Status Report of the UELN/EVS Data Base

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Abstract

Since the last report in 2001 the old national levelling network block of Switzerland consisting of only 13 measurements was replaced by a current network of 380 observations and more than 200 nodal points.

Some problems arisen with the connections to the neighbouring countries because of crustal movements in the areas of border connections respectively instable benchmarks.

1. The current contents of the UELN/EVS Data Base

In the last UELN report presented at the EUREF symposium in Dubrovnik in 2001 the extension of the UELN to Bulgaria was announced. Unfortunately the handing over of the data retarded. So the integration of the Bulgarian network can be realized only in the second half year of 2002.

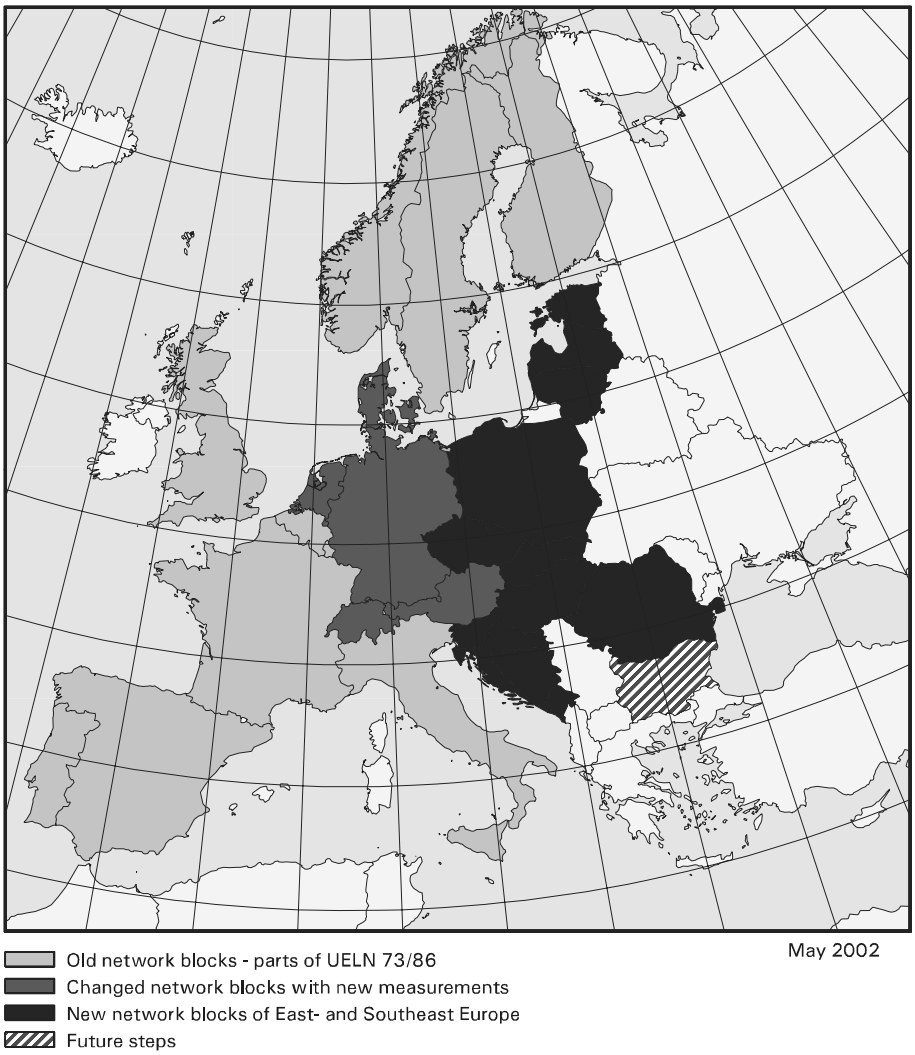

Figure 1: UELN 95/16 – Status of the adjustment and enlargement

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Besides the extensive enlargement of UELN to Eastern Europe the intensive enlargement by changing old network blocks of UELN 73/86 by current data is an objective of the UELN activities. Up to the adjustment version UELN 95/15 the levelling network of Switzerland has been represented only by 10 nodal points and 13 observations. In answering the request of the data centre the Federal Office of Topography of Switzerland made out a data set of the current Swiss first order levelling network and sent it to the BKG in March 2002. The data set contains 1183 points and 1330 measurements. The details are described in the next paragraph. Table 1 gives an overview about the current contents of the UELN database.

