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ANALYSIS OF THE REAL TIME MEASUREMENT PRESITION IN RIGA

REĀLĀ LAIKA MĒRĪJUMU PRECIZITĀTES ANALĪZE RĪGĀ

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Introduction

The European Position Determination System *EUPOS®* has achieved coverage in outstanding area of about 25331 million km^2 in Eastern Europe, 17 million km^2 in Russian Federation and 0,6 million km^2 in Ukraine [1,2]. Total number of GNSS permanent reference stations exceeds 900. LATPOS with 19 stations [3] and EUPOS-RIGA with 5 stations are among the *EUPOS®* stations mentioned above. G.Silabriedis and others in paper [4] have described a project of ortophoto map quality control which was carried out in Riga recently. In current article we are describing the continuation of the project [4] with a more detailed analyses of the applied real time kinematics (RTK) surveying.

DGNSS static survey for map quality control

. The control points were carefully selected which has been without doubt identified on the orthophotos with a sharp contours and easy to identify at the field. The coordinates of selected control points were determined on the digital ortophoto map and static DGNSS field survey was performed in order to control the quality. The surveying were carried out by using Topcon HiPer+ with L1,L2 frequencies and R8 GNSS TRIMBLE receiver with L1,L2, L2C and L5 frequencies and with a TSC2 TRIMBLE survey control

Figure 1. Field survey in RTK and static mode correspondingly..

. The observations were performed at the 344 sites in 7-10 minute sessions in static mode and with a following postprocessing by using Pinacle software. Let us denote the set of these points by P (post processing). As base stations for calculations were used just 3 surrounding EUPOS-Riga base stations (from total 5 EUPOS-RIGAbase stations). The distance from the control point to any of 3 base stations doesn't exceed 10 km. The field survey performance seen in following Figure 1.

The coordinates were calculated. The static surveying average RMS 0.8 cm in plane position and 1.02 cm in vertical position.
The ortophoto map discrepancy vectors were computed for each site and the distribution of model's size d were analysed. Mean value appears 15.9 cm and standard deviation 8.1 cm, median 15.0cm (Figure 2).

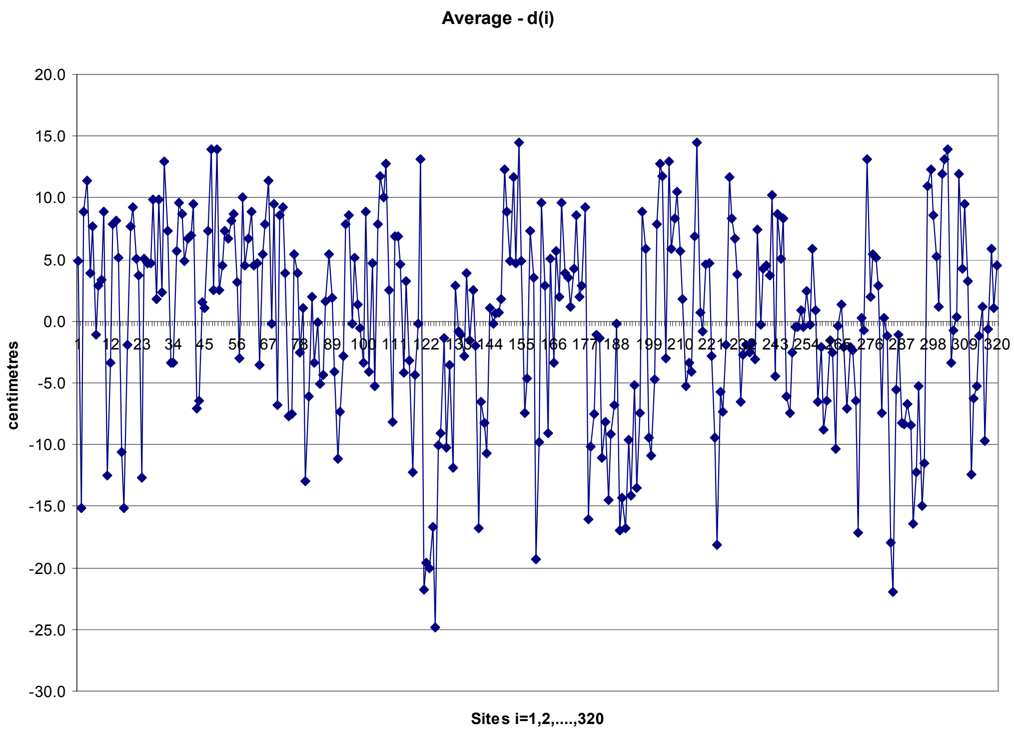


Figure 2. Distribution of dicrepancies (average -d_i).

