Implementation of New Positioning System in Riga

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Abstract

The ground based satellite tracking system has been developed at the Institute of Geodesy and Geoinformation (GGI), University of Latvia in cooperation with a Riga municipality surveying company named Rigas GeoMetrs SIA. The system consists of a satellite laser ranging system (SLR) and of a *EUPOS®-RIGA* GNSS RTK five reference station network developed in cooperation by both GGI and Rigas GeoMetrs SIA.

Introduction

Both the Institute of Geodesy and Geoinformation of the University of Latvia (GGI) and Rigas GeoMetrs SIA are active partners in European Position Determination System *EUPOS®* from the very beginning of this consortium [1]. Using standards of *EUPOS®* a subnet *EUPOS®-RIGA* has been developed by Rigas GeoMetrs SIA with cooperation GGI. It is an aim to use *EUPOS®-RIGA* for multipurpose application in positioning and navigation.

Satellite laser ranging system (SLR) for Low Earth Orbiters (LEO) has been developed by the Institute of Geodesy and Geoinformation. Rigas GeoMetrs SIA assisted in this development. With a financial support of Rigas GeoMetrs SIA was constructed the site for SLR.

Currently both systems together will be used for research in satellite geodesy for LEO satellite position determination in GGI. The future aim of improved quasi geoid model will be used by both partners.

Satellite Laser Ranging System

The SLR has been placed on the roof of 150 years old University building's capital wall (Figure 1, 2, 4). The site is at the distance of about 3.5 km far from the Satellite tracking station of the Institute of Astronomy and at the distance of 22 m from the central base station of RTK network *EUPOS®-RIGA* (Figure 3).

The SLR hardware is designed in GGI by integrating advanced industrially produced components. There is an alt/alt original small size telescope mount, EKSPLA PL2241 diode pumped 532 nm and 17 mJ energy laser with a 50 Hz frequency repetition rate and a 35 psec pulse length. GPS steered time service applied of the Quartzlock (UK) produced quartz clock. Hamamatsu PMT used. The experience gained by the SLR personnel in Riga has been applied to develop the control software and electronics.

A032-ET event timer has been applied for high accuracy achievements in satellite laser ranging. Event Timer A032-ET, made by Institute of Electronics and Computer Science (Riga, Latvia). Institute of Electronics and Computer Science (IECS) is non-profit research institution dealing with various directions of R&D activity [2]. Substantial knowledge and well-developed engineering know-how is applied to development and design of high-performance timing systems and devices with emphasis made on applications related to Satellite Laser Ranging (SLR).

Table. 1. A032-ET event timer comparison with similar devices (by courtesy of Y.Artyuk)

Manufacturer	Model	Resol. [Ps]	Jitter [Ps]	Linearity [Ps]	Stability [Ps/K]	Stability [Ps/hour]	Max. rep. rate [Hz]	Max. TOF
PESO	PET4/TIGO	1.2	3.5	3	<0.3	<0.5	>100	N/A
EOS	MRCS V.4	2	10	1	N/A	1	1000	N/A
HTSI	MLRO	0.5	<2	N/A	N/A	0.5	2000	N/A
IECS	A032-ET	1	7-9	<1	<0.5	N/A	10,000	1.5 hr

During last 30 years about ten models of Riga timing systems (total about 35 units) have been developed, made and delivered for SLR applications [2].
SLR is placed on the roof of 150 years old 5 storey University building. The joint system of both the GNSS network and SLR will be applied for LEO satellite positioning. The results could be used for geoid improvement, occultation studies (GOCE, GRACE, Terra-SAR) etc...

Fig. 1. SLR for LEO satellites

Fig. 2. SLR mount transportation

Fig. 3. Base station Centre (LU)

Fig. 4. SLR control centre

The final fint adjustment of a very complicated optical system currently is carried out and control satellite tracking tests are performed. There are three prisms located on the roof in three different directions for the SLR calibration. The calibration results with rms of about 10 mm seem quite normal (Figure 5).