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 Observation	Epoch of each Meas. known	Year of Input in UELN	Kind of Observations	Further Epochs
Austria	96	145	x	x	1966-1992	x	1995	DC	
Belgium	35	54			1969-1975		1980		
Bosnia/ Herz. + Croatia	46	64	x	x	1970-1973	x	1998	DC, Dh	
Czech Republic	53	82	x	x	1973-1992	x	1995	DC, Dh	1939-1959
Denmark	738	1035	x	x	1982-1994	x	1998	DC	1885-1905, 1943-1961
Estonia	35	45	x	x	1959-1996	x	1999	DC, Dh	
Finland	67	89			1935-1972	X	1980	DC	
France	126	1785			1962-1969	X	1980	DC	
Germany	498	1508	x	x	1974-1992	x	1995	DC, Dh	east 1953-1959 west 1934-1964
Hungary	43	51		x	1975-1978	x	1995	DC, Dh	
Italy	64	97			1942-1971	X	1980	DC, Dh	
Latvia	126	158	x	x	1968-1988		1999	DC, Dh	
Lithuania	46	72	x	x	1933-1998	X	2000	DC, Dh	
Nether-lands	842	932	x	x	1969-1975	x	1997	DC, Dh	1926-1940, 1950-1964, 1986-1996
Norway	120	194			1912-1978	X	1980	DC	
Poland	118	217	x		1973-1980		1996	DC	
Portugal	15	22			1943-1969	X	1980	DC, Dh	
Romania	65	89	x	x	1974-1986	X	1999	DC, Dh	
Slovakia	53	74		x	1973-1980		1996	DC	
Slovenia	11	15	x	x	1970-1973	x	1996	DC	
Spain	79	101			1925-1974	X	1980	DC, Dh	
Sweden	92	122			1950-1967		1980	DC	
Switzer-land	232	380	x	x	1943-2001	X	2002	DC, Dh	3 additional epochs
United Kingdom	45	60			1951-1958		1980	DC	

2. The new Swiss Network Block

The Federal Office of Topography handed over a data set containing the most actual measurements of the first order levelling network of Switzerland.

The 1183 points are the nodal points of the network as well as some selected stable intermediate points.

In detail were handed over 1183 points with

- Coordinates in the ETRS89
- Gravity values
- Heights in several Swiss height systems (LN02, LHN95)
- Velocities derived from a kinematic adjustment of all measurements since 1902

and 1330 observations with

- Geopotential differences
- Distances
- A-priori standard deviations as used in the Swiss adjust-

ment

– Years of observation.

The organization of the repeated levellings in Switzerland differs from those in most other countries. There are no separate epochs but a minimum of observation crews are working permanently. That's why the period of observation of the current Swiss network covers more than 50 years. Considering the recent crustal movements in the area of the Alps and this timing of the measurements, the increasing of closing errors was to be expected.

Here are the parameters of the separate adjustment of the Swiss network (only nodal points):

Number of fixed points:	1
Number of unknowns:	238
Number of measurements:	387
Degrees of freedom:	149
A-posteriori standard deviation referred to 1 km levelling distance in kgal × mm:	1.09
Mean value of the standard deviation of the adjusted geopotential numbers (≙ heights), in kgal × mm:	5.91
Average redundancy:	0.39

In order to test the influence of the very long epoch the measurements were reduced to a unified epoch 1960 using the velocities, which were handed over with the Swiss data.

Now the parameters of the adjustment changed as follows:

A-posteriori standard deviation referred to 1 km levelling distance in kgal × mm:	0.86
Mean value of the standard deviation of the adjusted geopotential numbers (≙ heights), in kgal × mm:	4.68

The differences between these two adjustment versions confirm the assumption of the influence of vertical crustal movements.

