A. Vallis
Latvia University of Agriculture

ANALYSIS OF 0 ORDER POINT MEASUREMENTS IN 1992 AND 2003 OF REPUBLIC OF LATVIA

On a basis of the reference frame of the Republic of Latvia are Common Nordic Observation GPS Campaign's performed in 1992 and 2003. Measurements have been worked out to establish and control 0 class points in Latvia. In these campaign's a correlation between Europe Reference Frame and geodetic coordinate system of Latvia LKS-92 is established. It is possible to compare and estimate correlation parameters of the instruments used. It is possible to compare and analyze influences and errors affecting geodetical measurements. It is possible to calculate deaf of the continent.

In 1992 in Latvia was established four 0. order points. These four points was joined up with 1th class old triangulation points – Kangari, Indra, Arājs and Rīga. All these points was included in EUREF as C order points. For all points involved in the campaign coordinates were calculated in ETRS-89 coordinate system. Point Riga (201) was chosen as a starting point of the coordinate system LKS-92 of the Republic of Latvia. Point Riga in adjustment was chosen as fixed point using 0 level error in each component. Global positioning of the campaign was performed using two frequency Ashtech receivers. With those receivers were measured vectors from all sites in Latvia to reference points. A closest reference point to Latvia was station Metsahovi in Finland, equipped with two frequency Turbo Rouge receivers (Madsen F., 1993).

Adjustment was performed using TOPAS software. TOPAS was able to adjust data only from 10 stations in one time. In the data processing process many physical influence factors were token or were not token in to account. For a primer, starting point coordinates as a staple were taken from ASV Defense Mapping Agency estimated almanacs. Influence of the ionosphere influence on the measurements could be calculated and modeled, and residuals of the ionosphere errors consider as zero level (Leick A., 1990).

Interpretation of the measurements are divided in four steps:

- Capturing of the measurement,
- Editing of the measurement,

- Gathering of the measurement,
- Processing of the measurement.

Results of data processing were adjusted using FILLNET software.

Table 1

GPS data flow of EUREF BAL 92 in Latvia

Station Name	Date							
	28.aug.	29.aug.	30.aug.	31.aug.	1.sep.	2.sep.	3.sep.	4.sep.
RIGA	**	****	****	****	****	****	****	****
KANGARI		****	****	****	****	****	****	****
INDRA		****	****	****				
ARAJSs					**	****	****	****

** Data latency approximately 2 hours.

GPS observations for the Common Nordic Observation Campaign were carried out from September 28th to October 4th, 2003. Stations from Denmark, Estonia, Finland, Greenland, Iceland, Latvia, Lithuania, Norway and Sweden – finally 133 stations took part in the Campaign. Most of the GPS sites are permanent (Ronnest H., 2003).

Table 2

EUREF BAL92 estimated station coordinates in ITRF92 of Republic of Latvia

Station Name	Country	EUREF Number	X	Y	Z	EUREF Class
ARAJS	Latvia	410	3277266.905	1309685.707	5295146.639	C
INDRA	Latvia	407	3177704.065	1662050.336	5257079.607	C
KANGARI	Latvia	406	3078175.304	1608797.664	5331767.522	C
RIGA (RI00)	Latvia	201	3183914.346	1421473.506	5322796.698	C

In Latvia in total were observed 6 stations: two permanent stations –RIGA (EPN GPS station), IRBE (Permanent GPS station involved in EUVN 97 campaign) and four non-permanent stations ARAJ, INDR, KANG, RI00 (0 order points of the national geodetic network of Latvia).

Table 3

Current station characteristic

Station	Antenna	Receiver	H	Cable
ARAJS	TRM33429.00+GP	TRIMBLE 4700	1.5561	Trimble Standart 3m
INDRA	TRM33429.00+GP	TRIMBLE 4700	1.5759	Trimble Standart 3m
IRBENE	ASH700936D_M	TRIMBLE 4000SSE	5.1115	Nonstandart
KANGARI	TRM33429.00+GP	TRIMBLE 4700	1.4089	Trimble Standart 3m
RI00	TRM22020.00+GP	TRIMBLE 4000SSE	1.3633	Nonstandart
RIGA	ASH700936D_M	ROUGE SNR-8000	0.0850	Nonstandart

Due to some inconsistence in the data occurrences of disagreements between sitelog and RINEX have been verified in co-operation with the national representatives.

