# 609. Some issues of the National Gravimetric Network development in Lithuania

**E. Paršeliūnas, R. Obuchovski, R. Birvydienė, P. Petroškevičius, A. Zakarevičius, V. Č. Aksamitauskas, M. Rybokas**
Vilnius Gediminas Technical University, Saulėtekio al. 11, LT-10223 Vilnius, Lithuania
**e-mail:** *gi@vgtu.lt*
**Phone:** +37052744703; **Fax:** +37052744705

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**Abstract**. The gravity height systems adoption is crucial in development of national geodetic reference. Successful solution of this questions guarantees the reliable determination of geopotential heights, usage of modern geodetic space techniques, maintenance of the navigation, geodetic and cartographic works, solution of geodynamic tasks, support the relations between the similar systems of other countries, participation in the international projects.

The gravity and height systems should be related with the geocentric geodetic coordinate system. In Lithuania such a system was adopted in 1994 as a Lithuanian Coordinate System (LKS 94). It is consist with European Terrestrial Reference System 1989 (ETRS 89). With adoption of LKS 94 the normal gravity field GRS 80 was introduced. It was recommend by the International Association of Geodesy (IAG). To introduce the new gravity system instead of Potsdam system the absolute gravity measurements were carried out in 1994. Such measurements were carried out by Jaakko Makinen (Finish Geodetic Institute). Measurements were performed by ballistic gravimeter JILAg-5 in the points VILNIUS, KLAIPEDA and PANEVEZYS. Absolute gravity measurements were repeated in 2002. The 5 µGal precision of the gravity acceleration was derived.

Some issues of development of the National gravimetric network are discussed. The main stress is given to the analysis of the precision of the gravity acceleration at the points of the gravimetric network. The calibration of the gravimeters was carried out before and after field survey. The difference of the gravity acceleration of the calibration bases is 202 mGal, and two zero order and two first order points are in it. The standard deviation of the linear scale coefficients of 0.00006 was received. The maximal change of the linear scale coefficients during all time of field campaign was 0.000159 (gravimeter No 183). During the three months of period of investigations the zero drift of the gravimeters was changed from 17 till 197 µGal/day.

The National gravimetric network was adjusted using software package GRAVSOFT. Total number of observations is 33777. The three absolute gravity stations were chosen as initial points. Standard deviation of the single observation equal to 5 µGal, and standard deviation of gravity acceleration of the single points equal to 3 µGal were received.

**Keywords:** gravity system, gravity reference, normal gravity field, gravimetric network

## Introduction

The gravity and height systems adoption is crucial in development of national geodetic reference. Successful solution of this questions guarantees the reliable determination of geopotential heights, usage of modern geodetic space techniques, maintenance of the navigation, geodetic and cartographic works, solution of geodynamic tasks, support the relations between the similar systems of other countries, participation in the international projects.

Usually the normal and real gravity systems are used in Earth gravity field investigations. More often the normal gravity field is used. The equipotential ellipsoid is used for normal gravity field description. The same ellipsoid is used for defining the Earth shape. Normal gravity field much more simple than real gravity field. There are great number of normal gravity fields, which are used in the geodetic practice. The level of knowledge of the Earth gravity field and its shape determines the choice of normal gravity field.

After the Second World War the F.R.Helmert normal gravity field and Potsdam gravity acceleration system were the most popular in Europe, in Lithuania also [1]. Nowadays the International Gravity Standartization Net 1971 (IGSN71) gravity system and common Earth ellipsoid of Geodetic Reference System 1980 (GRS 80) are used [2, 3].

Therefore after the IGSN71 proved to be not a sufficient accurate basis for new gravity observations, many countries designed and observed national networks [3]. In 1994 an attempt was made by on behalf of the IGC Subcommission Western Europe to unify a number of European national networks and named UEGN94. The network covered 11 countries.

From 1998 till 2002 the project "Unification of Gravity Systems in Central and Eastern Europe" (UNIGRACE) was carried out. Works for the unification of European gravity reference networks were continued by the Unified European Gravity Reference Network 2002 (UEGN02) [3].

