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COMMON SITE CALIBRATION PARAMETER CALCULATION OF TRIMBLE VRS MEASUREMENT METHOD FOR USE IN THE TERRITORY OF LATVIA

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Key words: Site Calibration, Trimble VRS NOW TEC, GNSS transformation parameters.

Introduction

Aim of the research is to determine national wide Site Calibration parametrs for practical use of Trimble VRS Now TEC network.

Latvian geodetic coordinate system was established at 1992 by means of global positioning campaign EUREF.BAL'92. Global positioning measurements where done from 28th of August till 5th of September [1]. As a reference frame in the territory of Latvia four ground benchmarks were used. Benchmarks Rīga, Arājs, Indra and Kangari. All benchmarks previously was used as triangualation network points, except point Rīga. Point Riga was established in Botanical garden of University of Latvia. Point was established for satellite laser ranging Station Rīga still serves as a collocation station of satellite laser ranging and global navigation satellite systems. Point is also used for diferent scientific purposes. In EUREF symposium, which was held in 1993 at Budapest, the EUREF Baltic States GPS campaign were found to be at the same level of quality as EUREF-89. EUREF endorses these results as an extension of the EUREF-89 solution. Baltic state GPS campaign where none of ITRS realizations were directly connected to it. LKS-92 measurement epoch is 92.75 and four stations where defined as zero order global positioning network for Latvia. First, second and third order of state network where established and connected to zero order global positioning network by means of GNSS campaigns.

Ellipsoid of rotation to LKS-92 and GRS-80 ellipsoid of rotation. The NKG 2003 GPS campaign was carried out in week from September 28th to October 4th 2003 under the framework of the Nordic Geodetic Commission [2]. Results show problems for correct epoch transmission in ETRS89, differences between NKG 2003 and EUREF.BAL'92 are in order of three centimeters. Main topographical information for scae 1:500 must be referenced in national coordinate system LKS-92. In Latvian there are state ovned permanent global positioning base station network LatPos. LatPos provide real time kinematic and post processing data and have status of state geodetic network [3].

For site calibration parameter determination GNSS data from permanently fixed Trimble and LatPos base stations was used. GNSS data post processing, network adjustment and calculation was done in Trimble Business Center software. For all national base stations was determined ETRS89 coordinates in epoch 89.0. Coordinates for the same stations in ETRS89 epoch 92.75 was taken from official data base as Transverse Mercator projection coordinates. Till today there was no transformation parameters or national wide site calibration parameters available.

Materials and Methods

National regulations clearly define National coordinate and height system for topographical and engineering surveys. Geospatial information law clearly define LKS-92 parameters and use. Also defines national geodetic network and benchmark precision.

In the background GNSS calculations is done in global spatial reference system, but in national level LKS-92 TM plane coordinate system and LAS 2000.5 height system must be used.

Trimble VRS NOW TEC correction service is available allround the Europe utilising in ETRS89 (Epoch 89.0) fixed GNSS base stations, but national geodetic coordinate system is based on ETRS89 (Epoch 92.75) reference system [4].

Input data

For common point position determination in both reference systems 36 GNSS permanently fixed receivers from 74 to 75 hours of data is used. 11 receivers have known coordinates in ETRS89 (Epoch 89.0) reference system and is used as fixed starting points. 25 receivers from LatPos permanent base station network is defined as State Geodetic Network and have fixed coordinates in LKS-92 TM plane National coordinate system (central meridian 24° E, scale factor 0,9996, delta X axis +500 km, delta Y axis – 6000 km). Normal height in LAS 2000.5 is calculatied from ellipsoidal height using latest version of kvasigeoid model - LV14_V4.ggf (Fig. 1).

Kvasigeoid model is calculated from 4th version named LV14_V4, as previous versions consisted of several type of errors and did not meet topographical survey needs for scale 1:500. This model was calculated by Geospatial Information agency of Latvia on december 2014. Model is evaluated by 65 mm precision [5].

Point ID is made as abbrivature from 3 letters of station location site name adding letter T as prefix.

Table 1

Known coordinates and ellipsoidal height in ETRS89 (epoch 89.0)

Point ID	Latitude N	Longitude E	Ellipsoidal Height, m
TAIZ	56°36'02,03243"	25°15'40,15554"	126,629
TJGV	56°38'52,96238"	23°43'53,02102"	68,772
TPRE	56°17'27,53520"	26°43'32,74438"	165,963
TRIG	56°57'10,48412"	24°04'53,18572"	46,366
TVTP	57°23'30,61970"	21°32'56,10111"	42,209
TKUR	58°14'58,32060"	22°29'50,82156"	36,117
TKAR	58°06'08,61003"	25°33'29,35110"	136,434
TMIS	57°36'07,10977"	27°13'36,41318"	225,373
TKLP	55°42'50,83731"	21°07'38,62922"	45,725
TKDY	55°18'20,48711"	23°55'21,44158"	82,391
TVIL	54° 43'17,51605"	25°20'15,53050"	202,152

