionally, there exits a control network around the datum point of the network, Constanta.

The total length of the whole network is about 6620 km with 6400 elevation control points. The number of nodal points is 65. (see figure 2)

3.1.2 Data editing and adjustment

The data centre at the BKG got measured height differences and normal height corrections as well as geographical latitude and free air anomaly for all points of the network. The anomalies had been interpolated from maps of the Bouguer anomaly and recomputed into free air anomalies.

In a first step the adjustment was repeated with the normal height differences in the same way as in the Romanian adjustment in order to control the data. The Romanian adjustment was carried out in the following way: At first the control network around the datum point was adjusted. The second step was the adjustment of the main network with 5 fundamental points of the control network as fixed points.

Then the geopotential number differences were computed from the measured height differences and the gravity values in the IGSN71, which were computed by the latitude and the free air anomaly. The 78 geopotential number differences of the main network and the 11 differences of the control network were adjusted together. The results are the following:

- number of fixed points 1
- number of unknowns 64
- number of measurements 89
- degrees of freedom 25
- a-posteriori standard deviation referred to 1 km 1.83 kgal·mm
- mean value of the standard deviation of the adjusted geopotential number differences 13.03 kgal·mm
- mean value of the standard deviation of the geopotential numbers (= heights) 24.01 kgal·mm
- average redundancy 0.281

A test adjustment of the measured height differences without any correction for the gravity resulted in an a-posteriori standard deviation of 1.6 mm/km. Also the discrepancies in several polygons were smaller without gravity corrections. That shows that the gravity values and/or the coordinates in these areas are not accurate enough.

3.2 Results of the new adjustment variant UELN-95/14

In order to integrate the network of Romania in the UELN, 5 border connections to Hungary were used. The 4 border polygons have circumferences between 184 km and 276 km. From the discrepancies of the polygons a standard deviation of 0.53 kgal·mm/km was computed. Table 2 shows the results of the adjustment variants UELN-95/13 (95/98) and UELN-95/14 (including Romania).

Type of data	**95/13**	**95/14**
Number of unknowns	3063	3162
Number of observations	4263	4397
Number of degrees of freedom	1200	1235
Redundancy, average	0.281	0.281
Standard deviation of adjusted geopotential differences [kgal · mm]:(mean value)	6.62	6.74
Standard deviation of adjusted geopotential numbers [kgal · mm]: (mean value)	19.64	19.72
Standard deviation of a posteriori weight unit referred to a levelling distance of 1 km [kgal · mm]:	1.10	1.11

Table 2 Results of the adjustment variants UELN-95/13 and UELN-95/14

In table 3 the results of the variance component estimation of the adjustment variant UELN-95/14 are shown.

Block	**Number of observations**	**Sum of redundancies**	**a posteriori standard deviation [kgal · mm]**
Austria	145	38.970	0.80
Belgium	54	19.487	1.22
Switzerland	13	4.456	1.06
Germany	756	272.018	0.85
Denmark	1036	312.873	0.59
Spain	101	27.251	1.85
France	175	46.855	2.01
Italy	97	33.022	1.76
The Netherlands	932	163.930	1.08
Portugal	22	5.860	1.77
Great Britain	60	15.000	1.72
Norway	194	70.992	1.67
Finland	89	20.142	0.76
Sweden	122	34.865	1.74
Czech Republic	82	27.483	1.07
Hungary	60	13.742	0.51
Poland	217	61.351	0.95
Slovakia	74	18.574	1.42
Bosnia/Herzegovina, Croatia, Monte Negro, Slovenia, Vojvodina	79	19.407	0.90
Romania	89	28.721	1.73
	4397	1235.000	

Table 3 Accuracy of the UELN-95/14 adjustment after variance component estimation with status of March 2000

4. Further Steps

The next steps of the extension of UELN will be the integration of the national levelling networks of Lithuania and Bulgaria. The handing over of the data of Bulgaria is planned for the autumn of 2000.

A representative of Lithuania will work at the BKG and hand over the national levelling data to the UELN data base in July/August 2000. After that it will be possible to integrate Estonia, Latvia and Lithuania in the UELN. Then there will be only a lack of about 400 - 500 km of Russian levelling line to close the connection between the Baltic states and Scandinavia (see figure 3).

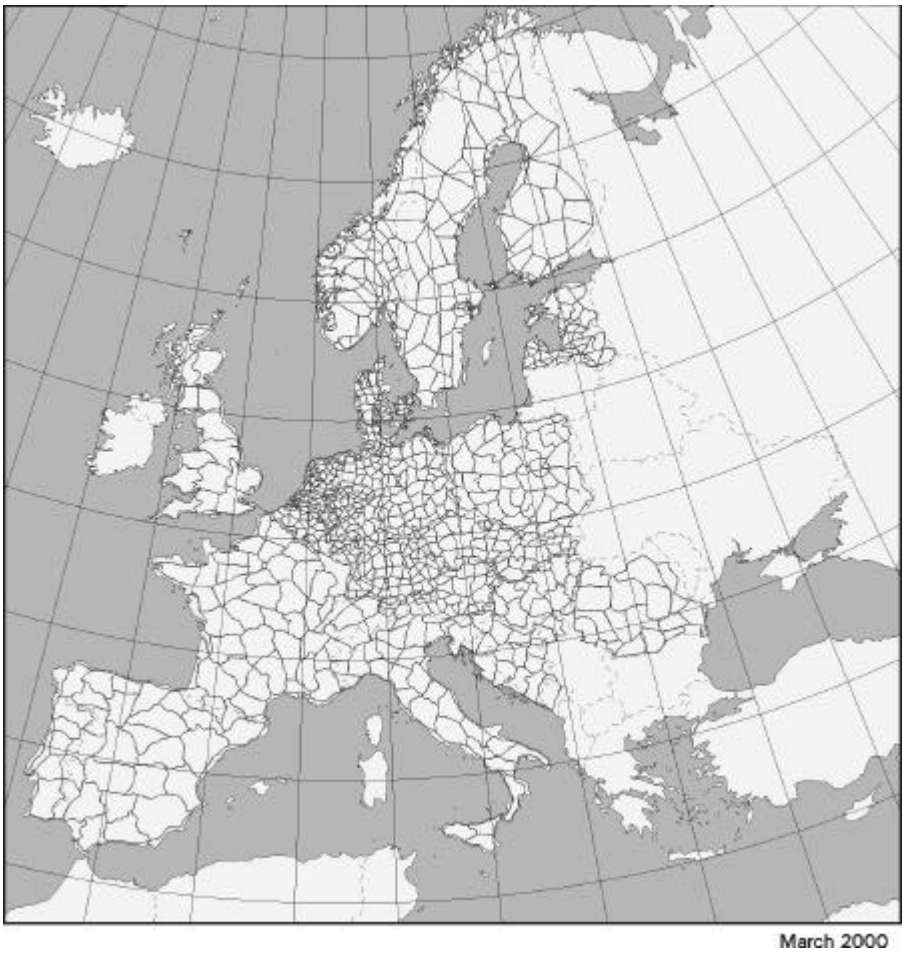

Figure 3: Available measurements in the UELN data base

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