Since 2007 the main Lithuanian geodetic activities were related to the development of the Lithuanian National Gravimetric Network. The National Gravimetric Network should implement unified gravity system in the territory of Lithuania and guaranty reliable connection with both other European and international gravity systems [1, 4–10]. Institute of Geodesy, VGTU is involved in establishment of the National Gravimetric Network. The development of the National Gravimetric Network was finished in 2009.

## Structure of the National Gravimetric Network

The gravimetric control of Lithuania consists from the three absolute gravity points and the first order gravimetric network, consisting of 48 points, and second order gravimetric network, consisting of 636 points (Fig. 1).

To introduce the new gravity system instead of Potsdam system the absolute gravity measurements were carried out in 1994. Such measurements were carried out by Jaakko Makinen (Finish Geodetic Institute). Measurements were performed by ballistic gravimeter JILAg-5 in the points VILNIUS, KLAIPEDA and PANEVEZYS [4]. Absolute gravity measurements were repeated in 2002 [8, 10]. The 5 µGal precision of the gravity acceleration was derived. The differences between the gravity acceleration values, obtained in 1994 and 2002, are not big and fall into the limits of the accuracy of measurements (Table 1).

**Table 1**. Average values of gravity acceleration

| Gravimetric point | $\Delta g_0^{02-94}$, µGal | $g_0^{v}$, µGal |
|---|---|---|
| VILNIUS | –10,7 | 981459083,6 |
| KLAIPĖDA | –4,4 | 981547766,6 |
| PANEVĖŽYS | –4,2 | 981527060,0 |

These points form the National zero order gravimetric network - the basis of the new gravity system and further densification of the gravimetric network.

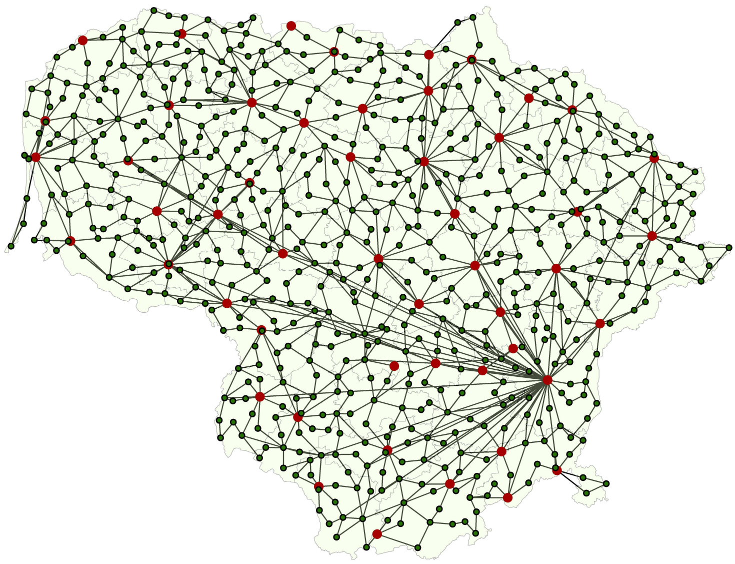

**Fig. 1.** The scheme of the gravimetric points placements (zero and first order points – in red color, second order points – in green, lines mark the measured gravity acceleration differences)

There are 51 gravimetric points in the National first order gravimetric network. Gravimetric measurements were carried out by LaCoster&Romberg gravimeters [5, 6]. Accuracy of adjusted gravity acceleration values of 4 μGal was received, and the standard deviation of the single observation of 14 μGal was derived.

The further development of the gravimetric control is based on the development of the second order network. During designing of the gravimetric network the attention was paid to roads network, to suitability of the points for gravimetric and geodetic measurements. Points were chosen on the main steps of the churches mostly

The gravimetric measurements are performed by the automatic gravimeters *Scintrex CG-5* 5 (No 182, 183, 184, 185). To clear up the abilities of these instruments and their accuracy, to improve the observational methods the research was done and analyses of gravimetric observations was performed.

## Calibration of the gravimeters

The calibration of the gravimeters was carried out before and after field survey. The difference of the gravity acceleration of the calibration bases is 202 mGal, and two zero order and two first order points are in it. Results of calibration are presented in Table 2.