Table 2

Known LatPos base station coordinates LKS-92 TM coordinate system ETRS89 (epoch 92.75)

Point ID	X, m	Y, m	Normal Height determined using LV14_V4,ggf, m
ALUKSNE	368767,729	684444,151	218,183
BALVI	336401,489	697627,262	125,674
BAUSKA	251271,229	511487,312	47,060
DAGDA	222580,586	719741,425	202,552
DAUGAVPILS1	194384,059	657579,760	108,401
DOBELE1	277175,283	456046,668	69,542
IRBENE	381137,166	371472,548	24,960
JEKABPILS1	263838,408	614761,955	94,747
KULDIGA1	316987,931	375188,239	40,005
LIELVARDE	291847,660	550573,366	65,119
LIEPAJA1	266705,144	316436,125	21,243
LIMBAZI	374452,065	542746,164	95,912
LODE	333120,232	599645,410	207,178
MADONA	303239,934	635457,430	152,953
MAZSALACA	413259,190	562588,958	60,876
OJARS	309093,593	504631,314	21,053
PALSMANE	362909,378	631206,579	120,478
PREILI	241689,638	668648,821	138,095
REZEKNE1	269831,799	705617,363	167,263
SALDUS1	280522,715	407977,007	120,418
SIGULDA	334306,016	554012,156	113,543
TALSI	345708,168	414728,454	93,825
TUKUMS	313969,185	449024,820	72,457
VALKA	405406,156	619828,498	75,761
VALMIERA1	377920,046	584171,776	56,089

Methotology of calculation

GNSS vector post processing, network adjustment and site calibration parameters is calculated using Trimble Business Center software version 3.70.1, output date 2016.04.01 [6].

GNSS vectors are processed using data registration interval 30 seconds, elevation mask 10 degrees above horizon. All GNSS vectors have fixed solutions. GNSS vectors are processed using IGS precise orbits.

Network adjustment is done using Least square adjustment. Network consist of 91 vector (Fig. 2) [7]. In this scheme with red color there are error ellipses. Site calibration parameters is computed using calculated geodetic parameter pairs of common GNSS antenna in both reference systems [8, 9, 10]. ETRS89 (epoch 89.0) coordinates is used as geodetic coordinates in degrees minutes and seconds format, national coordinates of the same station is used LKS-92 Transversal Mercator projection coordinates and elevation determined from kvazigeoid model.

Results

As results of the calculation horizontal and vertical calibration parameters was calculated.

Translation Translation X direction is 0.005 m, Y direction 0.035 m at the origin point. Scale is calculated 0,9999999809 (Table 3).

Table 3

Horizontal calibration parameters

Translation X:	0,005 m
Translation Y:	0,035 m
Rotation:	–0°00'00"
Origion X:	313460,987 m
Origion Y:	553425,707 m
Scale:	0, 9999999809

Vertical translation is 0.040 m, slope X direction -0.124 ppm, slope Y direction – 0.079 ppm (Table 4). Origin point is computed automatically. Residual diferences show the expectabble precision of the determined parameters.

Table 4

Vertical calibration parameters

Vertical translation at origion:	0.040 m
Slope X:	–0.124 ppm
Slope Y:	–0.079 ppm
Origion X:	266705.147 m
Origion Y:	316436.124 m

Mean residual differences between GPS and knewn coordinates was calculated to evaluate calculated parameter precisions (Table 5). Residual differences is 4 mm in plane, 5 mm in height and 7 mm in 3D. Maximum residual differences is in plane 10 mm in station Kuldiga, in height 13 mm and in 3D 14 mm in station Ojars.

Table 5

Residual Differences Between GPS and Known Coordinates

	Root Mean Square residual	Point	Maximum residual
Horizontal	**0,004 m**	KUL1	0,010 m
Vertical	**0,005 m**	OJAR	0,013 m
Three-dimentional (3D)	**0,007 m**	OJAR	0,014 m

Site calibration parameter verification is done using another GNSS data sessions with the same length but from different time period in December 2016. The results of the verification calculation show almost the same parameters. Difference in vertical translation at the origin was 6 mm. Verification of the results showed that the calculated parameters is close to mean residual.

