DEVELOPMENT OF THE LITHUANIAN NATIONAL GEODETIC CONTROL

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Introduction

The development of the Lithuanian National Geodetic Control was main EUREF related activity in 2002. Lithuanian National GPS Network was completed this year, while activities on establishment of National Geodetic Vertical Network (NGVN) are still going on. Lithuanian NGVN is composed of two orders. National Gravimetric Network was completed in 2002.

1. National GPS Network

The Establishment of Lithuanian National GPS Network, consisting of zero, first, second and third order networks, was completed in 2003. Density of Lithuanian National GPS Network is 1 point per 5 square kilometres.

Total number of the stations in the networks:

- Zero order GPS network - 4 points,
- First order GPS network - 48 points,
- Second order GPS network - 1026 points,
- Third order GPS network - 9700 points,

Most of third order GPS network points are established in pairs for the purpose of creating the direction for conventional instruments use directly from the GPS Network.

Lithuanian Zero Order GPS Network as a part of the European reference system materialization defined by EUREF, the ETRS89 (European Reference System 1989) was observed 11 years ago during BAL'92 GPS campaign. The requested information on the Lithuanian stations is presented bellow.

- There are 4 EUREF non-permanent stations and 1 permanent station in Lithuania
- Average distance between them is 150 km.
- Lithuanian EUREF points are in coherence with the set of stations in the EUREF database.
- EUREF points are used as zero order network, for densification and implementation of ETRS89.
- Strategies for network maintenance:
    - re-observe the Lithuanian EUREF points aiming the accuracy of class B standard,
    - establish one station of European Combined Geodetic Network,
    - produce hourly observation files at the permanent station VLNS.

2. National Geodetic Vertical Network

Lithuania is going to take part in the EUVN Densification Action. 6 more sites (to the existing 3) within a EUVN Densification Action program are going to be observed.

Since 1998 most of the main activities were related to the establishment of National Geodetic Vertical Network. The NGVN should implement unified system of heights in the territory of Lithuania and guarantee reliable connection with other European height systems. The NGVN should be continuously updated for the purpose of heights and their accuracy determination. Institute of Geodesy, VGTU is involved in establishment of National Networks. The main geodetic activities of Lithuania are supervised by the Department of Geodesy and Cartography at the National Land Service under Ministry of Agriculture. Establishment of NGVN will be finished in 2006. The NGVN is composed of two orders. First order of NGVN consists of 5 polygons of precise levelling lines. Most of the lines coincide with the existing levelling lines. Precise levelling of fifth polygon was finished in 1999 (Fig. 1). Precise levelling of second polygon was completed in 2002. Length of second polygon levelling line is 517 km. 263,5 km double levelling run was performed during 2002. Perimeter of the whole network (5 polygons) is ca. 1900 km. Digital levels Leica NA 3003 and bar coded staffs Wild GPCL-3 were

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used. Bar coded staffs were calibrated at the Finnish Geodetic Institute. Average number of stations is 17 in one km of levelling line. Average line of sight was 29m, maximal - 35m. Temperature of staff invar strip and air were measured at 1 and 2 metre readings by contact thermometers. Correction of staffs calibration, temperature variations, refraction, Moon, Sun and normal corrections were introduced. Closing error of the second polygon was 14 mm.

Based on experience of Lithuanian National Vertical Network observations in 1998–1999 could be seen that, forward and backward run height differences accumulates 0,3 – 0,4 mm/km. During observations of Lithuanian Geodetic Vertical Network in 1998-1999, was cleared out that in *NA3003* operation system there is a single possible sequence of observation in the station BFFB, which does not fulfil requirements of the first order network. Double run levelling height difference discrepancies *d* are mainly positive and are accumulating. This could happen due to: angle Δi (in digital levels – *CollDif*) change, rest of error of compensator, vertical drifts of staffs and level, wrong levelling methodic. Therefore interchanging FBBF sequence in the even stations with BFFB in uneven stations was suggested and implemented. This caused the necessary manual control of height differences between forward backward levelling.

