SYNCHRONOUS MEASUREMENT OF POSITION COORDINATES OF TWO GPS RECEIVERS

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ABSTRACT

This article presents the results of synchronous DGPS measurements. The measurements involved two identical receivers with the same software, installed permanently at a fixed distance between each other, in conditions eliminating multipath signal reception. The results analysis, however, shows that the compatibility of received satellite configurations ranges significantly.

INTRODUCTION

During previous tests of GPS and DGPS measurements significant differences were noted in the tracking of a satellite segment by receivers placed close to each other. In order to examine this phenomenon, these authors have examined the parallel operation of two receivers with identical parameters. The DGPS MiniMAX receivers, made by CSI, were capable of receiving corrections from the EGNOS system.

1. MEASUREMENT CONDITIONS

The parallel operation of GPS receivers was tested at the Maritime University of Szczecin. The choice of the place ensured optimal measuring conditions on the one hand, and the necessary supervision over the equipment used on the other. GPS receiver antennas were installed on the platform located over the roof of the University's main building in such a way that the entire radio horizon was accessible. Each of the antennas was placed in a location with known coordinates and distance between them.

2. RESEARCH METHODOLOGY

Two identical DGPS MiniMAX receivers made by CSI were used. Both receivers had the same firmware - version v.46. The receiver antennas were mounted at the same elevation on the antenna platform, at a site where reception conditions were the best. The actual distance between the antennas was 1630 mm. Data were registered by means of two PC computers featuring PC PocketMAX software. Data included in the NMEA protocols: GPGGA, GPGLL, GPGSA, GPGST, GPGSV, GPRMC, GPRRE, GPVTG and GPZDA were logged at 1 Hz frequency.

Both receivers were working with the SBAS function on (differential reception of correction from satellites) and the boundary angle of satellite elevation set at 5 degrees. Both receivers worked with the SBAS function activated (differential reception of corrections from EGNOS satellites) and the lower limit topocentric altitude of 5 degrees.
In order to ensure the appropriate reliability of the testing of parallel operation of the two receivers, the logging was continued for ten consecutive days (from 27 April to 6 May 2007).

3. RESEARCH RESULTS

From the registered data the following quantities were calculated for each 24-hour measuring session: mean latitude and longitude, parameters of mean error ellipsis (a, b and α). The measurement results are shown in Table 1.

Table 1. Mean latitude and longitude, error ellipsis parameters (a, b and α)

Date of measurement	Antenna	φ [N]	λ [E]	a [m]	b [m]	α [°]
1	2	3	4	5	6	7
2007-04-27	a5	53° 25' 44,965"	014° 33' 49,252"	1,21	0,63	16,3
	a6	53° 25' 44,929"	014° 33' 49,209"	1,59	0,87	27,2
2007-04-28	a5	53° 25' 44,967"	014° 33' 49,252"	1,15	0,56	17,7
	a6	53° 25' 44,912"	014° 33' 49,210"	2,86	1,14	6,0
2007-04-29	a5	53° 25' 44,970"	014° 33' 49,248"	1,19	0,56	20,0
	a6	53° 25' 44,929"	014° 33' 49,209"	0,97	0,67	339,4
2007-04-30	a5	53° 25' 44,963"	014° 33' 49,249"	1,20	0,56	17,8
	a6	53° 25' 44,927"	014° 33' 49,215"	0,97	0,63	343,6
2007-05-01	a5	53° 25' 44,961"	014° 33' 49,245"	1,09	0,57	13,3
	a6	53° 25' 44,925"	014° 33' 49,211"	1,01	0,63	348,6
2007-05-02	a5	53° 25' 44,972"	014° 33' 49,244"	2,35	0,84	339,9
	a6	53° 25' 44,928"	014° 33' 49,209"	2,11	0,67	334,5
2007-05-03	a5	53° 25' 44,961"	014° 33' 49,252"	1,01	0,62	8,0
	a6	53° 25' 44,923"	014° 33' 49,217"	1,61	0,93	16,6

2007-05-04	a5	53° 25' 44,968"	014° 33' 49,260"	1,22	0,89	12,8
	a6	53° 25' 44,919"	014° 33' 49,210"	1,00	0,65	342,8
2007-05-05	a5	53° 25' 44,966"	014° 33' 49,244"	1,13	0,59	19,0
	a6	53° 25' 44,935"	014° 33' 49,228"	0,98	0,76	354,8
2007-05-06	a5	53° 25' 44,915"	014° 33' 49,248"	10,95	2,41	336,4
	a6	53° 25' 44,934"	014° 33' 49,215"	0,85	0,60	332,4

Source: authors' study

The calculations were made with the use of MS Excel 2007 and Statistica V. 7.1 software.

Table 2 presents the error circle radius calculated for each measuring session, for the 95% probability, the distance between mean positions, percentage of conformity of two satellites tracked by both receivers and the difference of distance relative to real distance.

