Status of the UELN/EVS Data Base
Activities between June 2000 and May 2001 and Future Plans

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Abstract

In 2000 the UELN data centre received the data of the first order levelling network of Lithuania. So the 3 Baltic States could be integrated into the UELN adjustment. Some weaknesses should be redressed in the next years. The treatment of these tasks will be reported here.

1. Status of the UELN/EVS Data Base

Since 1999 the data of the national levelling networks of Estonia and Latvia has be available at the data centre. These data could not been integrated into the UELN, because the data of Lithuania were not available.
From July 2000 to August 2000 a representative of Lithuania worked at the BKG in Leipzig and prepared the Lithuanian levelling data for the integration into the UELN. The details are described in the next paragraph.

Regarding the collection of data for the creation of a kinematic height network we turned our attention to the data of Germany (see SACHER et al. 2000). The preliminary epoch of the Western part of the network with measurements between 1934 – 1964 was digitized, the identical points were found out and geopotential number differences were computed. In the 70ies a map of vertical recent crustal movements of the territory of Eastern Germany was derived from repeated levellings. A comparable work for the Western part of Germany doesn't exist yet.
At the moment a student of the Technical University in Dresden is working on her dissertation for diploma degree about the computation of vertical velocities of the whole German levelling network from two levelling epochs.

Table 1 gives an overview about the current contents of the UELN data base.

2. The National Levelling Network of Lithuania

2.1 Historical Overview

The historical development of the Lithuanian levelling network is closely tied to the varied history of the country.

The first levelling lines in the present territory of Lithuania were observed in the second half of the 19th century. The Western part of Lithuania was under Prussian jurisdiction, and the Prussian Kingdom was the most advanced in construction and using modern levelling technique. The vertical datum was defined by the reference mark number 3236 in Berlin. Some benchmarks of these times are still in use.

In the period between 1795 and 1918 a big part of the present area of Lithuania belonged to Russia. The Russian army observed some levelling lines along the railways in 1873-1903. The vertical datum was defined by so-called Baltic Black Sea mean sea level. Few benchmarks of the tsarist Russian levelling network are still in use.
In 1918 Lithuania recovered the political independence. In the period 1930-1940 the state levelling network was designed and observed. The total length of the levelling lines was 2010 km.

In addition, from 1920-1939 the Eastern part of the present territory of Lithuania belonged to Poland. So some levelling lines of the first order levelling network of Poland ran across Lithuanian territory. Few benchmarks of that network are still in use.

From 1940 to 1990 Lithuanian belonged to the former USSR. After World War II the Main Board for Geodesy and Cartography of the USSR started the modernization and unification of the total network

Within that frame some lines of the Lithuanian precise levelling network were reconstructed, partly reobserved and continued to the levelling networks of neighbouring republics of USSR. The adjustment which was finished in 1950 transferred the Baltic Height System (tide gauge Kronstadt) to the Baltic States.

In the period of 1954-1968 the fundamental levelling network of USSR was improved. Also some first order and second order lines that cross the Lithuanian territory were observed. In 1969 preparation works for the new adjustment of the total levelling network of USSR were started.

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Table 1 Contents of the UELN/EVS - Data Base

Country	Number of Nodal Points	Number of Observations	National Heights Available	Whole First Order Network	Epoch of Obser-vation	Epoch of each Meas. known	Year of Input in UELN	Kind of Obser-vations	Further Epochs
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	East 1953-1959 West 1934-1964
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	
Lithuania	46	72	X	X	1933-1998	X	2000	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	1 additional epoch*
United Kingdom	45	60			1951-1958		1980	ΔC	

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

The vertical datum was defined by the reference benchmark in the railroad station Oranienbaum of the city Lomonosov. The connection to the tide gauge Kronstadt was established by a hydrostatic levelling line which was performed in 1969. The adjustment was finished in 1977. For more details about the history of the network sea PARŠELIUNAS et al. (2000).

2.2 Present State

In 1970-1971 some first order and second order lines on the Lithuanian territory had been reobserved, but the results of the measurements had not been included into the adjustment of the total network of USSR.

In 1990 the independence of Lithuania was regained. The existing old levelling network as a part of the United Precise Levelling Network of Eastern Europe (UPLN) did not meet modern requirements of the independent country. So the project of the Fundamental Vertical Network of Lithuania was prepared (PARŠELIUNAS et al. 1998; BUGA et al 1999).In 1997-1999 one loop in the southern part of Lithuania was observed. In addition the ellipsoidal coordinates and heights of all ground benchmarks were determined by GPS. The total network should be observed in about 5 years.

The northern part of the Lithuanian levelling network is at the moment formed by the levelling lines which belonged to many various networks.