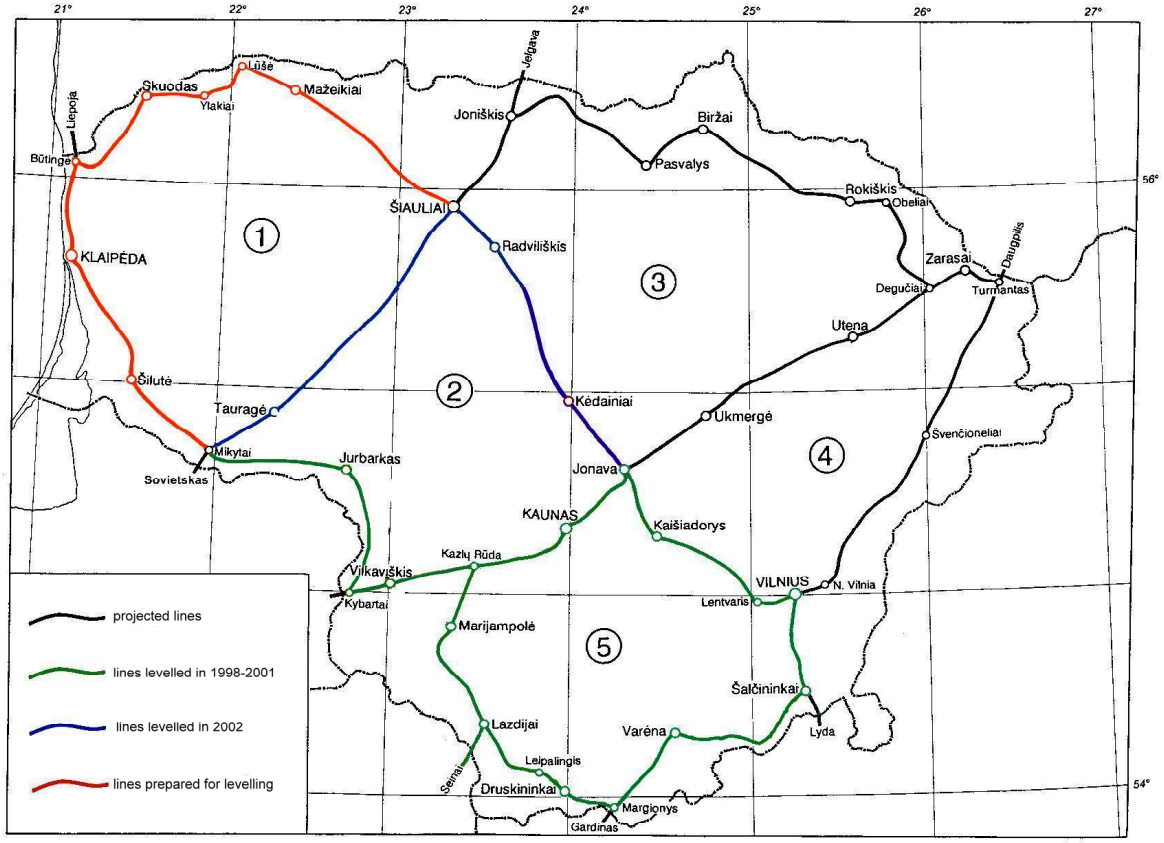

Fig. 1. First order lines of the NGVN

Results of Lithuanian geodetic vertical network levelling in 2001-2002 prove, that using suggested method double levelling run accumulation of height difference discrepancies decrease and systematic errors values are almost twice smaller.

One more improvement was suggested for a staffs. The sub-feet were fixed to staffs by two bolts. This improves the working conditions for staffman.

Every ground benchmark of the levelled polygon of the National Geodetic Vertical Network was coordinated by the GPS. Gravity values were determined from the Bouger anomaly maps.

3. National Gravimetric Network

National Lithuanian Gravimetric Network is built on three absolute gravity points measured by dr. Jaakko Mäkinen (Finnish Geodetic Institute) in 1994 and 2002. The ballistic gravimeter *JILAg-5* was used. Sites for gravimetric points were selected in calm and geologically stable locations. Points are in premises: VILNIUS -

cellar, PANEVEZYS – basement and point KLAIPEDA - ground floor. Monuments for the points are – reinforced concrete poles, 2 m in depth. There are brass marks fixed into monuments. Elevation of marks was determined by precise levelling. Differences between gravity values determined in 1994 and 2002 are presented in the table. Differences are computed at 800 mm height Δg_{800}^{02-94} and at marker height Δg_{0}^{02-94}. These are not large, and do not exceed 10,8 μGal, that is within an observation accuracy. Mean values of gravity g_0^{ν} at the markers level were used for the new adjustment of National Lithuanian Gravimetric Network. RMS error of the gravity value determined at the absolute gravimetric points is bellow 5μGal.

Mean values of gravity

Gravimetric point	Δg_{800}^{02-94} μGal	Δg_{0}^{02-94} μGal	g_0^{ν} μGal
VILNIUS	–10,8	–10,7	981459083,6
KLAIPĖDA	–4,5	–4,4	981547766,6
PANEVĖŽYS	–4,2	–4,2	981527060,0