Table 2. Error circle radius, conformity of tracked satellite segments and the distance between mean positions and the difference of distance relative to real distance

Measurement date	Antenna	M(95%) [m]	Conformity [%]	Distance [m]	Difference [m]
2007-04-27	a5	2,37	34%	1,37	0,26
	a6	3,13			
2007-04-28	a5	2,21	56%	1,87	-0,24
	a6	5,33			
2007-04-29	a5	2,28	43%	1,46	0,17
	a6	2,04			
2007-04-30	a5	2,29	56%	1,28	0,35
	a6	2,01			
2007-05-01	a5	2,13	55%	1,28	0,35
	a6	2,06			
2007-05-02	a5	4,31	56%	1,49	0,14
	a6	3,83			
2007-05-03	a5	2,06	41%	1,34	0,29
	a6	3,22			
2007-05-04	a5	2,61	41%	1,78	-0,15
	a6	2,06			
2007-05-05	a5	2,21	36%	0,99	0,64
	a6	2,14			
2007-05-06	a5	19,40	53%	0,85	0,78
	a6	1,80			

Source: authors' study

Figure 1 presents the distance between mean positions for each measuring session and percentage of conformity of the satellites tracked by the receivers.

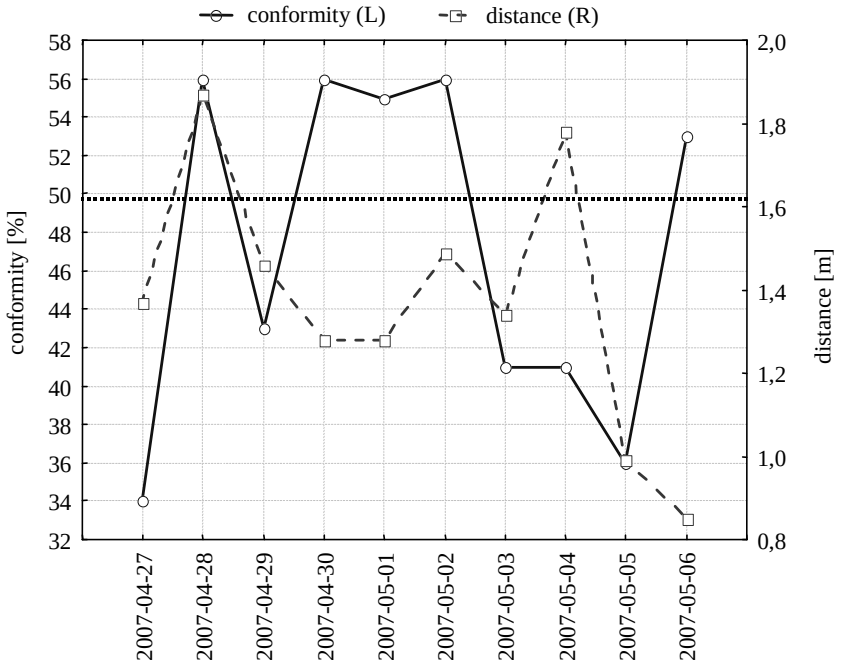

Fig. 1. Distance between mean positions of antennas (dashed line) for each measuring session. Conformity of the satellite segment tracked by both receivers (firm line), real distance between antennas (dotted line)
Source: authors' study

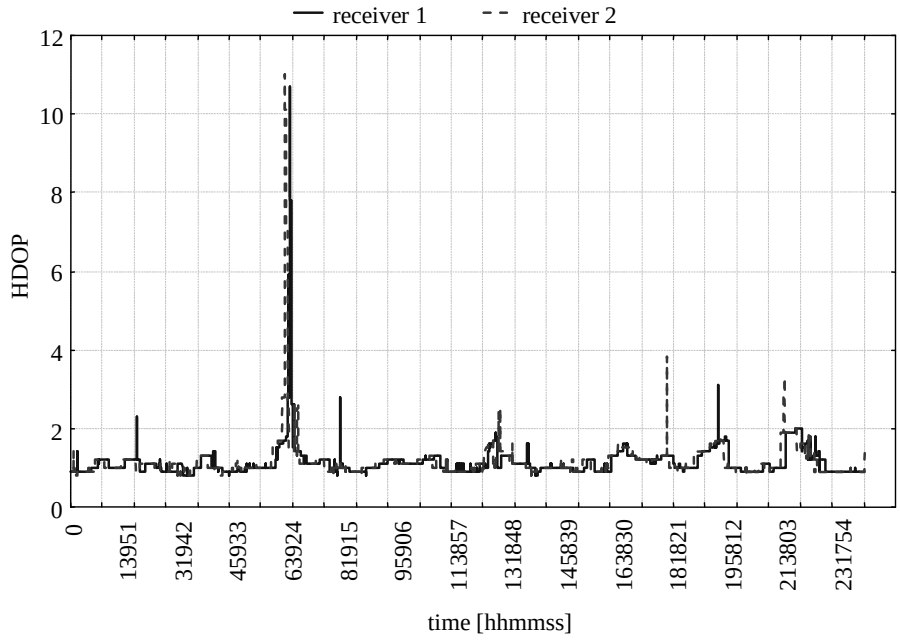

Fig.2 . Distributions of HDOP factor for both receivers on 27 April 2007
Source: authors' study

The obtained measurement results indicate a significant inconformity of the satellite constellation tracked by both receivers. Therefore, for selected measurement series additional graphs illustrating distributions of the HDOP coefficient in time were made (Figures 2 and 3). Figure 2 shows the HDOP distribution for both receivers on 27 April 2007, while Figure 3 the distribution on 30 April 2007.