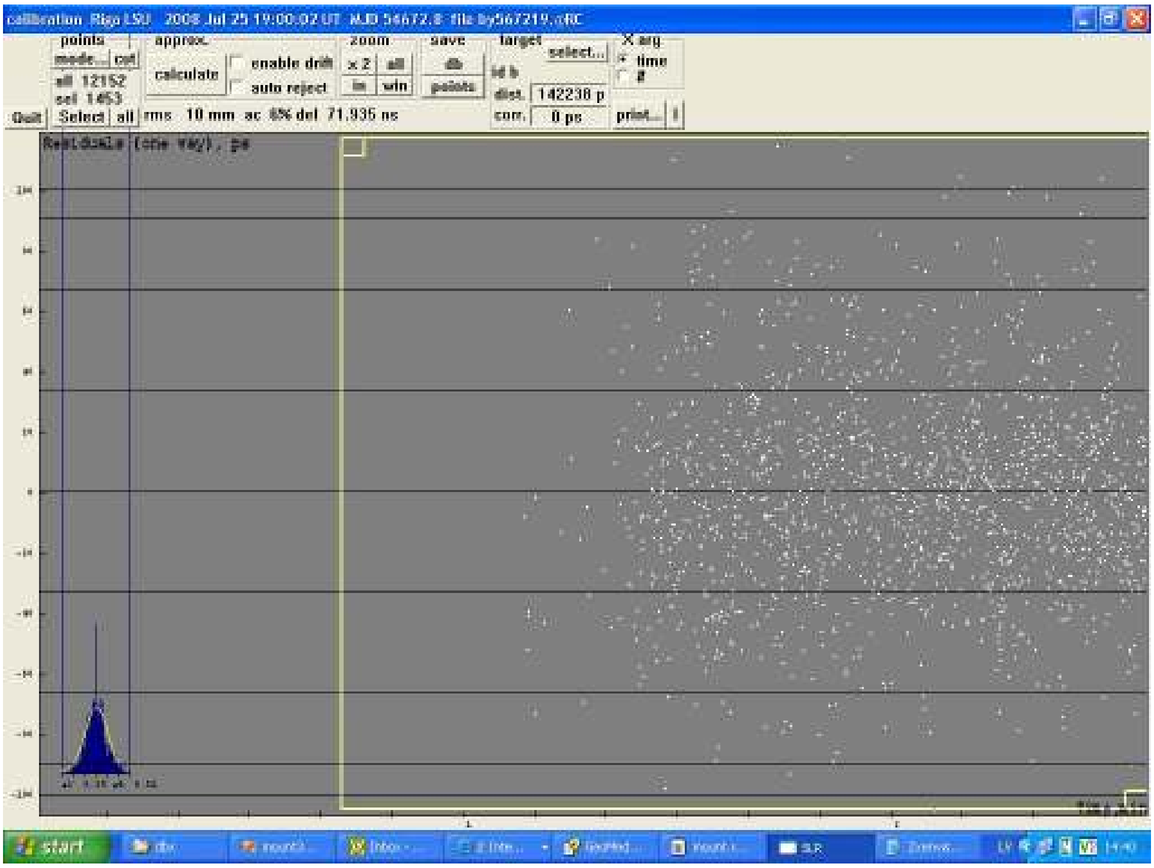

Fig. 5. SLR calibration results - rms 10 mm,autocorrelation of residuals 6%, estimated delay 72 nsec

GNSS RTK Network *EUPOS®-RIGA*

Ground based augmentation system *EUPOS®-RIGA* has been developed by Riga municipality surveying company SIA Rigas ĢeoMetrs as a multipurpose RTK network. Currently the *EUPOS®-RIGA* RTCM corrections for GPS and GLONASS satellites have been used mostly by land surveyors. The JAVAD receivers with chock ring antennas have been used in base stations which are connected to server by individual optical cables. The signals received at the analyses centre with latency of about 2-3 msec. The Geo++ software **[3]** has been used for the network solution and RTCM correction computation. Antennas for base stations are calibrated in Geo++, Garbsen, Germany. The field surveying with RTK static method in 90% of coordinate determination gives precision 1-2 cm in 5 seconds (Figure 19). The distances between the base stations ranges from 6.5 till 12 km (Figure 6). The monumentation of antennas is rather light using metal tubes fixed on the roof of University (Figure 3) and on the apartment houses (Figures 7 – 10).

