THE GPS AND TERRESTRIAL DATA PROCESSING IN THE CONTROL NETWORK "DOBROMIERZ"

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Abstract

This paper enclosed results of precise GPS and terrestrial measurements in deformation control network „Dobromierz“, which have been presented and compared. Achieved results were analysed in purpose of accuracy of common adjustment for measured by the both techniques data, as well as defining their usefullness for deformation detection in this network.

Key words

GPS, Total Station, control network, short GPS baselines processing.

1 INTRODUCTION

The "Dobromierz" network was established for geodynamic investigations in close surroundings of the Sudetic Marginal Fault (SMF). Network consists six sites of the network connected to geodynamic GPS profile (three sites) perpendicular to the SMF (see Fig. 1) [1]. Observations have been made there from 2001 to 2005 in frame of the COST 625 Action "3D Monitoring of Active Tectonic Structures" according to control-measurement system [1],[2]. Since 2006 measurements have been taken in the same configuration and financed by the Polish Science Fund grant for the years 2005 - 2008. Twice a year the following surveys are made: simultaneous (in the short period of time) GPS static and terrestrial - (angle and length) (September – October), and after the half-year period only the terrestrial one (April). Precise common GPS vector and terrestrial data processing in the same geodetic datum is important because of deformation detection purpose.. Geodetic calculation software "GEONET" (by the Prof. Roman Kadaj) was used [3]. Because of expected 0.5 – 2.0 mm/year changes in the network, accuracy of adjusted results should be below predicted change values. Taking under consideraton long measurement period (September 2001 – October 2006) and the number of campaigns (11), results equal in accuracy to the changes will be acceptable because of possibility to forecast change trend.

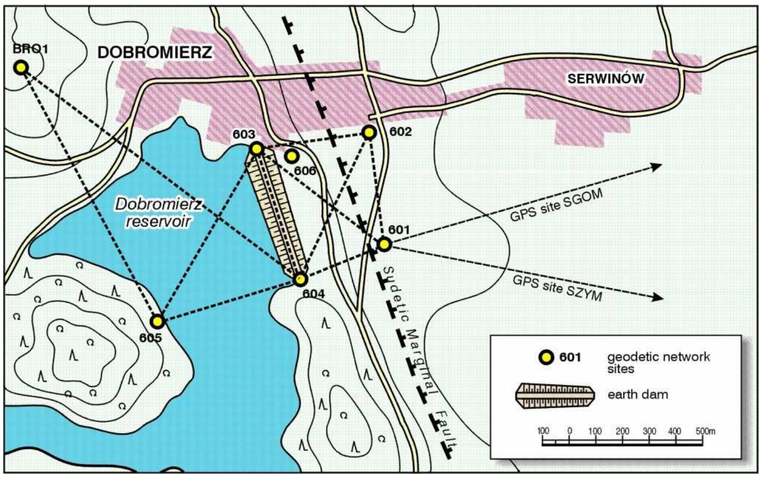

Fig. 1 The “Dobromierz” network

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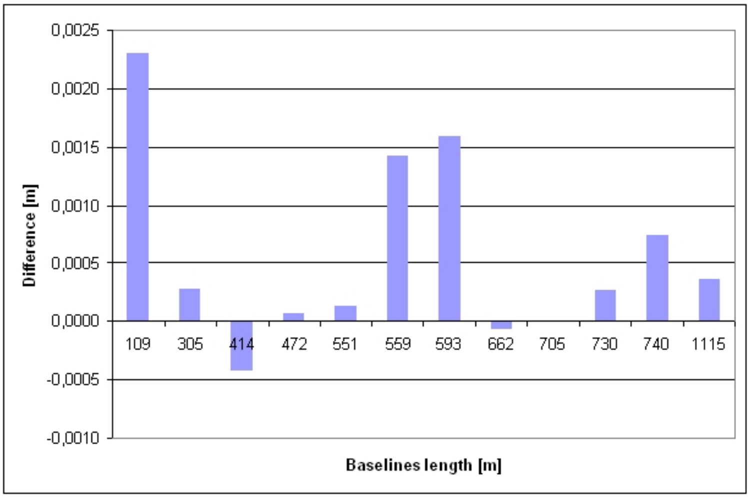
2 TERRESTRIAL MEASUREMENTS