The average numbers of epochs between cycle slips are visualized. Stations INDRA and KANGARI are located in very good environmental conditions (Fig. 1).

Table 4

Data quality and availability

Station Name	GPS Days						
	271	272	273	274	275	276	277
ARAJS	89	87	89	90	89	89	89
INDRA	97	95	99	99	97	97	97
IRBENE	-	91	93	-	94	94	94
KANGARI	97	94	98	98	97	97	97
RI00	83	80	79	80	81	81	81
RIGA (EPN)	87	85	88	89	90	90	90

Multipath can be used to visualize RMS- values, to get an idea of the data quality. Multipath in L1 and L2 are expressed in Fig. 1 and 2.

A complete list of all Multipath values in L1 and L2 has been made afterwards and visualized in the table 5.

Table 5

Multipath values in L1 and L2

Station Name	GPS Days													
	271		272		273		274		275		276		277	
ARAJS	0.46	0.55	0.46	0.52	0.46	0.53	0.45	0.57	0.45	0.54	0.43	0.55	0.45	0.58
INDRA	0.26	0.28	0.26	0.27	0.26	0.27	0.26	0.28	0.26	0.27	0.26	0.28	0.26	0.28
IRBENE	-	-	0.14	1.10	0.18	1.31	-	-	0.16	1.28	0.17	1.31	0.16	1.33
RI00	0.72	1.32	0.73	1.26	0.24	1.37	0.22	1.37	0.24	1.29	0.23	1.31	0.26	1.32
RIGA (EPN)	0.42	1.20	0.42	1.29	0.43	1.29	0.42	1.15	0.43	1.24	0.43	1.30	0.42	1.18

Latvia

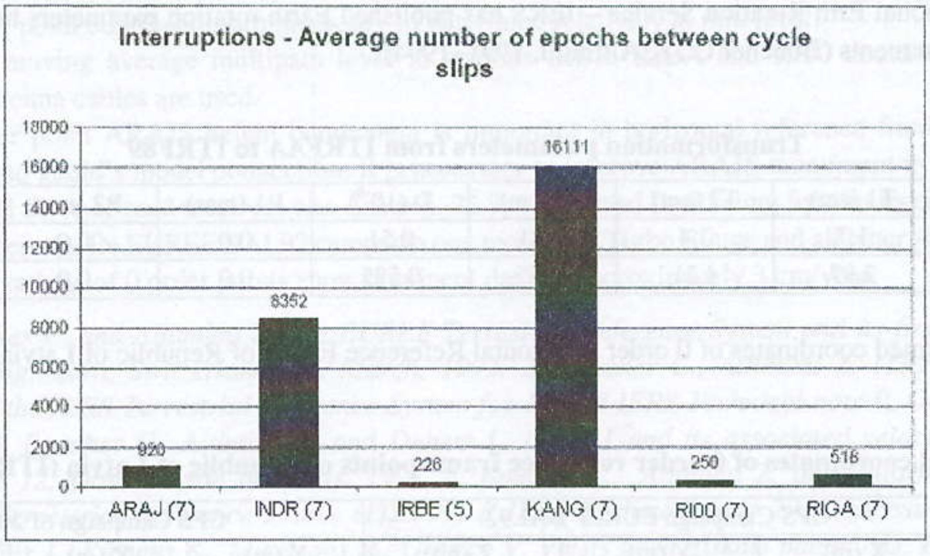

Fig. 1. The average numbers of epochs between cycle slips

In EUREF BAL92 was observed four 0. order points: RIGA (M 1884), ARAJS, INDRA, KANGARI and coordinates were calculated on epoch of 1992, but in GPS campaign of 2003 coordinates were calculated on epoch of 2000. To perform an objective analysis it is necessary to transform these coordinates to one common epoch ITRF 89 using transformation parameters in table 4 and equation 3 (Boucher C., Z. Altimini, 1991–1994).