EUPOS®-RIGA network behavior analyses

There the *EUPOS®-RIGA* network behavior was analyzed. The diurnal behavior was calculated using the International GNSS Service (IGS) GPS base station Riga 1084 which is located 3.5 km West from *EUPOS®-RIGA* Central station (LU). The coordinates of *EUPOS®-RIGA* stations were calculated for each hour using GNSMART software.

The analyses results are depicted in Figure 11 for Central base station and in Figures 15-18 for other stations. There are hourly discrepancies of X, Y, Z Cartesian coordinates in each of 24 hours. It is seen that the coordinate changes during 24 hours are less than 0.1 mm (Figure 11) for Centre (LU) and between 0.1-2mm with some higher peaks for other base stations (Figures 15 – 18). Gridlines in Figure 11 0.02 mm each, in Figure 15, 17 and 18 – each 1 mm, in Figure 16 – each 2 mm.

The monthly behavior in January 2008 is shown in Figures 12-14. There are all the 5 base stations together, where in Figure 12 Northing component, in Figure 13 – Easting component and in Figure 14 the Up component. Gridlines 0.5 mm for plane coordinates and 1.0 mm for Up coordinate.

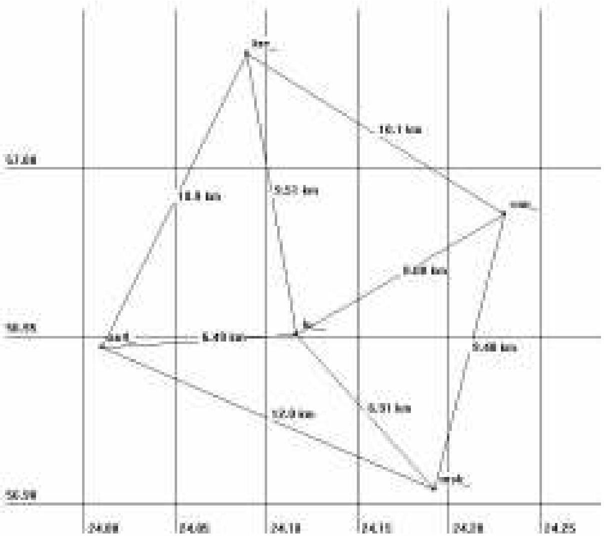

Fig. 6.. EUPOS®-RIGA base station network

Fig. 7.Base station North (Kre)

Fig. 8. Base station East (Van)

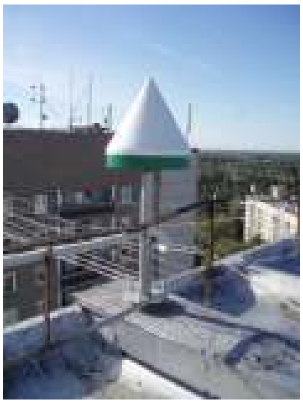

Fig. 9. Base station South (Msk)

Fig. 10. Base station West (Ann)

