Zdunek K., Zieliński J. B., Sjöberg L., Sledziński J., Butkiewicz E., Fischer H., Försberg A, Jaworski L., Knap T., Kujawa L., Nawrocki J., Osuch D., Piechocińska J., Rösch K., Stomma A., Vorbrich K. (1989), First results of the measurements with GPS the travers Józefosław- Borowiec in March 1989. Interkosmos Symp., Cracow, Proc. of the 18-th Interkosmos Symp. "Use of Artificial Satellites Observations for Geodesy", Cracow, Obs. of Art. Sat. of the Earth, No. 27, Warsaw, Poland, vol. 2, pp. 7-18.

Zieliński J. B., 1986a, Accuracy of the GPS surveying technique and its possible application to the Wegener Project. Dep. of Geod., Rep. No. 85.3, Delft Univ. of Techn., Delft, the Netherlands.

РАЗВИТИЕ СПУТНИКОВЫХ МЕТОДОВ ОПРЕДЕЛЕНИЯ ПОЗИЦИИ

Войтех Пахельски

Резюме.

Работа подводит главные итоги, полученные за срок 1986-90 г. в области теории радио-позиционных методов и методов уравнивания, принимаемых для геодезической обработки наблюдений Допплера и GPS.

GPS DATA PROCESSING WORKS IN THE SPACE RESEAI CENTRE.

Stomma, D. Łapucha, J.B. Zieliński, R. Zdunek
Space Research Centre, PAS
Warsaw Poland

ABSTRACT. The main task of this work was the software developmen processing of GPS observations. In the paper results of GPS pseudo-ra carrier beat phase observations are presented.

1. INTRODUCTION

Most of GPS receivers make two types of observations, namely carrier bea and pseudo-range. Both observations are a function of a topocentric r satellite and differ with internal precision. Carrier beat phase and pseud have precision of submilimeter level and a few meters, respectively. In tl geodetic applications the phase measurements are mainly used. Pseudo combined with phase measurements can be used for relative kinematic posit Approximate geocentric coordinates and clock corrections, which can be ot from pseudo-range single point positioning, are necessary for the proces carrier phase relative positioning.

In 1988 we had not our own data, so for analyses of pseudo-ranges w observations from Schwarzwald campaign carried out by Geodetic Insti Stuttgart University using WM101 receivers. In the present time pseudo software is used for the processing of other observations including Polisl paigns.

In March 1989 the first GPS measurements in Poland were performed alo geodynamic traverse Józefosław-Borowiec which consisted of 11 short (~ 3

baselines. Five WM102 receivers were used in the campaign. Three of them were from the Department of Geodesy of the Royal Institute of Technology in Stockholm and two from Geodetic Institute of Stuttgart University. The end sites of the traverse were occupied during four days,the short baselines were measured in one day sessions. In addition the small test network in Borowiec with baselines from 168 to 310 m was measured once during the campaign. Data were analysed by three software packages: POPS, the software based on SLSQ program made available by Dr.B.W.Remondi and modified by D.Łapucha (Łapucha, 1989); PUMA program made available by Prof. E. W. Grafarend, converted to sequential adjustment by Dr. W. Pachelski and further developed by A. Stomma. Changes made by A.Stomma are particularly described in (Stomma, 1989), (Stomma et al., 1990).

2. AN ANALYSIS OF ALGORITHMS AND ACCURACY OF THE GPS POINT POSITION DETERMINATION USING PSEUDO - RANGE OBSERVATIONS.

A mathematical model of single point positioning of pseudo-range observations is given in (Łapucha, Stomma, 1989). Two ways of implementation of receiver clock

Table 1. Repeatability of coordinates with different models of clock error.(m_p- point position error, m_0- standard deviation of unit weight)

Variant	day	X	Y	Z	m_p	m_0
		[meters]				
2-nd degree polyno-mial	1	4170892.9	629855.8	4769126.0	3.4	11.9
	2	919.5	857.5	141.3	2.1	8.6
	3	904.0	848.6	131.0	4.6	18.3
4-th degree polyno-mial	1	4170897.1	629856.6	4769129.3	2.8	9.7
	2	917.1	857.3	139.4	1.3	5.1
	3	907.6	851.6	133.1	1.4	5.6
separate						

error were analysed; with polynomial representation and separate clc for each epoch. In the second case sequential adjustment was used. P data collected during three days for one station with similar three-h window were analysed.
Repeatability of coordinates show that model with separate clock ı each epoch is the best one. Comparison of above solution for differen to estimate the real accuracy of about 10 meters.