Angle-line measurements are performed with the precise Total Station - Leica TCA2003 which standard errors are given as: the line error (1 + 1 ppm) [mm] and the angle one 1.5 [cc]. Also the Leica GPR1 Professional prisms (additive constant = 0) were used. All geometric network elements (available by the topography) are measured in three full series each site. Forced centering on concrete pillars is used also in whole network. Measuring each angle-length elements atmospheric corrections are introduced by average of temperature, pressure and humidity for the beginning and end of line. The reduced values are being recorded.

Comparing last spatial length measurements (Graph 1) in both opposite directions the 0.0 do 2.3 [mm] discrepancies were achieved.



Graph. 1 Discrepancies in repeated spatial length measurement taken in opposite directions

3 GPS MEASUREMENTS AND DATA PROCESSING

The GPS static campaigns are performed in the 10 hour sessions on all nine sites of the „Dobromierz“ network and geodynamic profile. During the 2001-2005 period daily session each year occured, while in 2006 the two10-hour sessions were organised in following two days. Equipment used (antennas) since 2001 was not homogeneous because of logistic conditions.

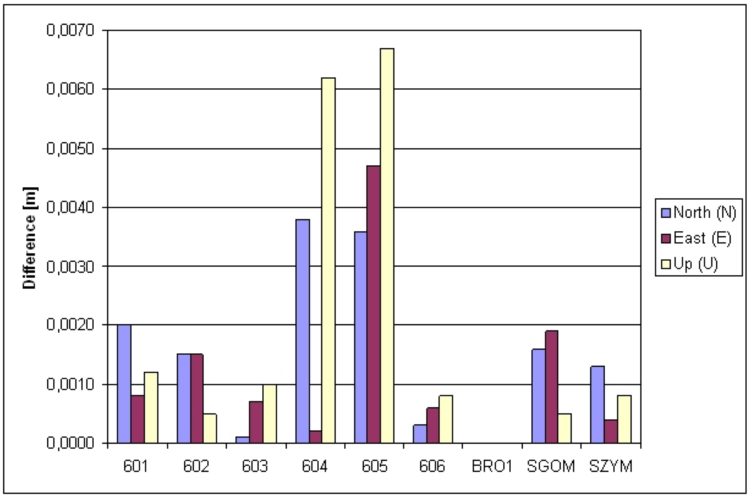
GPS baselines calculation were processed with Leica Geo Office v.4.0 separately for both sessions. The processing constraints presented below corresponded to described in 2001 [1] by Cacoń et al..

- frequency - L1, L1+L2,
- sampling interval - 15 s,
- ionospheric modelling - CODE (regional),
- tropspheric modelling - a priori Saastamoinen, Hopfield, No troposphere, Computed (during baseline processing),
- fixed site - 602.

3.1 GPS ACCURACY

10-hour session occupation time was taken to achieve baseline mean error close to 1 mm value as it is described in [4] by the American Army Corps of Engineers. Double 2006 session has been made to verify previous achieved results, which would help to estimate real error.This estimation is done simply by average results of separate session solutions and difference between sessions calculation. Achieved difference in coordinate components could be taken as their accuracy for further processing or analysis. For 2006 campaign mean differences for coordinate components are following: horizontal

(North) 1.6 mm and (East) 1.2 mm. For the height component (Up) the difference is 2.0 mm. Particular values are presented on graph. 2.



Graph. 2 The accuracy of coordinates from double 2006 GPS session

4 TERRESTRIAL AND GPS DATA CONFORMITY ESTIMATION

For conformity of data purpose, processed GPS baselines (for both sessions) and measured average Total Station's spatial distances were compared. Following resultant differences were averaged and presented in the table 2. Because of existing outlier (3 times bigger than average) differences in the first baseline calculation, next the baselines were processed with use of different tropospheric delay modelling (table 2) and processing frequency. Ionospheric conditions for such a small network could be considered constant, but regional ionosphere model (CODE) were used. Outlier differences exist on only three baselines, so average differences without outliers were also presented.