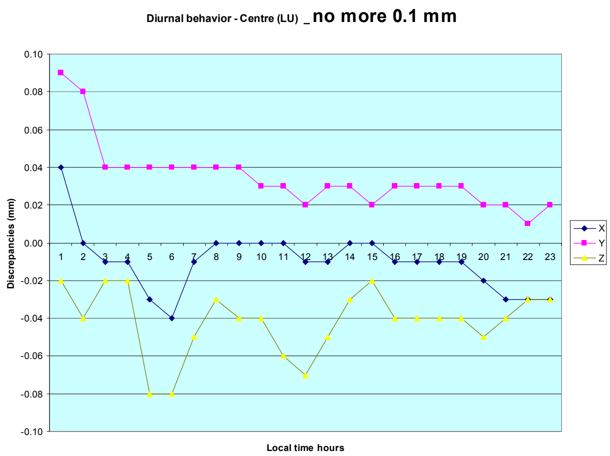

Fig. 11. Diurnal behaviour of station Centre

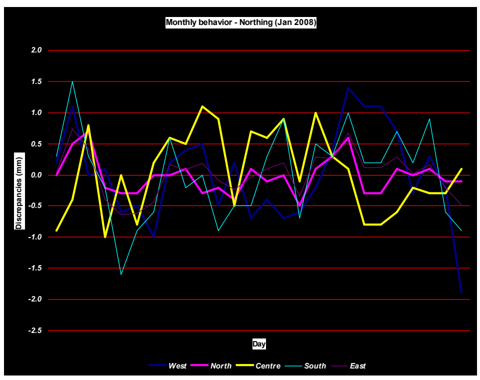

Fig.12. Monthly behaviour (Northing)

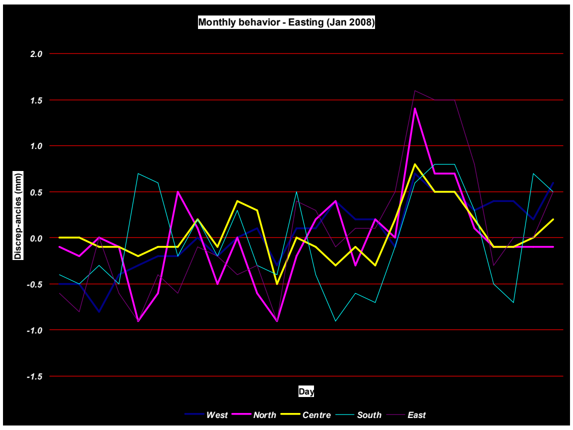

Fig. 13. Monthly behaviour (Easting)

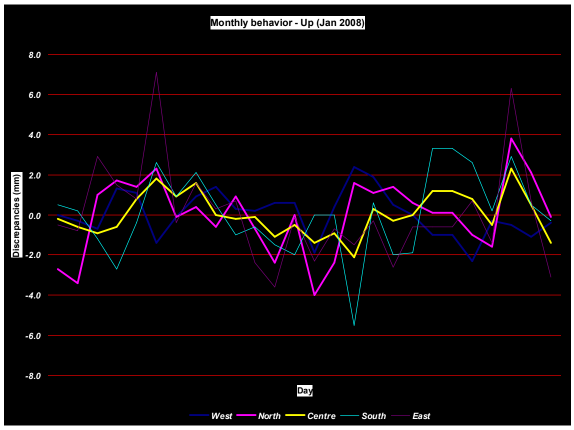

Fig. 14. Monthly behaviour (Up)

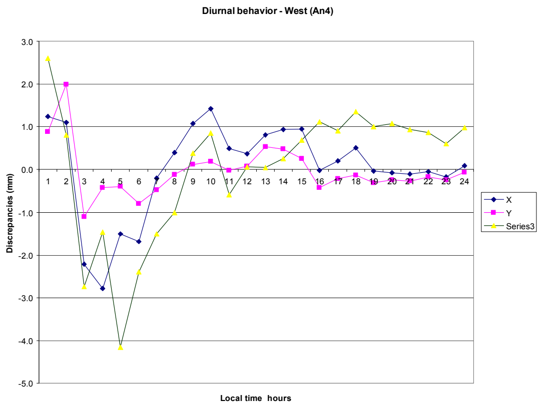

Fig. 15. Diurnal behaviour North (Kre)

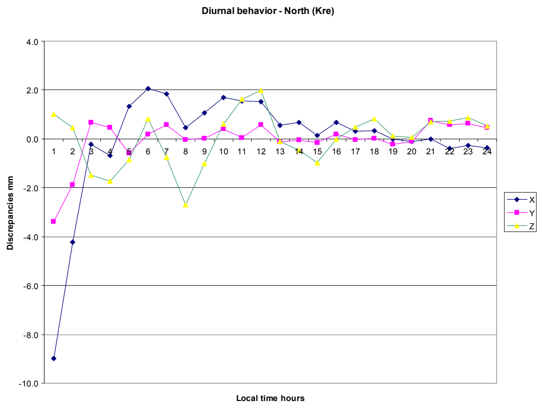

Fig. 16. Diurnal behaviour East (Van)

