Estonian National Vertical Network

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Estonian Vertical Network (EVN) is consisting of the national system of levelling lines (I, II, III order) and benchmarks, which are based upon levelling lines established during the years 1933–1943. Before the latest war the zero point of Estonian levelling network was the mean sea level height of twelve years (1923–1934) from Tallinn tide gauge station and after the war it was the Kronstadt zero. The present heights of EVN benchmarks are expressed in the Baltic Height System of 1977.

The aim of the renovation of the Estonian levelling network is the updating of the existing levelling network on the basis of the principles of establishing an integrated geodetic fundamental network. That would set up premises for the compilation of a new levelling catalogue reduced to a definite moment of time, specification of the geoid model, integration of the EVN to the unified Baltic Height Network and connection of different national levelling systems.

The first levelling network as a system of high-precision levelling lines covering the whole Estonia was established within the framework of the Baltic Geodetic Commission in 1933–1943. As much as 1151 benchmarks were monumented in the course of establishing the all-Estonian levelling network. All knot points and end points of the levelling lines were supplied with fundamental benchmarks (in total 23). The established levelling lines with slight modifications have served as basis for high-precision levellings of following years.

The main characteristics of the high-precision levellings in Estonia are given in table 1.

In addition to the high-precision levellings, the precision levelling (in total 728 km) was carried out in 1936–1943 and the second order levelling (1380 km) was performed by Main Board of Geodesy and Cartography (MBGC) in 1981–1983.

Table 1. Main characteristics of the high-precision levellings in Estonia in 1933–1991

Institution	Years	Levelling lines	The 1 km mean error values	
			random mm	systematic mm
Cadastre Department	1933–1943	6 loops in mainland, in total 1800 km	±0,32	±0,03
MBGC	1948	The line Narva–Tallinn–Pärnu–Ikla (505 km)	±0,50	±0,05
Academy of Sciences	1951–1969	Mainly at the lines established in 1933–1943 (2067 km)	±0,48	±0,08
MBGC	1970	The line Narva–Tallinn–Pärnu–Ikla (505 km)	±0,53	±0,06
Academy of Sciences	1970–1991	6 loops on the continental part and 2 on the islands, in total 2208 km	±0,46	±0,04

The renovation of the Estonian vertical network is carried out in connection with extensive works with respect to reconstruction of national high-precision geodetic (GPS) network, that was started in 1996.

The national geodetic GPS network consists of 212 points (including 13 base points), the average distance between neighbouring points is ~15 km (figure 1). The network was monumented in 1996, observations were performed in 1997 and the results were presented in 1998. In the computations also the data from permanent GPS stations of neighbouring countries are used.

In order to establish an integrated geodetic network, the design of GPS network has taken into consideration the location of national levelling lines and that of points of the gravimetric remeasurement network. There are approximately 120 GPS points on the high-precision levelling lines. It enables to include a number of GPS points directly into the improved vertical network.

At the first stage of the establishment of the integrated network 23 points of national GPS network were connected with high-precision levelling lines in 1998, where the high-precision digital level DiNi 11 was used.

The first over-Estonian system of high-precision and precise levelling lines that formed 6 loops and were established in 1933–1943 will be taken as basis in renovating the EVN. It is rational to establish the Estonian levelling network as a system of loops covering the country, with 6 loops in the mainland and 2 loops in the islands (figure 2). This will result in an integrated dense levelling fundamental network and foresee the establishment of new networks in the islands of Saaremaa and Hiiumaa, where high-precision levelling was performed in 1962 and 1966 respectively.

Within the range of the Tallinn there will have to be established a new high-precision line, which is necessary for connecting the lines heading for Tallinn knot point, and for connecting the Suurupi initial benchmark (co-located with the absolute gravity and GPS Permanent Stations) and the Greater-Tallinn levelling network.

As a result of the above-mentioned the perimeters of the new high-precision levelling loops in the mainland are in the range of 270–450 km, which is in conformity with the requirements of the instruction of I, II and III order levelling. At the same time, the demarked lines are covering the territory of Estonia quite evenly. The main line of Narva–Tapa–Tallinn–Pärnu–Ikla enables us to be linked in the research programme of the Baltic Sea level (BSL).

Situation of the EVN (long levelling period, destruction of benchmarks) and participation in international study projects required co-ordinated improvement of the Estonian height network. The best variant for the renovation of the Estonian levelling network would be the establishment of the integrated geodetic fundamental network by a new repeated levelling of all levelling lines and the connection of selected high-precision GPS points together with the gravimetric survey of the South-Estonian levelling lines.

Considering the velocities of the land uplift, if possible it would be reasonable to level the whole network quickly, within 5 years at least (450–500 km per year).

During the new repeated levelling for the purpose of determining the initial level of the EVN and participating in the continuing international projects EUVN and BSL, the main tide gauge stations situating on the coast of Estonia will have to be connected properly to the high-precision levelling benchmarks.

Table 2. Levelling loops of Estonian National Vertical Network

No	Loop	Levelling lines	Length of the loop km
1	I	Tapa–Jõhvi–Mustvee–Jõgeva–Tapa	270
2	II	Tallinn–Tapa–Türi–Lelle–Rapla–Tallinn	370
3	III	Tallinn–Lelle–Pärnu–Haapsalu–Tallinn	450
4	IV	Lelle–Põltsamaa–Abja–Uulu–Pärnu–Lelle	320
5	V	Põltsamaa–Jõgeva–Tartu–Puka–Abja–Põltsamaa	310
6	VI	Tartu–Petseri–Mõniste–Valga–Puka–Tartu	340
7	VII	Saaremaa	200
8	VIII	Hiiumaa	120