3. The integration of the new Swiss network block in the UELN

The exchange of the old Swiss network block by the new observations requires the height differences to the border points of the neighbouring countries. Seven of the 13 points, which formed the old Swiss network block, are no longer included in the new network. They have been destroyed or were taken out because of their instability (see table 2). However, the including of the boundary points is necessary for the connection to the neighbouring countries. So some additional observations containing the old boundary points were introduced.

In a first adjustment variant 95/16-1 the new Swiss network block was introduced without any corrections.

Table 2: Remarks on the Swiss boundary points

Boundary point	Country	Year of measurement	Remarks
26	A	1976	probably stable
27	A	2e+11	very stable
28	A	1974	stability unknown, new measurements are planned
75	F	1952	destroyed
76	F	2e+07	destroyed, was very instable, new measurements are planned
77	D	1953	destroyed
81	I	2e+07	area of subsidence, velocity ca. 5 mm/y

Table 3: Comparison of UELN adjustment results for different variants of the Swiss network

		95/15	95/16-1	95/16-2	95/16-3	95/16-4
Full network	s_0	1.13	1.19	1.12	1.11	1.12
	$s_{)h}$	6.72	7.42	6.70	6.51	6.5
	s_H	19.67	20.49	19.60	19.27	19.29
CH	s_0	1.06	1.10	0.88	0.88	1.09
	$s_{)h}$	8.03	2.44	1.93	1.93	2.39
A	s_0	0.80	0.82	0.86	0.85	0.81
	$s_{)h}$	3.63	3.73	3.87	3.83	3.66
D	s_0	0.84	0.85	0.84	0.84	0.85
	$s_{)h}$	3.82	3.85	3.84	3.83	3.84
F	s_0	2.01	2.44	2.37	2.02	2.03
	$s_{)h}$	14.00	16.92	16.49	14.12	14.16
I	s_0	1.76	3.51	1.82	1.84	1.75
	$s_{)h}$	13.99	26.69	14.42	14.57	13.93

The adjustment variant 95/16-2 contains the Swiss measurements reduced to the epoch 1960 as described in paragraph 2.

The adjustment variant 95/16-3 is the same as in 95/16-2, but without the border connection containing point 76. This point got 2 different numbers in France and in Switzerland, respectively. The height difference after the adjustment between these points was about 10 cm.