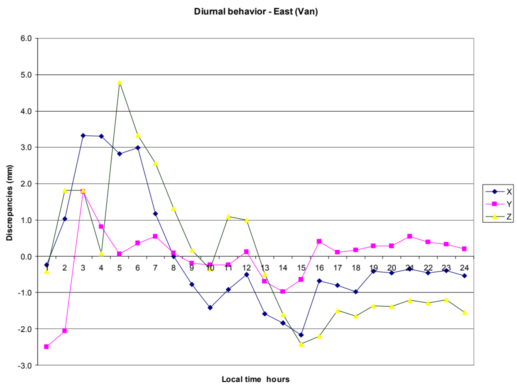

Fig. 17. Diurnal behaviour South (Msk)

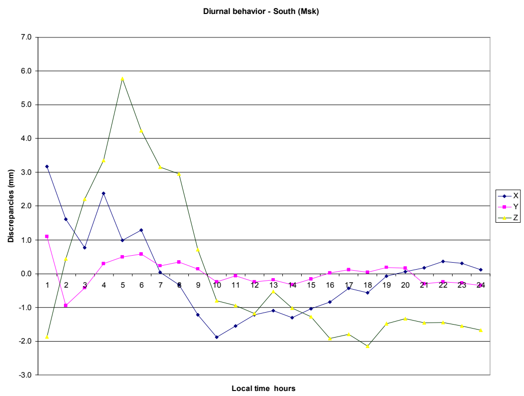

Fig. 18. Diurnal behaviour West (Ann)

Conclusion

The SLR will be used for LEO satellite observations. However, the ILRS request is to have additionally Lageos observations as a reference. It will take some time to improve the SLR for this capability.

Joint application of SLR and *EUPOS®-RIGA* observations will be used for GOCE satellite position determination on the passes over Riga.

The weather conditions, of course, are rather disadvantaged for SLR application in Riga. For examle, in year 2007/2008 the sky was completely cloudy starting from October 2007 till April 2008.
The continuously operating GNSS base station network doesn't depend from weather conditions. Five station positioning solution is more reliable than single one.

The *EUPOS®-RIGA* positioning system will be applied for both the research work and for practical applications in land surveying and transport navigation.

The *EUPOS®-RIGA* field tests carried out in land surveying approves that within 90% of 5-15 second static surveying sessions applying *EUPOS®-RIGA* network solution RTCM corrections gives rover measurement accuracy not exceeding 2 cm in plane (Figure 19) [4]. In Figure 19 there is the accuracy in cm on the horizontal axes and percentage on the vertical one.

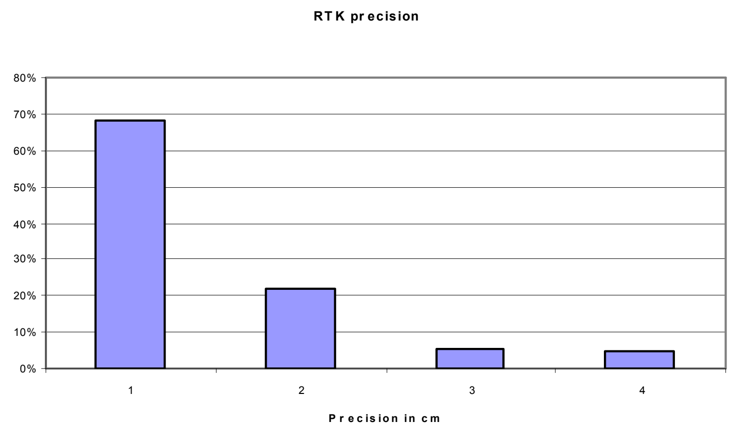

Fig. 19. GNSS rover field measuring accuracy.

Acknowledgement

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