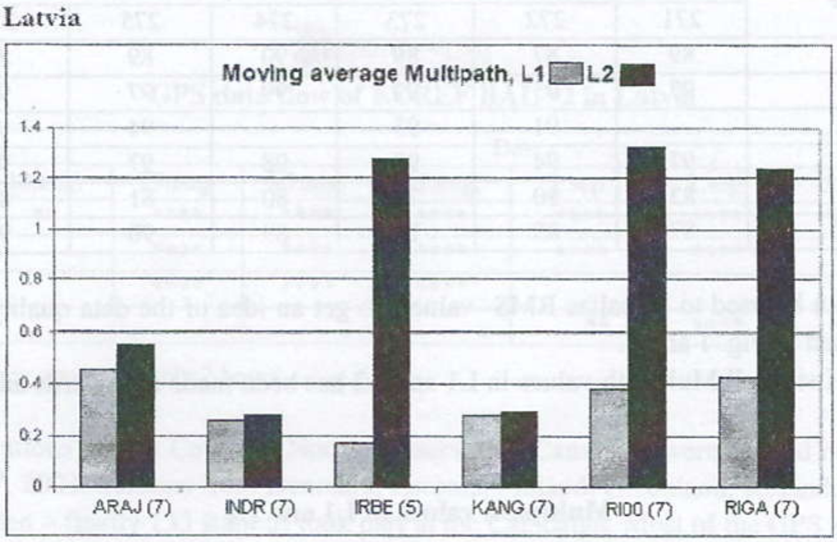

Fig. 2. The average numbers of epochs between cycle slips

$$\begin{bmatrix} X_{89} \\ Y_{89} \\ Z_{89} \end{bmatrix} = \begin{bmatrix} X_{AA} \\ Y_{AA} \\ Z_{AA} \end{bmatrix} + \begin{bmatrix} T1_{AA,89} \\ T2_{AA,89} \\ T3_{AA,89} \end{bmatrix} + \begin{bmatrix} D_{AA,89} & -R3_{AA,89} & R2_{AA,89} \\ R3_{AA,89} & D_{AA,89} & -R1_{AA,89} \\ -R2_{AA,89} & R1_{AA,89} & D_{AA,89} \end{bmatrix} \bullet \begin{bmatrix} X_{AA} \\ Y_{AA} \\ Z_{AA} \end{bmatrix} \quad (3)$$

where X_{89}, Y_{89}, Z_{89} – ITRF89 coordinates; X_{AA}, Y_{AA}, Z_{AA} – coordinates on epoch AA; $T1_{AA,89}$, $T2_{AA,89}$, $T3_{AA,89}$ – translations on X, Y, un Z axis from epoch AA to epoch 89; $R1_{AA,89}$, $R2_{AA,89}$, $R3_{AA,89}$ – rotations allround X, Y and Z axis from epoch AA to epoch 89; $D_{AA,89}$ – scale coefficient from epoch AA to epoch 89.

International Erth Rotation Service – IERS has published Earth rotation parameters between epochs of GPS measurements (Boucher C., Z. Altimini, 1991–1994).

Table 6

Transformation parameters from ITRF*AA* to ITRF89

Epoch	T1 (cm)	T2 (cm)	T3 (cm)	D (10^{-8})	R1 (mas)	R2 (mas)	R3 (mas)
ITRF92	1.7	3.4	-6.0	0.51	0.0	0.0	0.0
ITRF2000	2.97	4.21	-8.65	0.585	0.0	0.0	0.0

Transformed coordinates of 0 order Horizontal Reference Frame of Republic of Latvia are expressed in tab. 7.