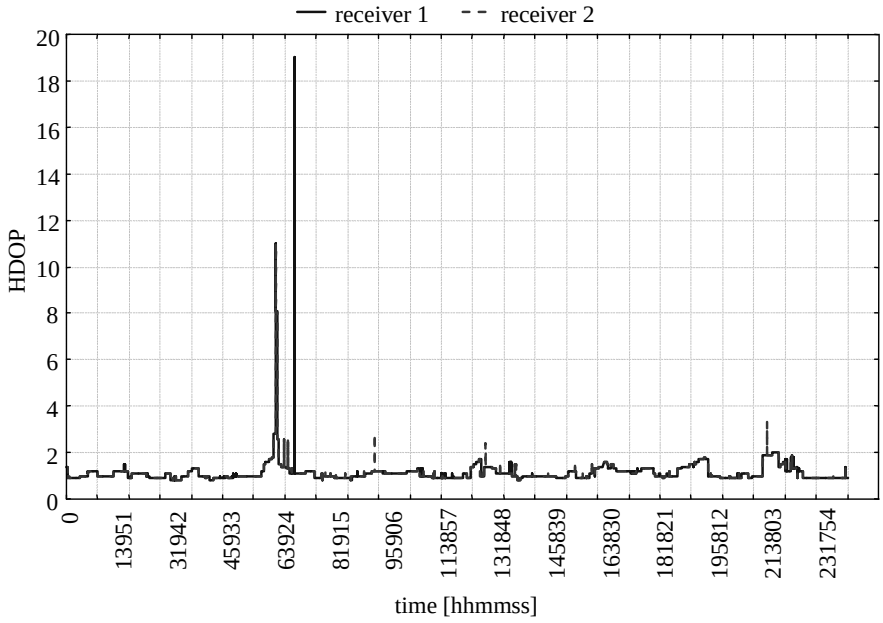

Fig. 3. Distributions of HDOP factor for both receivers on 30 April 2007
Source: authors' study

4. MEASUREMENT RESULTS ANALYSIS

1. **The accuracy of positional measurements displayed by the receivers operating in the SBAS mode ranged from 1.88 m to 5.33 m (in one case the error reached the value of nearly 20 m).**
2. **The tests have shown a larger scatter of mean positions when the receivers used a signal from GPS satellites (SBAS) than when measurements were made using corrections transmitted by DGPS radiobeacons [7].**
3. **During the measurements there occurs a significant inconformity in the tracked satellite segment, despite of comparable conditions of reception and identical receivers used. The reasons for such differences call for clarification and additional research. One such reason may be the multipath effect of reception (possible reflections from roofs etc.).**
4. **The distributions of the HDOP factor during the measurements show high correlation in time, despite substantial changes of the factor occurring at times (values up to 20) separately in either of the receivers.**
5. **In some periods of time there occurs a visible increase of HDOP which for both receivers reaches value above 10. The deterioration of the factor takes place in all registered measuring sessions and is most probably connected with the system geometry.**

CONCLUSIONS

1. **The research has confirmed that there occurs a significant inconformity of tracking a satellite segment in the case when, theoretically, both receivers should track the same segment of satellites (identical receivers with the same software, with antennas located next to each other).**
2. **In order to eliminate possible multipath effect of reception the tests should be repeated for the GPS itself and for its differential versions in the location where the probability of this effect will be the lowest, e.g. open area such as meadow or field.**
3. **In situations when a DGPS is used for operation requiring high accuracy of positional measurements the system should be integrated with inertial systems. This will enable the minimization of a sudden drop in positional measurement accuracy (impulse changes of the HDOP factor).**

REFERENCES

Banachowicz A., Bober R., Banachowicz G., Wolski A., (2005) ***Spatial Accuracy of GPS/DGPS Position in a Fairway,*** **Reports on Geodesy No. 2 (73), Warsaw.**

Januszewski J., (2004) ***GPS and other satellite systems in marine navigation (in Polish),*** **Akademia Morska, Gdynia.**

Felski A., Specht C., (1995) ***Some aspects of optimized use of DGPS systems in the Southern Baltic Sea*** **(in Polish), Zeszyty Naukowe AMW No. 3, Gdynia.**

Specht C., (1997) ***Polish DGPS systems as an element of radionavigational shield of the southern Baltic (in Polish),*** **Zeszyty Naukowe AMW No. 2, Gdynia.**

Specht C., (2007) ***System GPS,*** **Wyd. Bernardinum, Gdańsk.**

Wolski A., Bober R. Szewczuk T., (2007) ***An effect of urban development on the accuracy of the GPS/EGNOS system,*** **TransNav 2007, Gdynia.**

Zaleski J., (2006) ***Dokładność określania pozycji przy wykorzystaniu różnych stacji DGPS,*** **supervisor mgr inż. R. Bober, engineer's thesis, Akademia Morska w Szczecinie.**