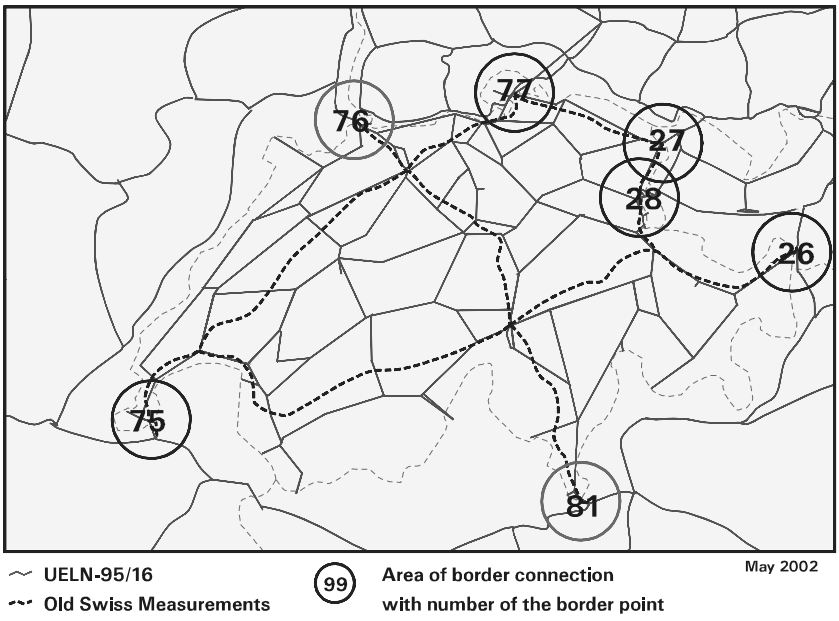

Figure 2: Swiss part of UELN

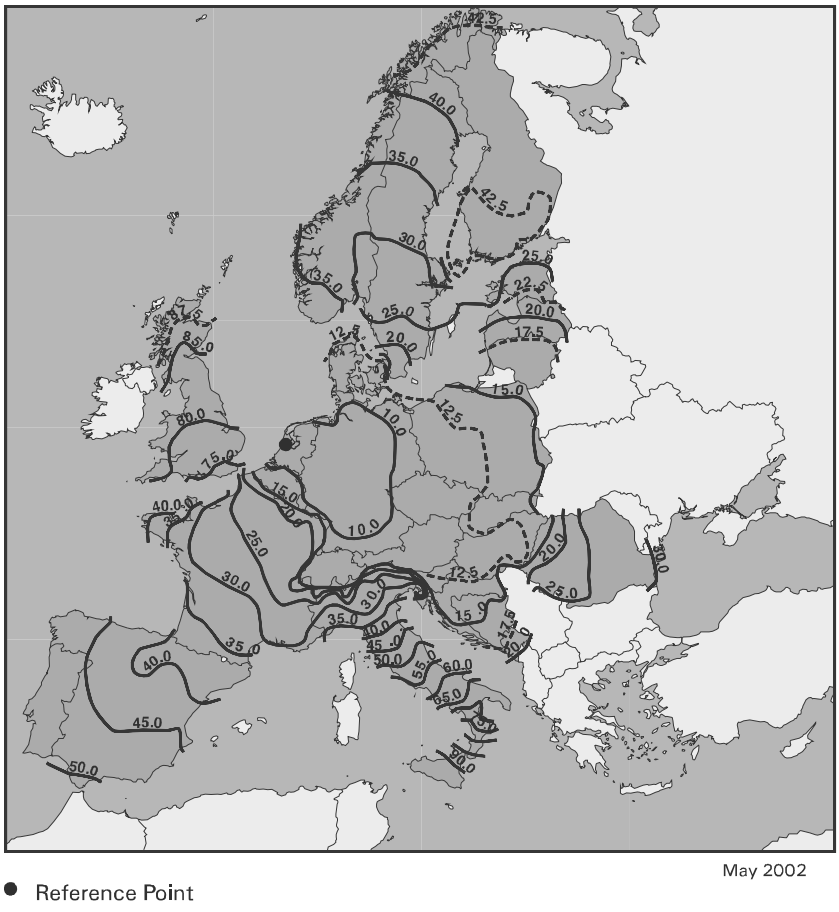

Figure 3: UELN 95/16-1 – Isolines of precision

The adjustment variant 95/16-4 contains the Swiss network without corrections as in variant 95/16-1, but the connections containing the boundary points 76 and 81 are removed by introducing 2 different point numbers for the same point. The differences of the adjusted heights at the points 76 and 81 are 10.5 cm and 19.4 cm, respectively. In this variant doesn't exist any connection between Switzerland and Italy.

Table 3 shows the different adjustment results (a-posteriori standard deviation s0 referred to 1 km levelling and mean value of the standard deviation of the adjusted geopotential differences s) h in kgal A mm) for the 4 variants and the

previous adjustment 95/15 containing the old Swiss network block. The different weights of the observation groups in the variance component estimation lead to the distribution of the errors of the border connections towards the groups with the lower weights (France, Italy).

The results of variant 95/16-1 are unacceptable because of the big strain at the boundary points 76 to France and 81 to Italy (see figures 2 and 3). The variants 95/16-2 and especially 95/16-3 show better results, but the reduction of the observations to a common epoch is problematic. Because of the using of the velocities from the kinematic adjustment for the reduction the observations are not independent.

That's why variant 95/16-4 should get the preference. (see figure 4)

Nevertheless the analysis of all these variants shows the necessity of the establishment of some new stable boundary points at the borderline to France and Italy.