- The azimuth of discrepancy vectors were analysed by counting them with stepwise values of 30˚, i.e.0-30, 30*60, etc. This if Figure 3. The distribution of modul's size were compared with Gausian normal distribution (Figure 4).

$$f(x,\mu,\sigma) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right),$$

where x is the value for which you want the distribution, μ is the arithmetic mean of the distribution, σ is the standard deviation of the distribution. T-test for normal distribution of map discrepancies control gives estimate 0.952

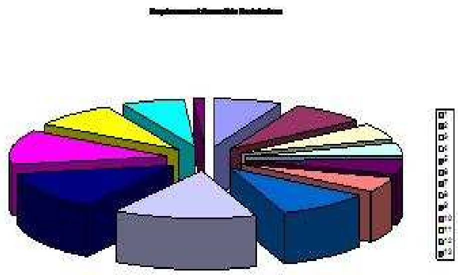


Figure 3. Azimuth distribution.

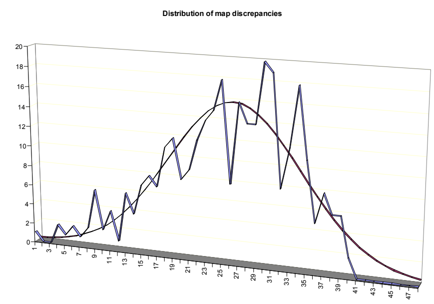
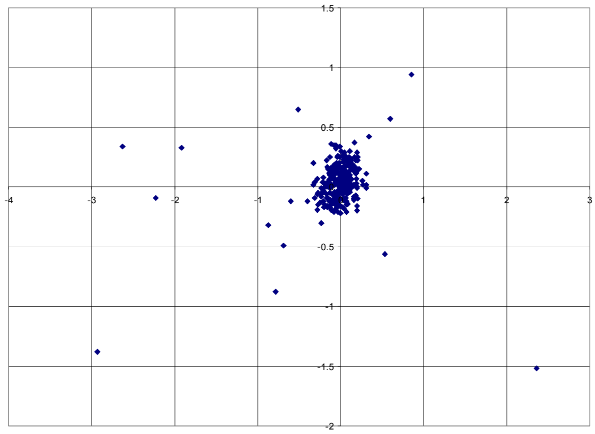


Figure 4.Dicrepancies vector module distribution (outliers omitted).

Static survey control and RTK survey precision test

In order to check the eventual multypath there were made repeated measurements at the 166 sites in RTK mode with network solution of all 5 EUPOS-RIGA base stations. The RTCM corrections were obtained via GSM GPRS. Results were achieved in very short time - in 5 – 10 seconds. The set of results of RTK sessions is denoted by R.

In Figure 5 the precision of ortophoto map is represented according the GNSS static survey results at the sites of set P (including outliers). In Figure 6 the RTK survey precision represented by comparing the RTK survey results (set R) with static survey results (set P). 70% of RTK survey results within the precision of ± 1 cm, 90% of precision ± 2 cm in plane.



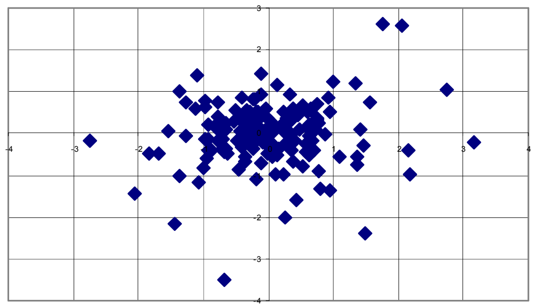
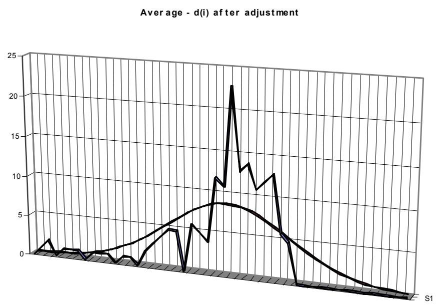


Figure 5. Map discrepancies. Gridlines each 1m.

