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Position Determination of Control Network Points in the Smart Station Technology using ASG-EUPOS System

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Abstract. Paper covers experiment results concerning usefulness of Leica Smartstation® for detailed horizontal and verical surveying. The experimental work was carried out in the university campus Kortowo during the modernization of ASG-EUPOS permanent station (especially in the north-eastern territory of Poland, in June 2011). The analysis was performed to check the performance of this system for setting the control network points in this area. Each control point coordinates were determined using RTK real time service called NAWGEO (VRS, MAC and POJ). Obtained coordinates were compared to the results of static surveys (taken as the reference coordinates) in the system PUWG "2000" and Kronsztadt'86. Analyzed coordinate differences confirmed the characteristic accuracy of the RTK GNSS techniques. Reported accuracy of measured control points in most cases are in line with GUGiK recommendations.

Keywords: ASG-EUPOS system, control network points, Smart Station technology

1 Introduction

In the paper, experiment results concerning usefulness of Leica Smartstation® set for detailed horizontal and vertical surveying are presented. The experimental work was carried out in urban and wooded areas (in the university campus Kortowo) on 21-22 June 2011, during the modernization of permanent reference stations belonging to the ASG-EUPOS system (News, 2011). The coordinates

of the analyzed control network points were determined using RTK Real-time service NAWGEO (VRS, MAC and POJ). Obtained coordinates were compared to the results of static surveys (taken as the reference coordinates) in the system PUWG "2000" and Kronsztadt'86.

2 Objective and research methodology

The aim of the study is to analyze the feasibility of geodetic detailed measurements using the SmartStation technology. In our experiment we tested the usefulness of Leica Viva series-15 equipment for control network points position determination (Chwaliński, 2011). Measurements were performed using the patches from the NAWGEO ASG-EUPOS service. ASG-EUPOS is one of the systems streaming GNSS data over Internet. It was developed as a part of Project EUPOS - European Position Determination System (Milev *et al.*, 2004) and is a new multifunctional system of precise satellite positioning in Poland (Bosy, 2008). It makes GNSS corrections and raw observations collected at 116 reference stations accessible to the users, what provides precise real time positioning, post-processing and supports navigation in the whole area of Poland. This new system, which is based on reference stations network including EUREF-POL, POLREF and EUVN points, accomplishes ETRF89 reference system (Graszka, 2007). One of the most accurate real time positioning services provided by ASG-EUPOS is NAWGEO service, which is RTK VRS network solution. It enables streaming of RTCM corrections for applications requiring a high level of accuracy by using the latest mobile communication technologies such as GPRS or UMTS in any area covered by a cell-phone network (Uradziński *et al.*, 2008). Location of the position of the measuring SmartStation® set, thus the coordinates of the network control points, was determined three times by four sets of solutions: MAC and VRS and using a single reference stations: LAMA and OLST. Each time the position of the measured points was determined from a thirty 1-second measurement epochs (Recommendations, 2011), using GPS RTK on-the-fly initialization (Bakuła *et al.*, 2008). 10 control network points were measured, which were

located in areas with limited visibility and close to the objects that may cause multipath effect (Chwaliński, 2011). All control network points were settled in the ground using metal pins named "control point" (with a length of 75 mm) and all measured points obtained their own names indicating their location in the area of Kortowo (Doskocz and Uradziński, 2011): point No.1 APTEKA - located close to the academic pharmacy, point No.2 BIBL - located close to the Academic Library, point No.3 CHDOL - located in the lower part of the Faculty of Humanities Center square, point No.4 CKONF - located by Conference Center, point No.5 DS_3- located in front of the student's house No. 3, point No.6 DZIEKANAT - located close to the main building of Faculty of Geodesy and Land Managment, point No.7 GORAGORKA2 - located in the upper part of the path leading to the Academic Church, point No.8 PKOSA - located close to the PKO S.A. Bank, point No.9 PRZEDSZKOLE - located at the main Kortowo entrance, close to the Urban Kindergarten No.40 in Olsztyn, point No.10 ZOOTECHNIKA - located close to the main building of the Faculty of Animal Bioengineering. All the experimental points were determined using RTK real time service called NAWGEO (VRS, MAC and POJ). Obtained coordinates were compared to results of static measurements (adopted as reference coordinates in the system PUWG "2000" and Kronsztadt'86) determined by Uradziński and Doskocz (2010). Recording session time (static occupation) lasted about one hour with interval set to 5 seconds and 10-degree elevation mask. In this experiment Topcon HyperPro GPS/GLONASS receivers were used. All static measurements were conducted in time, when tree canopies were not yet covered by the leaves. For post-processing purposes reference data was obtained from nearby OLST permanent station using ASG-EUPOS POZGEO D service (ASG-EUPOS, 2008). Designated vectors were adjusted in Topcon Tools software with respect to OLST reference point. The RMS errors did not exceed 10 milimeters (with 95% confidence level) in horizontal and vertical components (Table 1).