**Table 2.** The calibration coefficients of the gravimeters

| Year | 182 | 183 | 1834 | 185 |
|---|---|---|---|---|
| 2007 | 1,013 470 | 0,999 524 | 1,000 386 | 0,999 914 |
| 2008 | 1,013 300 | 0,999 377 | 1,000 312 | 0,999 819 |
| 2009 | 1,013 115 | 0,999 151 | 1,000 210 | 0,999 708 |

The standard deviation of the linear scale coefficients of 0.00006 was received. The maximal change of the linear scale coefficients during all time of field campaign was 0.000159 (gravimeter No 183). During the three months of period of investigations the zero drift of the gravimeters was changed from 17 till 197 µGal/day.

## Preliminary analysis of gravimetric measurements

The measurement campaign was organized in "loops" of 8 to 12 points, and the initial and final point was the same (more often – absolute gravity station or first order point). Totally the 30 loops were performed. The performance of the each loop observations took about 10-12 hours.

Gravimeters were organized in two groups: 183 and 184; 182 and 185. It was performed 23 loops by the first pair of gravimeters, and 7 – by second. It were performed 10 cycles of observations at each point. Duration of single cycle is $55^{s}$.

The biggest external disturbances were observed at point JONAVA. The possible reason is a big factory, distance to which is only about 1 km. Its influence was observed at point ŠVEICARIJA (6 km) also, but at point GEGUŽINĖ (14 km) – not. The errors of the readings of the gravimeter No 183 are presented in the Fig 2.

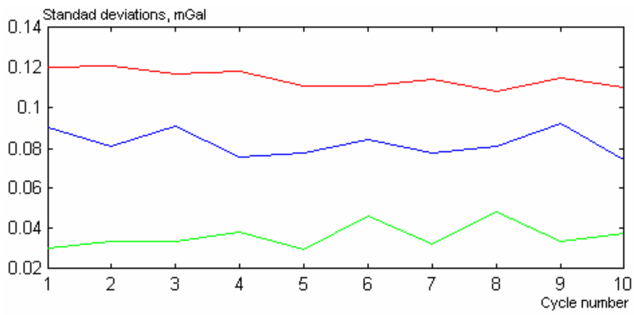


**Fig. 2.** The standard deviations of the readings of the gravimeter No 183, µGal (JONAVA – red line, ŠVEICARIJA – blue line, GEGUŽINĖ – green line)

Some preliminary analysis of gravimetric measurements was carried out after each day of measurements. For example, differences of the reduced readings of two gravimeters were calculated and plotted (Fig. 3: blue – differences of reduced readings, green – approximating line, red – predicted differences of readings).

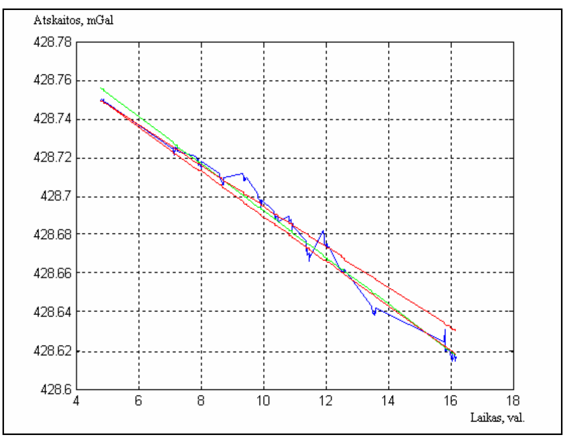


**Fig. 3.** Differences of the reduced readings (183-184, 2007.11.20)

These plots give the additional information on the stability of the gravimeters. For example, in Fig. 4 it is seen the unpredictable big differences of reduced readings, that show the great changes of the drift.