Table 7

Transformed coordinates of 0 order reference frame points of Republic of Latvia (ITRF89 Epoch)

Point Name	GPS Campaign EUREF BAL92			GPS Campaign of 2003		
	X (m)	Y (m)	Z (m)	X (m)	Y (m)	Z (m)
ARAJS	3277266.905	1309685.707	5295146.639	3277266.632	1309685.878	5295146.687
INDRA	3177704.065*	1662050.336*	5257079.607*	3177703.566	1662050.167	5257080.299
KANGARI	3078175.304	1608797.664	5331767.522	3078175.020	1608797.820	5331767.591
RIGA	3183914.346	1421473.506	5322796.698	3183914.095	1421473.701	5322796.796

* Antenna was fixed on the directive monument of the point INDRA.

It is important, that measurements in point INDRA in 1992 was centered on different monument then in 2003. Measurements in point INDRA was excluded from calculations.

Using point shift it is possible to establish shift of the tectonic plate of Eurasia, which goes to North-east. Shift azimuth of points: RĪGA (M 1884) is 47°18', ARĀJS is 45°57', KANGARI is 42°05'.

Shift and speed of the shift of 0 order reference frame points of Republic of Latvia is shown in tab. 8 and 9.

Table 8

Shift of the 0 order reference frame points of Republic of Latvia

Point Name	Shift component		
	d X (m)	d Y (m)	D Z (m)
ARAJS	-0.273	0.171	0.048
KANGARI	-0.284	0.156	0.069
RIGA	-0.251	0.195	0.098

Table 9

Speed of the shift of the 0 order reference frame points of Republic of Latvia

Point Name	Shift component		
	V X (m/y)	V Y (m/y)	V Z (m/y)
ARAJS	-0.025	0.016	0.004
KANGARI	-0.026	0.014	0.006
RIGA	-0.023	0.018	0.009

Conclusions. 1. Stations RIGA and RI00 are located in bad environmental conditions – trees, buildings, traffic affects GPS measurements.

2. Reference frame of Republic of Latvia in 14 years of independency is tightly connected to Europe Reference Frame using GPS technologies.

3. 0 order point coordinates are necessary to determine relatively at mm level.

4. High moving average multipath level in stations IRBE, RIGA and RI00 could occur because nonstandard antenna cables are used.

5. 0 order point ARAJS height component is important in horizontal reference frames if they are used in DTM and geoid's model connection. It is necessary to improve ARAJS monument in the future.

6. In 2003 51 % of used receivers was Ashtech, 22 % was Jawad Positioning System receivers and 20 % was Trimble receivers. IN EUREF BAL92 campaign one receiver is Turbo Rouge and all other Ashtech.

7. Observations of 0 order points show continent deaf of approximately 3 cm/year.

1. Boucher C. and Altamimi Z. The EUREF Terrestrial Reference System and its first realizations, EUREF Meeting, Bern, Switzerland 4–6 March, 1992. 2. Boucher C., Altimimi Z. ITRF90 and other realizations of the IERS Terrestrial Reference System for 1990 // IERS Technical note 9, Observatorie de Paris, 1991. 3. Boucher C., Altimimi Z. and Duhem L. ITRF91 and its associated velocity field, IERS Technical note 12, Observatorie de Paris, 1993. 4. Boucher C., Altimimi Z. and Sillard P. The 1997 International Terrestrial Reference Frame (ITRF97) // IERS Technical note 27, Observatorie de Paris, 1999. 5. Lazdāns J., Kūkums K., Miķelsons R., Gremze V. Valsts ģeodēziskais pamattīkls. LR VZD, Rīga, 1994. 6. Leick. A. GPS satellite surveying:Satelite surveying / Inc. – USA, New York Chichester Brisbane Toronto Singapoure: John Wiley and Sons, 1990. – 352 p. 7. Madsen F., A new GPS-network in the Baltic countries, National Survey and Cadastre – Denmark, 1993. 8. Ronnest H., Data validation report. Common Nordic Observation Campaign GPS week 1238 – 2003. Denmark. (Acrobat reader document).

Recenzował: Dr inż. Władysław Mierzwa, AGH