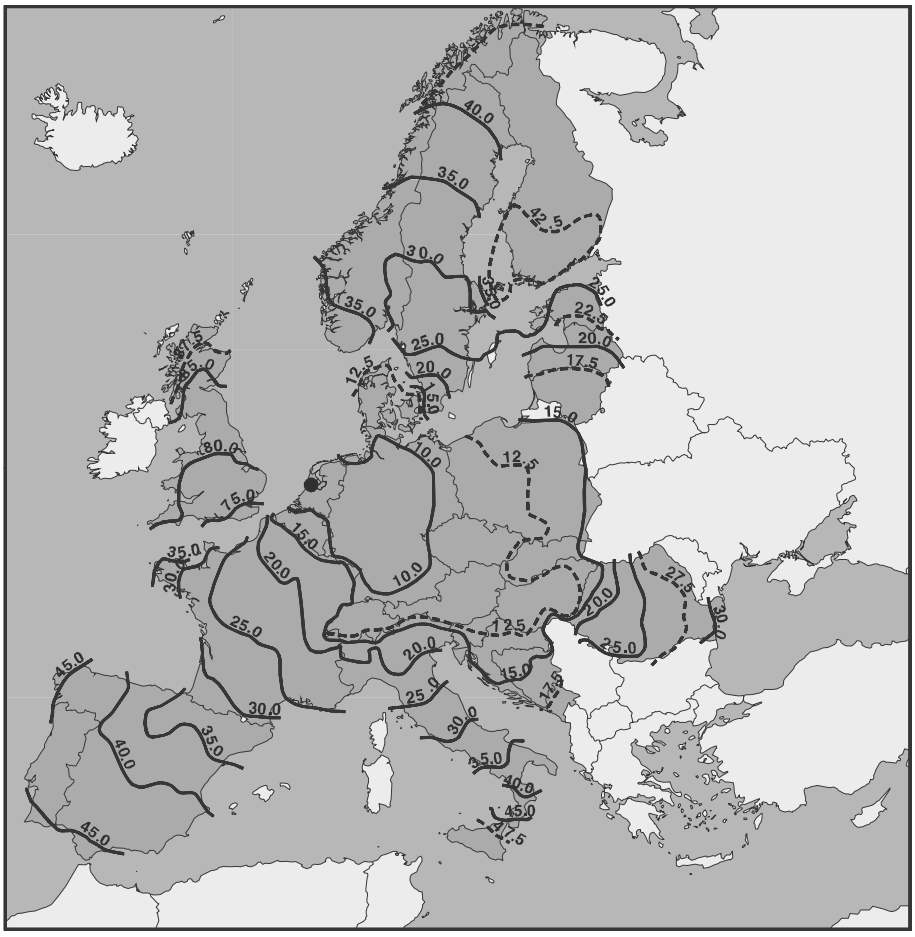

Figure 4: UELN 95/16-4 – Isolines of precision

Here are the parameters of the adjustment variant 95/16-4:

Number of fixed points:	1
Number of unknowns:	3617
Number of measurements:	5066
Degrees of freedom:	1149
A-posteriori standard deviation referred to 1 km levelling distance in kgal Ä mm:	1.12
Mean value of the standard deviation of the adjusted geopotential numbers (heights), in kgal Ä mm:	19.29
Average redundancy:	0.286

Table 4 shows the results of the variant component estimation.

Table 4

Group of measurements	Number of observations	Sum of redundancies	A posteriori standard dev. [kgal mm]
Austria	144	39.057	0.81
Belgium	54	19.484	1.22
Switzerland	387	150.423	1.09
Germany	766	272.992	0.85
Denmark	1038	312.871	0.59
Spain	101	27.231	1.84
France	175	46.293	2.03
Italy	97	32.538	1.75
Netherlands	935	163.949	1.09
Portugal	22	5.861	1.77
Great Britain	60	15	1.72
Norway	194	70.992	1.67
Finland	89	20.142	0.76
Sweden	122	34.865	1.74
Czech Republic	82	27.478	1.07
Hungary	60	13.728	0.51
Poland	221	63.392	0.96
Slovakia	74	18.55	1.41
Croatia, Bosnia/ Hz., Slov.	79	19.393	0.9
Romania	89	28.722	1.73
Estonia	46	10.377	1.31
Latvia	159	35.559	1.67
Lithuania	72	20.091	0.94
Total	5066	1449	