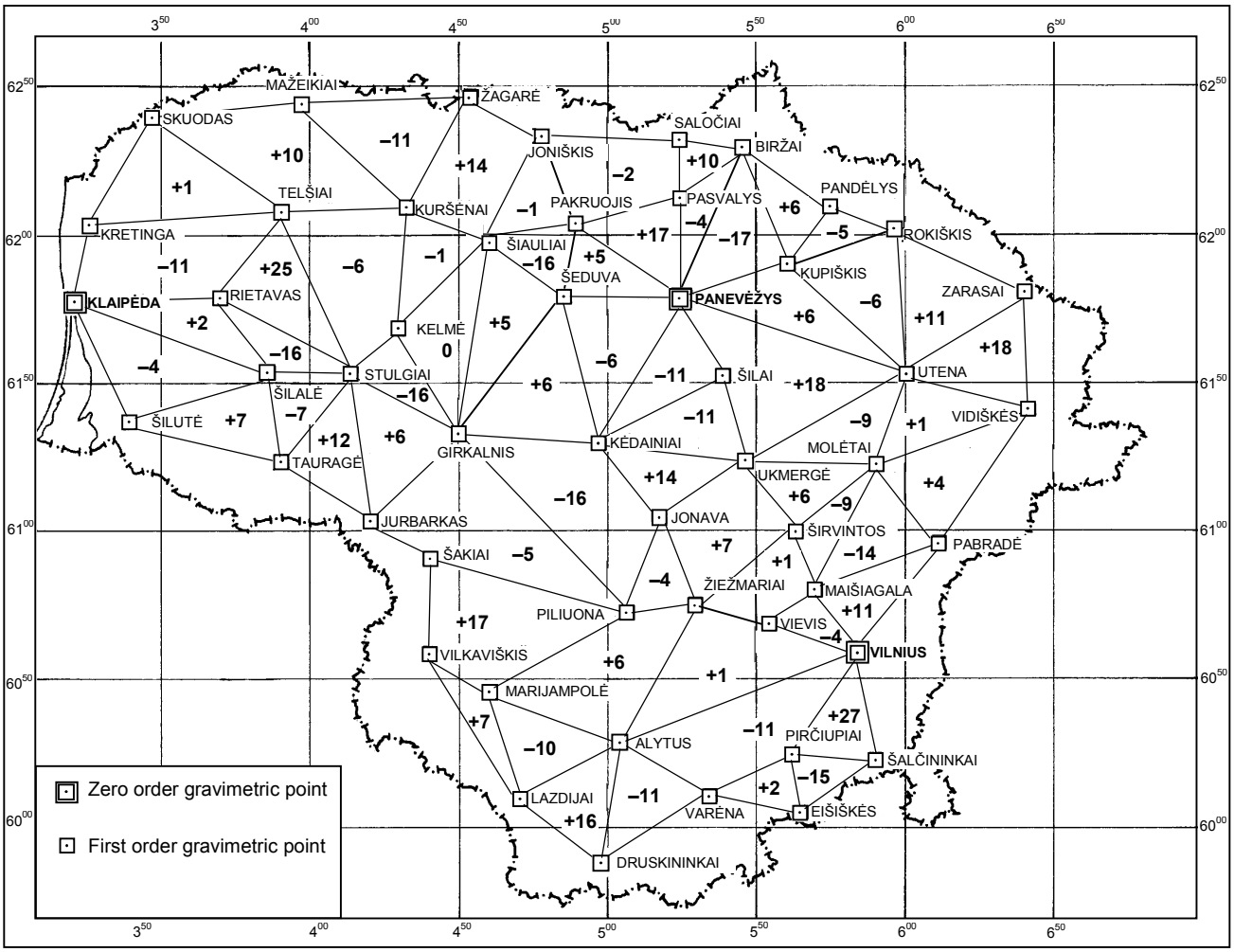

Fig. 2. Closing errors of First Order National Gravimetric Network

Satellite points have been established at the close neighbourhood of absolute gravimetric points. Gravity value at the satellite points was determined by relative observations from absolute points using *LaCoste & Romberg* gravimeters. A precise levelling and soil moisture measurement of the points is performed periodically. Ground water level is observed continuously.

Gravity observations for establishment of National Gravimetric Network were carried out during the 1998-2001. 3-6 gravimeters *La Coste & Romberg* were used for National First Order Gravimetric Network observations. 21 vector spans (19%) were observed with 6 gravimeters, 7 vector spans (6%) - with 5

gravimeters, 6 vector spans (5%) - with 4 gravimeters, 79 vector spans (70%) - with 3 gravimeters. Some observations of First Order Gravimetric Network were performed together with specialists of Polish Institute of Geodesy and Cartography.

Closing errors of First Order Gravimetric Network figures are shown in Fig 4. There is 51 gravity point in the National First Order Gravity Network of Lithuania. Corrections of calibration and corrections for Moon-Sun influence were applied. There are 62 closed figures (48 triangles and the rest quadrangles). 60% of closing errors are less than 10 μGal. Maximum closing error is 27 μGal. Closing error of the polygon of 24 outside vectors is 40 μGal. Error of vector observation computed from closing errors – 6 μGal.

Six adjustments of the network following different strategies and using different software were made. Errors of absolute gravity points were taken into consideration during the adjustment. RMS error of one observation is 14μGal. RMS error of gravity value at the First Order National Gravimetric Network in relation to absolute gravimetric points is bellow 5μGal.

National Lithuanian Gravimetric Network data have been sent to The International Gravity and Geoid Commission (IGGC) for the European Gravimetric Network UEGN2002.

Conclusions

The development of the Lithuanian National Geodetic Control is going on. Existing National GPS Network fulfils needs of geodetic community. Completed National Gravimetric Network as well as repeated absolute stations observations are essential inputs to research and solution of practical needs. The nearest task – completing the National Geodetic Vertical Network First Order – is going to be carried out for the year 2006. The new National Height System is going to be adopted even sooner. Lithuania is going to contribute to closing the precise levelling loop around the Baltic Sea within this or next year. All these activities will result to higher precision geoid determination and GPS levelling improvement as well.

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