3. New adjustment version UELN 95/15

3.1 Preparation of the Lithuanian Levelling Data

The source data used for the integration of the Lithuanian levelling network were located in levelling catalogues of different epochs. The number of benchmarks, measured height differences and distances between the benchmarks were digitized from these catalogues in Lithuania and handed over to the UELN data base.

In order to compute the gravity, correction coordinates and gravity values are needed. The coordinates of some benchmarks were also digitized from catalogues. Most of the coordinates were found in digital maps at a scale 1 : 50 000. The coordinates were transformed into the ETRS89.

Most of the gravity data were taken from the gravity data base of the Geodetic Commission of Nordic Countries (FORSBERG et al 1999). The Bouguer anomalies were interpolated using the software package GRAVSOFT (TSCHERNING et al. 1994).

3.2 Results of the test adjustments

The Lithuanian network consists of 1467 benchmarks and 1490 measurements between them. The measurements form 25 loops with circumferences between 14 km and 786 km and with misclosures between 0.1 kgal · mm and 42.7 kgal · mm. The parameters of the single adjustment of the Lithuanian network are:

Number of fixed points:	1
Number of unknowns:	1466
Number of measurements:	1490
Degrees of freedom:	24
A posteriori standard deviation referred to 1 km levelling distance:	0.92 kgal · mm
Mean value of the standard deviation of the adjusted geopotential numbers (≙ heights):	8.62 kgal · mm
Average redundancy:	0.016

Before integrating the Lithuanian network together with the other Baltic networks into the UELN the connections between the national network blocks were tested by a common adjustment of the 4 network blocks of Poland, Lithuania, Latvia and Estonia.

The number of points and measurements in the adjustment was reduced by summarizing the geopotential number differences between the nodal points.

The parameters of the common adjustment are the following:

Number of fixed points:	1
Number of unknowns:	375
Number of measurements:	498
Degrees of freedom:	123
A posteriori standard deviation referred to 1 km levelling distance:	1.22 kgal · mm
Mean value of the standard deviation of the adjusted geopotential numbers:	21.08 kgal · mm
Average redundancy:	0.247

The results of the variance component estimation for the 4 network blocks are shown in Table 2:

Country	Number of observations	Sum of redundancies	A posteriori standard deviation kgal · mm/km
Poland	221	59.968	0.95
Lithuania	72	20.096	0.94
Latvia	159	35.558	1.67
Estonia	46	10.377	1.31

Table 2 : Results of the variance component estimation of the test adjustment

3.3 Results of the adjustment version UELN 95/15

The adjustment variant UELN 95/15 contains the same measurements as the adjustment variant UELN 95/13, which was delivered to the participating countries under the name UELN 95/98, extended for the national levelling networks of Romania and of Estonia, Latvia and Lithuania (see Figure 1).

Figure 1 UELN adjustment version 95/15

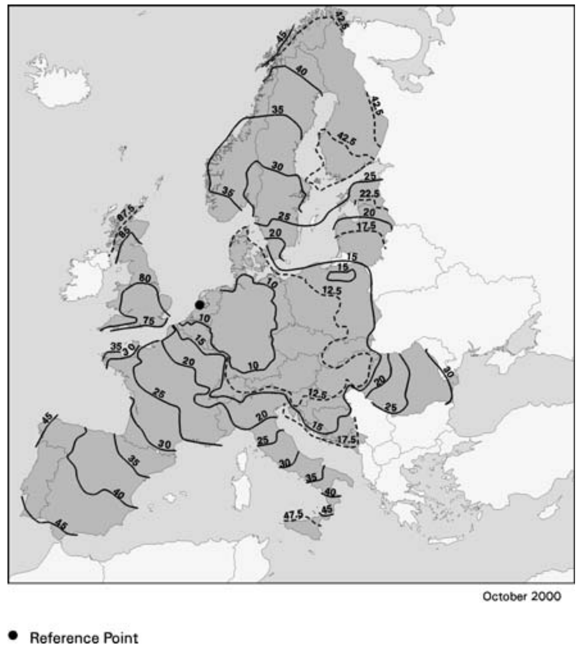

Figure 2 Precision of the adjusted UELN heights related to the reference point Amsterdam

Additionally an improved value was introduced for the connection between Denmark and Germany over the Fehmarn Belt observed by hydrostatic levelling. The old value was incorrect because of a printing error in the publication about that topic. This correction caused a little improvement in the adjustment results. The misclosure of the loop containing this connection was reduced from 56,7 mm to 42,6 mm at a distance of 719 km.

The precision of the network blocks of the Baltic States obtained from the variance component estimation of the whole UELN is in principle the same as that which was estimated in the test adjustments.