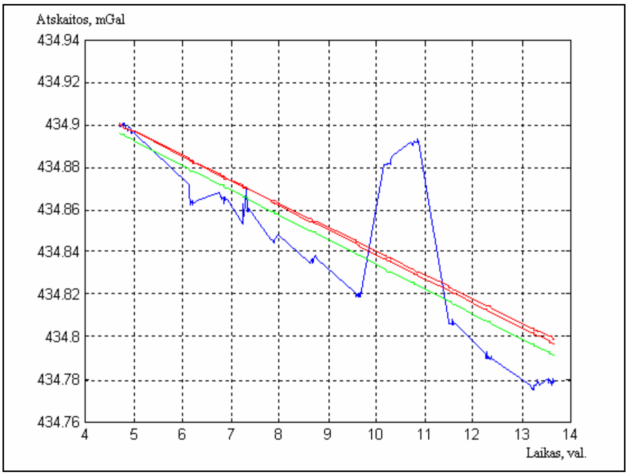


**Fig. 4.** Differences of the reduced readings (183-184, 2007.10.29)

The National gravimetric network was adjusted using software package GRAVSOFT. Total number of observations is 33777. The three absolute gravity stations were chosen as initial points. Standard deviation of the single observation equal to 5 µGal, and standard deviation of gravity acceleration of the single points equal to 3 µGal were received. The obtained corrections to the initial points: VILNIUS – –2 µGal, KLAIPEDA – +2 µGal, PANEVEZYS – 0 µGal. Differences of the gravity acceleration values of the first order gravity points at two epochs – 2001 and 2009 – are shown in the Fig. 5.

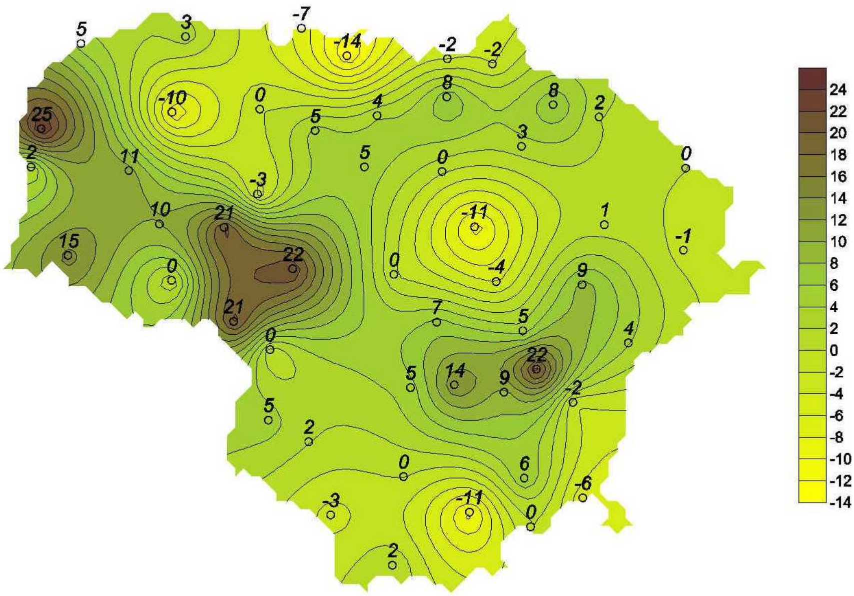


**Fig. 5.** Differences of the gravity acceleration at first order gravimetric points at two epochs (2001 and 2009). Isogals are drawn at each 2 µGal.

Differences do not exceed 15 µGal mostly. But, for example, for points MAISIAGALA and GIRKALNIS they are +22 µGal, and for point KRETINGA difference is +25 µGal. That could be explained by some local environmental changes at these points caused by renovation works of the churches itself. Therefore further investigation of the geodynamic proceses, which have caused the variations of the gravity acceleration in the territory of the country, should be carried out in the future.

## Conclusions

1. The calibration of the gravimeters was carried out before and after field survey. The difference of the gravity acceleration of the calibration bases is 202 mGal, and two zero order and two first order points are in it. The standard deviation of the linear scale coefficients of 0.00006 was received. The maximal change of the linear scale coefficients during all time of field campaign was 0.000159 (gravimeter No 183).

2. During the three months of period of investigations the zero drift of the gravimeters was changed from 17 till 197 µGal/day.

3. The National gravimetric network was adjusted using software package GRAVSOFT. Total number of observations is 33777. The three absolute gravity stations were chosen as initial points. Standard deviation of the single observation equal to 5 µGal, and standard deviation of gravity acceleration of the single points equal to 3 µGal were received.

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