Figure 6. RTK precision. Gridlines each 1 cm.

The discrepancies of set R toward set P were computed for each site.The distribution of differences between the results are shown in the Figures 6 and 7. Average values of coordinate differences are 0,0 and 0,1 cm for North and East coordinates correspondingly and standard deviations are 0,9 and 0,5 cm correspondingly. Normal distribution curve was designed and the site difference distribution repriduced in Figure 6. The jeast square method (LSE) was applied to adjust the RTK results and the residuals for each point were used to compute the difeerences with results of set P. The difference distribution reproduced in Figure 7. One can see that the improvements is minimal. Horizontal axes gridlines 1 mm in both Figure 6 and Figure 7.



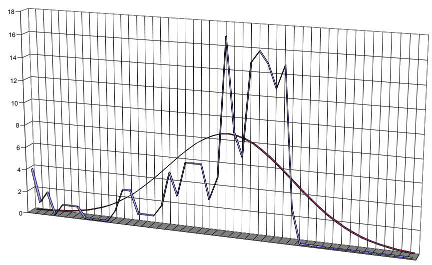


Figure 6. Distribution of the RTK survey duscrepancies.

Figure 7. Distribution of the adjusted RTK discrepancy values

Column diagram in Figure 8 depit the comparison of site position precision after and before LSE adjustment applied. Each gridline corresponds 10% for vertical axe. First columns represents precision of 0 to 1 cm, second from 1 to 2 cm, e.t.c.

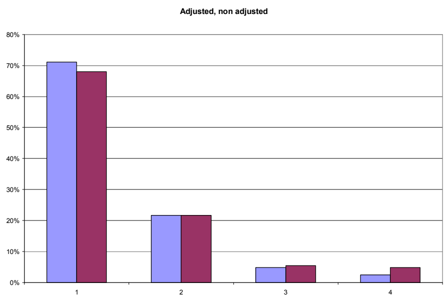


Figure 8. Percantage of precision results.

Conclusion

EUPOS-RIGA permanent DGNSS station network is a subset of European Position Determination System *EUPOS*® which covers very large area of Europe.

The primary aim of DGNSS static survey was to perform a quality control of recently produced ortophoto map in Riga city area.

DGNSS static survey was performed in 366 sites within the EUPOS-RIGA reference network. After omitting the outliers the outliers of the positions of ortophoto map 344 survey results were analysed. The session length 7-10 minutes in each site.

The static surveying average RMS 0.8 cm in plane position and 1.02 cm in vertical position.

Map discrepancies Mean value detected 15.9 cm and standard deviation 8.1 cm, median 15.0cm

In order to check the eventual multypath the RTK survey were performed in 166 sites previously measured in static mode.

Network solution of all 5 EUPOS-RIGA base stations were applied. The RTCM corrections were obtained via GSM GPRS.

Results were achieved in very short field work time - in 5 – 10 seconds.

RTK survey precision in comparison with static survey 0.9 cm, standard deviation 0.8 cm.

Real time RTK surveying precision in plane in EUPOS-RIGA environment is 2 cm for 90 % occasions.

The results precision analyses of both the ortophoto map and the RTK survey represented in Figure 9.