The parameters of the adjustment version UELN 95/15 are shown in Table 3:

	UELN 95/13	UELN 95/14	UELN 95/15
Number of fixed points:	1	1	1
Number of unknowns:	3063	3162	3389
Number of measurements:	4263	4397	4693
Degrees of freedom:	1200	1235	1304
A posteriori standard deviation referred to 1 km levelling distance [kgal · mm]:	1.10	1.11	1.13
Mean value of the standard deviation of the adjusted geopotential numbers [kgal · mm]:	19.64	19.72	19.67
Average redundancy:	0.281	0.281	0.278

Table 3: Results of the adjustment variants 95/13-95/15

Figure 2 shows the precision of the adjusted heights related to the datum point Amsterdam.

Table 4 shows the results of the variance component estimation of the adjustment variant UELN 95/15.

Group of measurements	Number of observations	Sum of redundancies	A posteriori standard dev. [kgal · mm]:
Austria	145	39.022	0.80
Belgium	54	19.491	1.22
Switzerland	13	4.464	1.06
Germany	766	272.801	0.84
Denmark	1038	312.878	0.59
Spain	101	27.254	1.85
France	175	46.863	2.01
Italy	97	33.022	1.76
Netherlands	935	163.975	1.08
Portugal	22	5.857	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	27.519	1.07
Hungary	60	13.730	0.51
Poland	221	63.405	0.96
Slovakia	74	18.562	1.41
Croatia, Bosnia/ Herz., Slovenia, Monto Negro, Vojvodina	79	19.409	0.90
Romania	89	28.723	1.73
Estonia	46	10.377	1.31
Latvia	159	35.559	1.67
Lithuania	72	20.091	0.94
Sum	4693	1304.000	

Table 4: Accuracy of the UELN 95/15 adjustment after variance component estimation

4. Future steps

Most of the European countries are participating in the UELN project. Except for islands and city states all countries of Northern and Western Europe are integrated. The integration of the Bulgarian levelling network was planned for this year and we hope it will be carried out after some organizing work. The Bulgarian network will open the connection to Turkey as well as to Greece and so to Southeast Europe (see Figure 3).

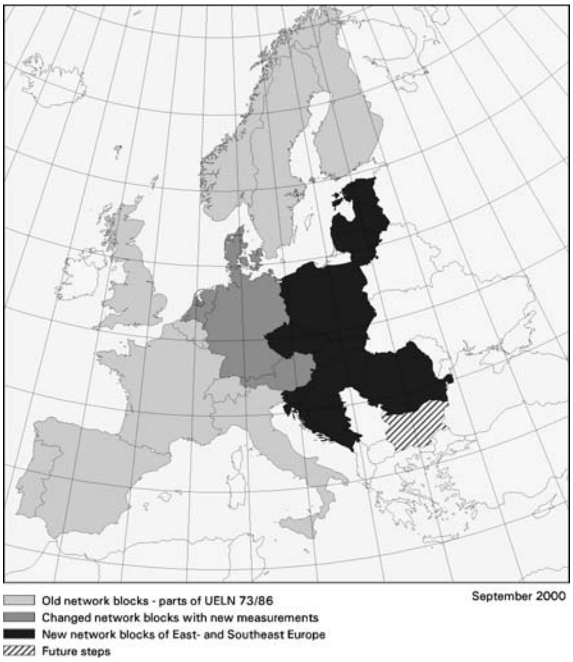

Figure 3: UELN 95 – Status of the Adjustment and Enlargement

Two weak spots of the UELN are the connections of the United Kingdom and of Scandinavia with the continental network. Both of them are realized by only one height difference and so without any control.

An improvement of the connection to the United Kingdom is possible by using the levelling connection between France and UK through the channel tunnel measured already some years ago. In the resolution No. 4 of the EUREF Symposium in Bad Neuenahr-Ahrweiler 1998 the involved countries were urgently requested to make available the missing data.

A better integration of the Scandinavian network block can be obtained by extending the UELN in the Eastern direction up to including Russia. Figure 4 shows the situation around the Gulf of Finland.

The integration of the national levelling network of Russia would lead not only to the closing of the UELN around the Baltic Sea but also to a direct connection of the tide gauges Amsterdam and Kronstadt. Last but not least the integration of the networks of Russia as well as of Belarus and of the Ukraine would extend the UELN to the Eastern boundary of Europe.

Figure 4: Extent of the UELN95 around the Baltic Sea and the Gulf of Finland

One weak spot can be redressed by the data centre itself: The current network block of Switzerland contains only 13 observations. Meanwhile the complete measurements of 2 epochs are available and it is planned to replace the old Swiss network block by a new dense first order levelling network.

We request all countries of Western Europe whose national parts of UELN are still the same as in the adjustment UELN 73/86 and which have any more current data to make available these data to the data centre in order to improve the accuracy and topicality of the UELN.

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