All designated control network points coordinates were averaged and the RTK results (MAC, VRS, LAMA, OLST) were compared to GNSS static survey results. Obtained coordinate differences were

Table 1. *Accuracy of GNSS vector determination by static occupation*

Vector	RMS (X,Y) [m]	RMS (H) [m]
APTEKA-OLST	0.002	0.002
BIBL-OLST	0.002	0.003
CHDOL-OLST	0.004	0.007
CKONF-OLST	0.002	0.003
DS3-OLST	0.004	0.006
DZIEKANAT-OLST	0.002	0.005
GORAGORKA2-OLST	0.004	0.007
PKOSA-OLST	0.002	0.003
PRZEDSZKOLE-OLST	0.002	0.003
ZOOTECHNIKA-OLST	0.001	0.002

assessed by criteria in Section 5 of Head Office of Geodesy and Cartography (GUGiK) recommendations from 2011 (Recommendations, 2011).

The following graphs, which was performed in Excel® (part of Microsoft Office software), show the position differences (Fig. 1-4) distinguishing the designated horizontal component

$$\mathrm{d}L = \sqrt{\mathrm{d}X^2 + \mathrm{d}Y^2}$$

and vertical component ($\mathrm{d}H$).

3 Analysis of results

The obtained results of the measurements indicate an accuracy in control network points position determination, where the three nearest reference stations (ELBL, GIZY, OLST) could not be included in RTK solution (due to hardware limitations). At stations ELBL, GIZY, OLST, it was only possible to obtain RTK patches for single station, which was confirmed by measurements carried out with OLST station (Fig. 4). When examining the measurement results as control measurements in the RTK solution, should be noted that the position in the plane (X, Y) was set correctly - dL differences did not exceed 0.06 m, while the differences in height dH exceeding or

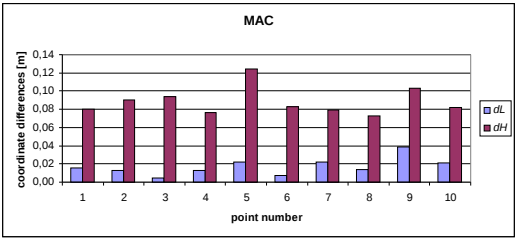

Figure 1. *Position differences of control network points determined using MAC service*

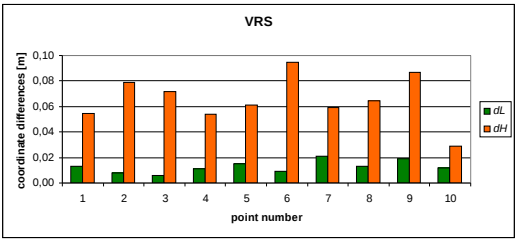

Figure 2. *Position differences of control network points determined using VRS service*

close to 0.09 m were not observed only in the case of measurements obtained from OLST reference station.

4 Conclusions

Considering the situation of control network points position determination, the experiment carried out generally met the recommended technical requirements: the number of satellites used in eight observational sessions (among 120 conducted sessions) did not fall below 6, the parameter PDOP generally did not exceed the size of 3 and horizontal component of the designated positions only in a few cases showed differences $dL > 0.02$ m.

Control network points position determination, according to paragraph 18.9 GUGiK recommendations (Recommendations, 2011), should be implemented by RTK receiver with an option of network corrections or corrections obtained from single reference station away not more than 5 km. In the conducted experiment, this crite-

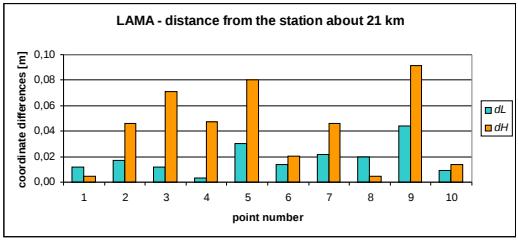

Figure 3. *Position differences of control network points determined using LAMA reference station*

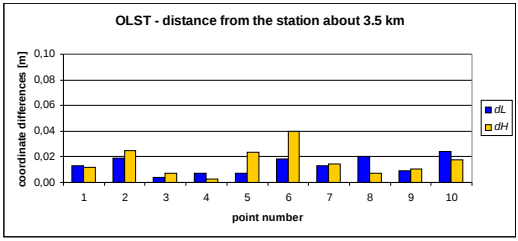

Figure 4. *Position differences of control network points determined using OLST reference station*

rion was fulfilled only by a solution obtained from a single reference station OLST (Fig. 4).

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