Tab. 2 Mean differences of measured GPS baselines and Total Station spatial distances [m]

Processing Frequency	**L1**			
Troposphere Model	**Computed**	**Saastamoinen**	**Hopfield**	**No Troposphere**
DOY 288	-0,0075	-0,0062	-0,0066	-0,0075
DOY 289	-0,0064	-0,0061	-0,0064	-0,0074
Both (without outlier vectors)	-0,0033	-0,0024	-0,0028	-0,0041
Processing Frequency	**L1+L2**			
Troposphere Model	**Computed**		**Saastamoinen**	
DOY 288	-0,0065		-0,0062	
DOY 289	-0,0068		-0,0062	
Both (without outlier vectors)	-0,0029		-0,0023	

Achieved results are interesting mainly for two reasons. Firstly by the common minus sign for all differences, and secondly by three outlier vectors beginning in the site 0605 (0605 - 0603, 0605 - BRO1, 0605 – 0604) (Fig. 2 and Graph 3).

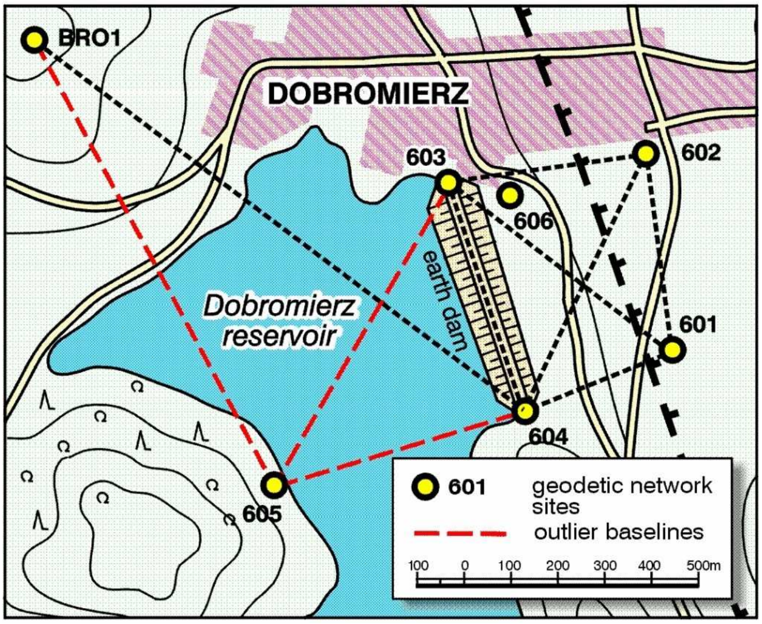
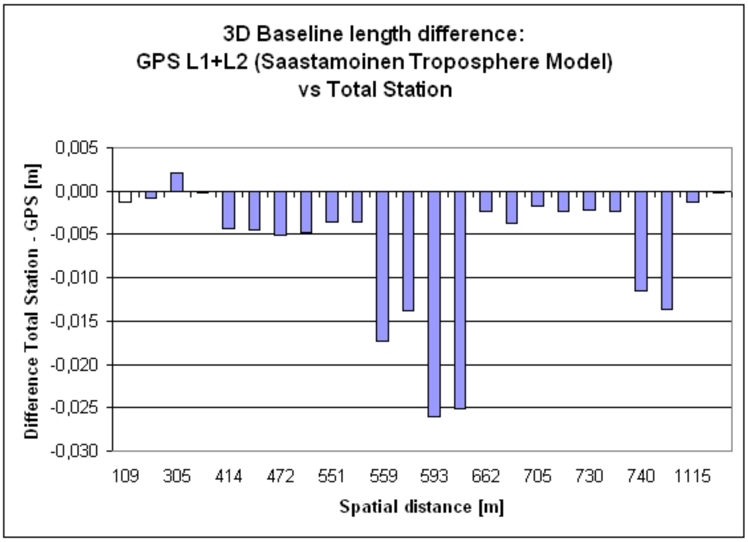