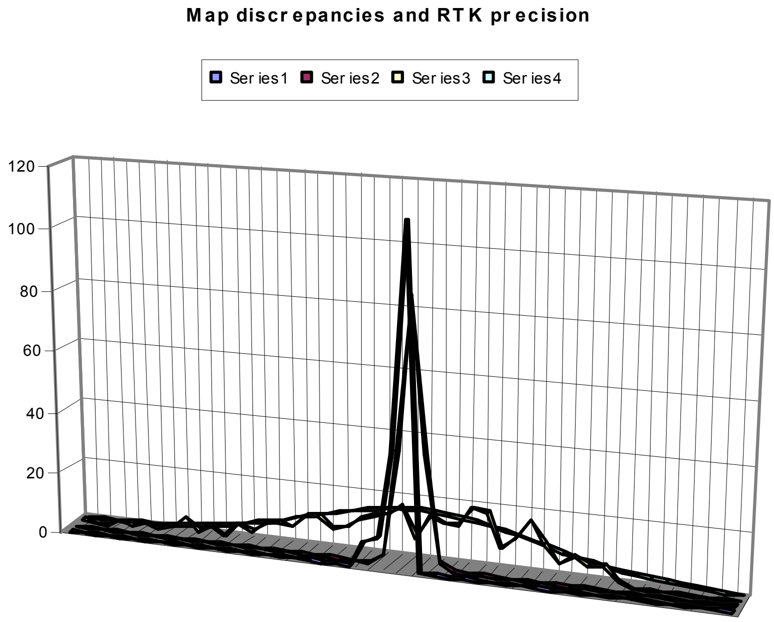


Figure 9. Ortophoto map precision distribution (lower curves) and RTK survey precision distribution (upper curves). Horizontal axe gridlines 1 cm each, vertical axe gridlines – frequency of precision values in performed experiment.

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Balodis.J., Plotņikovs S., Silabriedis.G. Reālā laika mērījumu precizitātes analīze Rīgā. *EUPOS-RĪGA ir pastāvīgās darbības DGNSS staciju tīkls. Tas ir Eiropas pozīciju noteikšanas sistēmas EU-POS® apakškopa. EUPOS® pārklāj ļoti plašu Eiropas daļu. Sākotnējais mērķis bija pārbaudīt ar DGNSS statisko mērījumu palīdzību nesen izgatavotās Rīgas teritorijas ortofoto kartes kvalitāti. Lietojot EUPOS-RĪGA atbalsta tīklu, 366 vietās tika veikti DGNSS statiskie mērījumi. Izslēdzot no tālākiem pētījumiem kartes rupji kļūdainās vietas, tika atlasīti analīzei 344 punkti. Statisko mērījumu sesijas katrā vietā ilga 7-10 minūtes. Mērījumu vidējā kvadratiskā kļūda izrādījās 0,8 cm plaknē un 1.02 cm augstumam. Kartes kļūdu vidējā vērtība izrādījās 15,9 cm ar standarta variāciju 8,1 cm, mediāna 15,0 cm. Lai pārbaudītu iespējamo daudzkārtējo atstarojumu iespējamo ietekmi, 166 vietās tika veikti atkārtoti mērījumi ar citu metodi – ar reālā laika mērījumu metodi (RTK). Tīklveida risinājumam tika izmantotas visas 5 EUPOS-RĪGA bāzes stacijas, RTCM korekcijas tika saņemtas, lietojot GSM tīkla GPRS režīmu. RTK režīmā rezultāti tika iegūti 5-10 sekunžu laikā ar precizitāti 0,9 cm un standarta variāciju 0,8 cm salīdzinājumā ar statiskās metodes rezultātiem. 90% gadījumos precizitāte bija 2 cm robežās.*

Balodis J., .Plotnikovs S., Silabriedis G. Analysis of the real time measurement presition in Riga. *EUPOS-RIGA permanent DGNSS station network is a subset of European Position Determination System EUPOS® which covers very large area of Europe.*
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RTK survey precision in comparison with static survey 0.9 cm, standard deviation 0.8 cm. Real time RTK surveying precision in plane in EUPOS-RIGA environment is 2 cm for 90 % occasions.

Balodis.J., Plotņikovs S., Silabriedis.G. Анализ точности измерений в реальном времени в Риге. *EUPOS-RIGA это сеть станций постоянного действия ДГНСС – составная часть Эвропейской системы позионного определения EUPOS® покрывающую значительную часть континента. Первичная задача была с помощью статических измерений ДГНСС проверить качество недавно созданной ортофотокарты города Риги. Используя опорную сеть EUPOS-RIGA в 366 точках проведены статические измерения ДГНСС. С целью исключения из дальнейших исследований мест грубейших ошибок на карте для анализа отобраны 344 точки. Продолжительность сессий статических измерений в каждой точке 7-10 минут. Средняя квадратическая ошибка на плоскости была 0, 8 см, а по высоте 1, 02 см. Среднее значение ошибок на карте 15, 9 см со стандатным отклонением 8, 1 см, мэдиана – 15, 0 см. Для проверки возможного влияния многократного отражения, в 166 точках были сделаны повторные измерения другим методом – методом реального времени РТК. В исследовании использовались все пять базисные станции EUPOS-RIGA. В режиме РТК получены результаты и течении 5-10 секунд с точностью 0, 9 см и стандартным отклонением 0, 8 см при сравнении с результатамы статического метода. В 90% случаев точность была в пределах 2 см.*