4. Conclusions and Outlook

Since the last EUREF symposium in Dubrovnik 2001 the UELN didn't expand to the East, but the process of intensive enlargement was continued. That means the substitution of such national network blocks that were already part of UELN-73/86 by current measurements with a denser network configuration. Figure 5 shows the current network configuration.

While including the new Swiss network block in the UELN the precision of the network decreased because of recent crustal movements in the border area and instable points, respectively. The analysis of the data shows the necessity of the establishment of some new border points and of the observation of new connections. Only after that a new UELN solution containing the new Swiss network can be published.

The influence of recent crustal movements inside the Swiss network could only be restrained by a kinematic adjustment.

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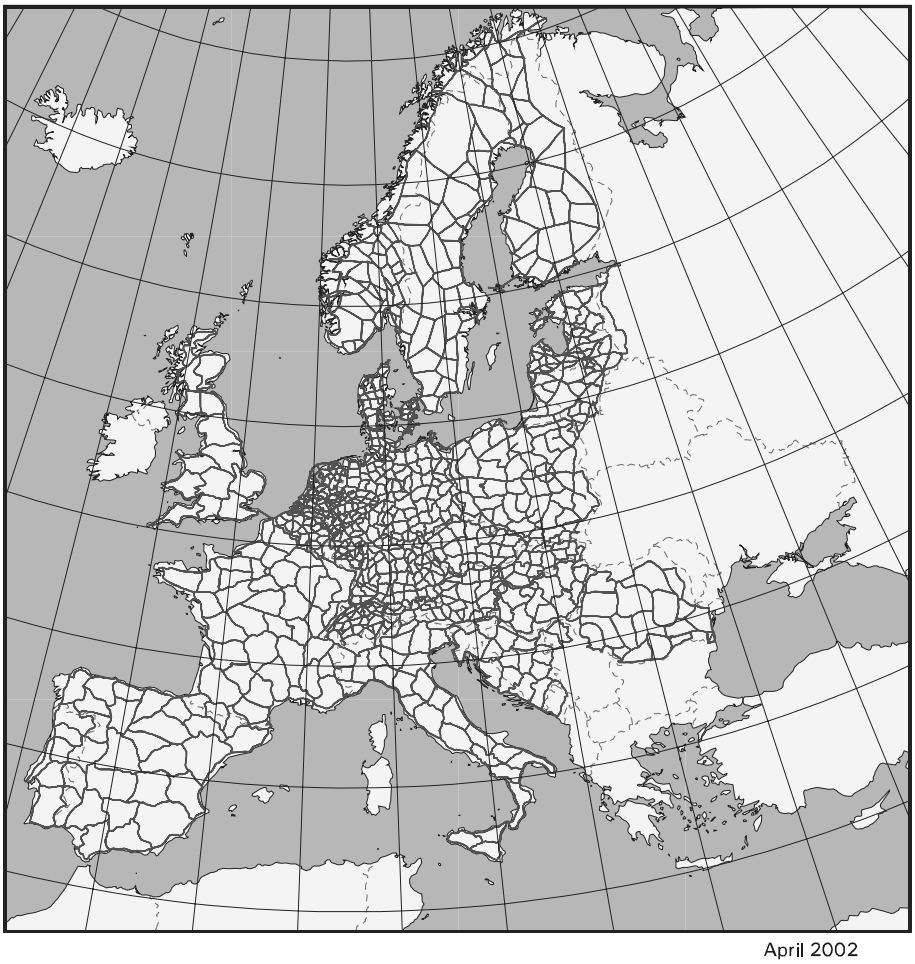

Figure 5: UELN 95/16