Fig. 2 The outlier baselines location



Graph. 3 Discrepancies of GPS baselines and terrestrial measurements

Expected conformity measure of the GPS baselines and measured distances for range of 100 - 1200 m (considering electromagnetic distance measurement (EDM) error and instrument levelling error) should be below 5 mm [4]. Majority of results are inside this range. Almost five times bigger difference for outlier distances is caused by delaying laser waves over the water reservoir and extending distance. Additionally small mean height of targeting line over the water (5-10 m) could gain an effect of extending. That hypotesis seems to be confirmed by different processing strategies for baselines (see Tab. 2), because there are no effect of decreasing differences particularily for the outlier ones. The closest results of GPS and Total Station data were achieved by the Saastamoinen [5] troposphere delay modelling. As it was expected difference between L1 and L1+L2 solution on such short baselines is rather small and does not increase data conformity. [8].

5 COMMON DATA PROCESSING

Surveying Total Station data stored in GSI files and the GPS RINEX v. 2.10 files were processed according to the shown below procedure (Fig. 3). Projection of the GPS baselines on GRS80 ellipsoid (by the Krüger's „average latitude“ method) [6] and reduction of spatial distances and measured angles were done with the GEONET software [3]. Also common, robust adjustment on GRS80 ellipsoid was performed by this software. After adjustment the mean error of coordinates is below 2 mm and mean errors of distances and angles are on expected level (Tab. 3).

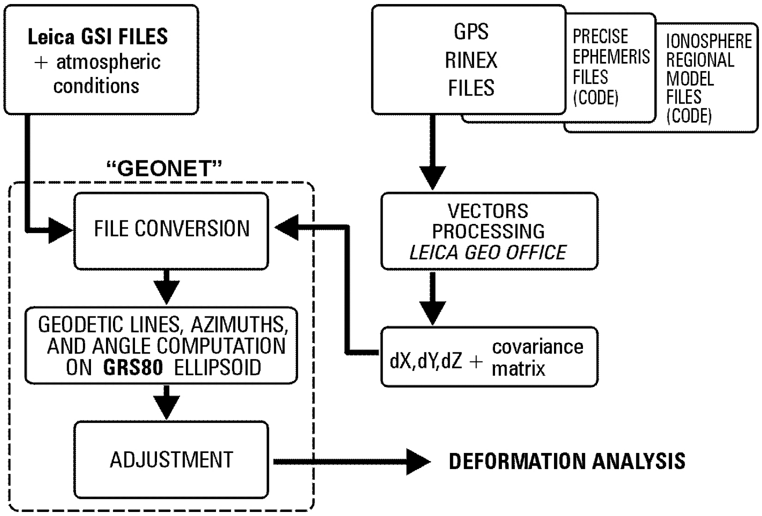


Fig. 3 Procedure of GPS and Total Station data processing

Tab. 3 Mean error values after adjustment

ERROR	VALUE
Length error [mm]	**1.25**
Angle error [cc]	**2.34**
Coordinate **B** error [mm]	**2.02**
Coordinate **L** error [mm]	**1.10**

6 CONCLUSION

Performed survey and calculations offered possibility of defining real accuracies of results and quality of data gathered in the "Dobromierz" network. Geodynamic network origin needs the particular precision of survey and care of data processing. During calculations atmospheric influence was revealed (laser wave delay) on distances measured by the Total Station. The GPS baselines processing are free from that influence. Better results of conformity of terrestrial and GPS data could be achieved by the site specific troposphere modelling. This should reduce scale factor error [7] between measurements taken by different techniques.

Considered differences between techniques needs further investigations. It is crucial because of precise Total Stations (like TCA2003) are used for construction and deformation/safety purposes, where the highest precision is required.

Mean errors of coordinates confirm high quality of the data and good conformity of GPS and terrestrial measurements. These results allow author to determine displacements as well as deformation parameters in common geodetic datum based on GRS80 ellipsoid.

Literature

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