3. RESULTS OF THE FIRST GPS CAMPAIGN IN POLAND

The main task of this work was to test and develop available software GPS phase observations processing. Since there was a possibility to L1 measurements, modified SLSQ and PUMAS results were from L The preliminary version of program for cycle slipes detection and : stations separated up to ~ 30-40 km was written. It is based or approximation of raw phase data differenced between epochs ar ferenced data. Using this program L1 cycle slips from the first Polish G were detected and corrected.
First results with phase observations using POPS and modified SLSQ a in (Zdunek et al. ,1989).
Then a particular attention was paid to program PUMAS, which ı before with a large data set. Introduced important changes in PUI scribed in (Stomma ,1989). Results of POPS, modified SLSQ and PUM in (Stomma et al.,1990). Taken into account version of PUMAS w changed formula of observational equation as it was given in above pap SLSQ and PUMAS were used on the same data set. Ambiguity resol programs was not performed. For 11 short baselines accordance in ences between POPS L1 and SLSQ is 6-33 mm, ~ 18 mm in avera systematic character. Analogical discrepancies for POPS L1 and worse than previously, 6-87 mm, ~ 39 mm in average. For 7 from modified SLSQ and PUMAS show good agreement in distances up tc other differences are 15 mm, 18 mm, 28 mm, 46 mm. All distances fi and SLSQ are shorter than from POPS L1. Shortening is in average e

from POPS L1 frequency are shorter than from L1/L2 combination in average ~ 1 ppm.
For test network discrepancies between all programs and ground measurements in distances are not greater than 6 mm and in height differences not worse than 23 mm.
Differences of POPS L1/L2 4-day results of Józefosław-Borowiec baseline (271.5 km) and their mean value are 16-51 mm and 102-122 mm for distance and height difference, respectively.
Comparison with available ground distance measurements for 4 baselines (26.9-46.9 km) gives for POPS L1/L2, POPS L1, modified SLSQ, PUMAS discrepancies 2-20 mm, 11-71 mm, 66-200 mm, 55-218 mm, respectively.

4. CONCLUSIONS

Program for pseudo-range observations processing, written by D.Łapucha is tested and ready to use.
Further development of other programs is necessary and this work is now being in progress.

This work was done under the project CPBP 01.20.

REFERENCES

Łapucha D., 1989, The problem of processing of GPS satellite phase observations (in polish); Geodezja i Kartografia, No.3 pp 3-13.

Łapucha D., Stomma A., 1989, An analysis of algorithms of the GPS point position determination using pseudo-range observations, presented at 18-th INTERCOSMOS SYMPOSIUM on Use of Artificial Satellite Observations for Geodesy and Geophysics, Cracow, Poland; Geodezja i Kartografia (in press).

Stomma A., 1989, Description of PUMAS1 program, manuscript.

Stomma A., Zdunek R., Zieliński J.B., 1990, Results of the first GPS campaign in Poland in March 1989, presented at the 2-nd INTERNATIONAL

Positioning with the GPS, Canada, Ottawa (in

Zdunek R., Zieliński J.B., Sjöberg L., Śledziński J., Butkiewicz E., F
Forsberg A., Jaworski L., Knap T., Kujawa L., Nawrocki J.,
Piechocińska J., Rösch K., Stomma A., Vorbrich K., 1989, First re
measurements with GPS the traverse Józefosław-Borowiec in M
Proc. 18-th INTERNATIONAL SYMPOSIUM on Use of Artificia
Observations for Geodesy and Geophysics, Cracow, Obser
Artificial Satellites of the Earth No. 27 Warsaw, Poland pp 7-18.

ГПС ИССЛЕДОВАНИЯ В ЦЕНТРЕ КОСМИЧЕСКИЖ ИСЛЕДОВАНИ

А. Стомма, Д. Лапуха, Й. Б. Зелинский, Р. Здунэк

РЕЗЮМЕ. Главной задачой этой работы ябляется развитие
для обработки наблюдений ГПС. В работе представляются
из псевдо-расстояний и фазовых наблюдений.