Conclusions

1. Using calculated site calibration parameters it is possible to get coordinates at 14 mm level.

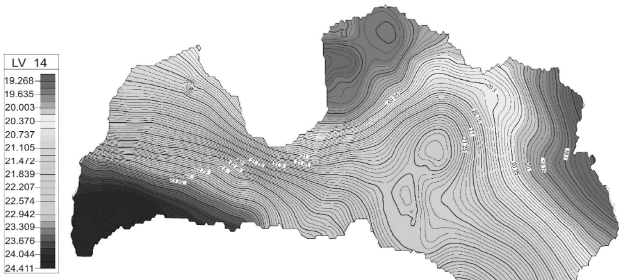

Fig. 1. Kvasigeoid model - LV14

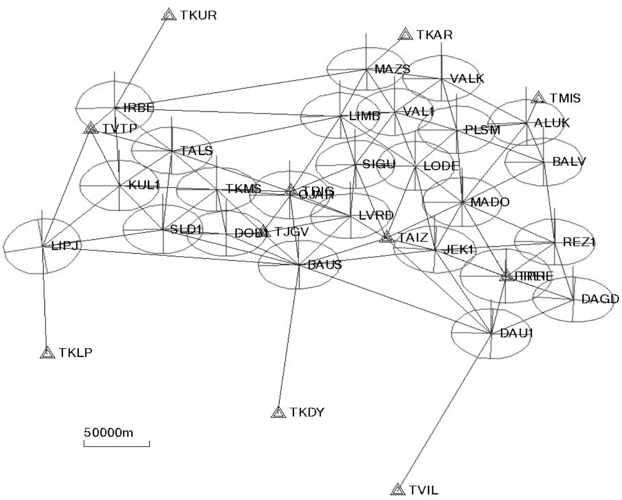

Fig. 2. Adjusted GNSS vector scheme

2. Site calibration parameters and precision fully consistent with national regulations for topographic and geodetic survey for cadastral purposes.

3. Calculated site calibration parameters can be used all over the territory of Latvia.

4. Site Calibration is the basic methodology used to ensure uniformity of measurements made by different surveyors.

5. State Geodetic network should be monitored and connection parameters should be kept up to date by governmental organisations.

6. Applied surveying must be instantly suppported by govermental organisations.

References

1. Madsen, F.; Madsen, B.1992. A new GPS network in the Baltic countries, KORT-OG MATRIKELSTYRELSEN, 1–12.
2. Lotti, J.; Kaminskis, J.; Paršeliūnas, E. 2007. Improvement and extension of ETRS89 in Latvia and Lithuania based on the NKG 2003 GPS campaign, Geodezija ir kartografija 23(1): 13–20.
3. Aleksejenko I., Kalinka M., Balodis J., Janpaule I., Kosenko K. LKS-92 coordinates transformation to ITRF2000, The 9th International Conference “Environmental engineering”.
4. Žagars J., Zvirgzds J., Kaminskis J., Globālās navigācijas satelītu sistēmas (GPS), p. 157 – 169.
5. http://map.lgia.gov.lv/index.php?lang=0&cPath=2&txt_id=130
6. http://tbchelp.trimbleinsphere.com/tutorial/, Importing GNSS data, ImportingGNSSData.zip
7. http://tbchelp.trimbleinsphere.com/tutorial/, Processing GNSS Baselines, Processing GNSSBaselines.zip
8. http://tbchelp.trimbleinsphere.com/tutorial/, Calibrating a site, CalibratingaSite.zip.
9. http://www.can-net.ca/index.php?option=com_ content &view=article&id=32&Itemid=74, Site Calibrations.
10. http://apps.trimbleaccess.com/help/en/ TrimbleAccess =2016.12, General Survey Help v2016.10.pdf.

Common site calibration parameter calculation of Trimble VRS measurement method for use in the territory of Latvia

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According to nationa law roles, Geospatial information law article 11, paragraph 4 in cross-border international projects to get results in national coordinate system LKS-92 and LAS 2000.5 height system common transformation parametrers maust be calculated. Problem is that National Geodetic network is locally fixed to ETRS89 (epoch 92.75), but have no known transformation parameters. Trimble VRS Now TEC network is fixed to the same datum, but different epoch (epoch 89.0). For practical use of Trimble VRS Now TEC coorection service in local coordinates it is necessary to connect measurements to local reference. Aim of the research was to determine common Site Calibration parameters for use in all territory of Latvia. Determined parameters was evaluated to 14 mm precision.

Розрахунок параметрів калібрування вимірювання ділянок методом Trimble VRS для використання на території Латвії

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Згідно закону про геопросторову інформацію Стаття 11, пункт 4 в транскордонних міжнародних проектах, щоб отримати результати в національній системі координат LKS-92 і системі висотLAS 2000,5 необхідно розрахувати параметри трансформації. Проблема полягає в тому, що Національна Геодезична мережа локально фіксується на ETRS89 (епоха 92,75), але не має ніяких відомих параметрів перетворення. Мета дослідження полягала у визначенні параметрів калібрування ділянки для використання їх на всій території Латвії. Параметри визначено з точністю 14 мм .

Расчет параметров калибровки измерения участков методом Trimble VRS для использования на территории Латвии

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Согласно закону о геопространственной информации Статья 11, пункт 4 в трансграничных международных проектах, чтобы получить результаты в национальной системе координат LKS-92 и системе высот LAS 2000,5 необходимо рассчитать параметры трансформации. Проблема заключается в том, что Национальная Геодезическая сеть локально фиксируется на ETRS89 (эпоха 92,75), но не имеет никаких известных параметров преобразования. Цель исследования заключалась в определении параметров калибровки участка для использования их на всей территории Латвии. Параметры определены с точностью 14 мм.