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An Effect of Urban Development on the Accuracy of the GPS/EGNOS System

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ABSTRACT: This article presents the results of research into the accuracy of position determination by a GPS/EGNOS system in a densely built-up residential area. These results are compared with the relevant results obtained for a position in an open area.

1 INTRODUCTION

The EGNOS system makes up a superimposition for the GPS and GLONASS systems which allows to enhance the accuracy, availability, reliability and continuity of position determination.

The accuracy of position determination in the GPS/EGNOSS system is about 3-5 m (p=0.95) and depends on a number of factors. The number and configuration of observable satellites is one of the factors significantly affecting the accuracy. These depend on the position of the antenna and its environment. The antenna location has an influence on the number of tracked satellites, while the environment may cause the effect of multitracking.

This article attempts at assessing the accuracy of position determination by a GPS/EGNOS system in an urban densely built up area and at comparing it with positions obtained in an open area.

2 RESEARCH AREA

Three characteristic measurement locations were chosen within Szczecin area (Fig. 1) for the assessment of position determination accuracy obtained with the use of a GPS/EGNOS system:

- measuring point *Glinki(A),* located in an open area without buildings, with grassy ground, offering good conditions of signal reception;
- measuring point *ul. Bolesława Śmiałego(B),* located in a narrow street with rows of adjacent buildings about 25 metres high. The antenna was installed on a car roof (at height of 2 metres): the celestial sphere was considerably covered by buildings, so reflections from walls could be expected;
- measuring point *AM Szczecin(C),* located on an antenna platform, about 35 metres above the ground, overlooking the roofs of neighbouring buildings; the antenna could see the whole celestial sphere, although there were chances for reflections from neighbouring roofs and slight shades from radio antennas at a distance of 2 to 4 metres.

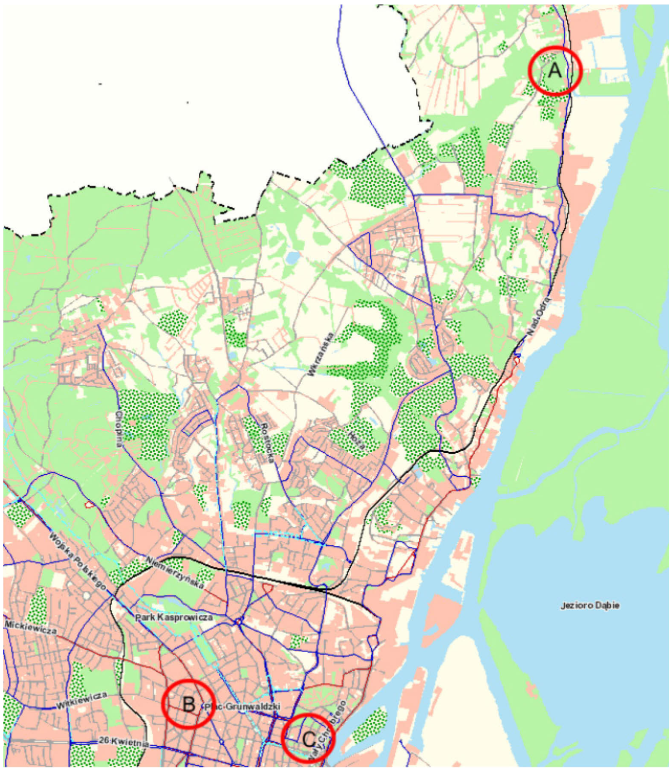
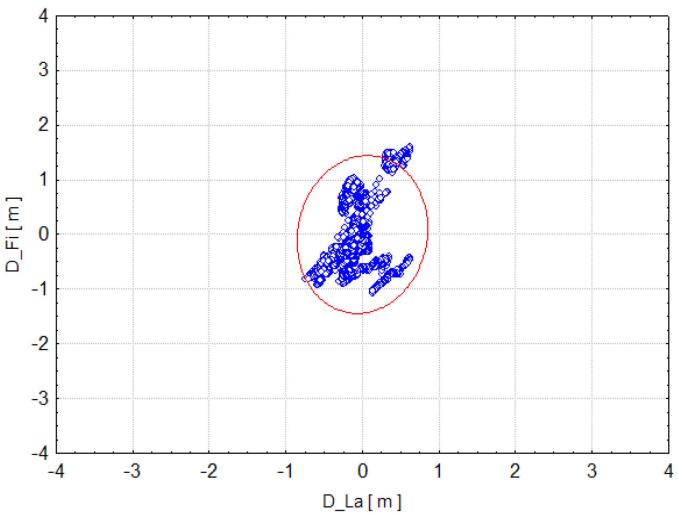


Fig. 1. Szczecin – measuring points: A – Glinki, B – ul. Bolesława Śmiałego, C – AM Szczecin

The three different measuring points are located in conditions characteristic of most measurements performed by GPS/EGNOS receivers. The measuring point *Glinki* is very good measuring location, typical of field measurements; the location at *AM Szczecin* (Maritime University) well represents conditions found on board ships, while the point at Bolesław Śmiały Street is a typical location for measurements carried out in a city traffic.

a)



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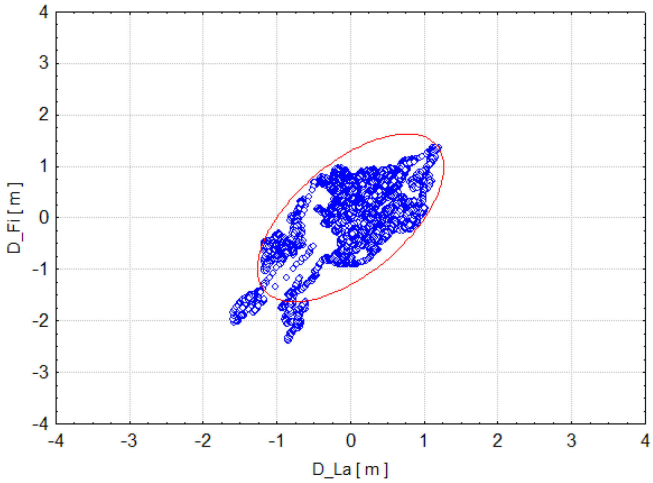

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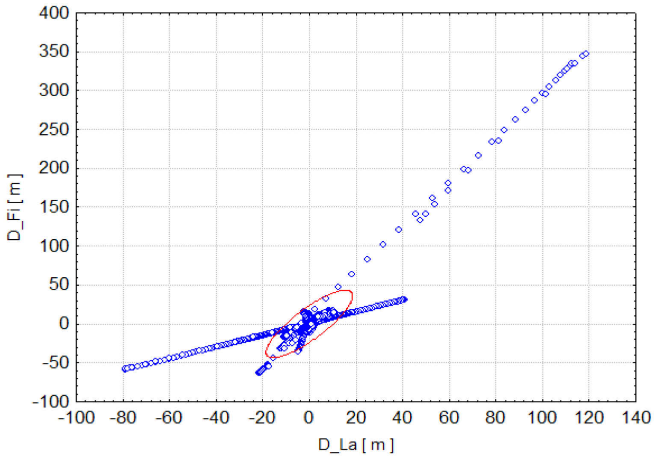
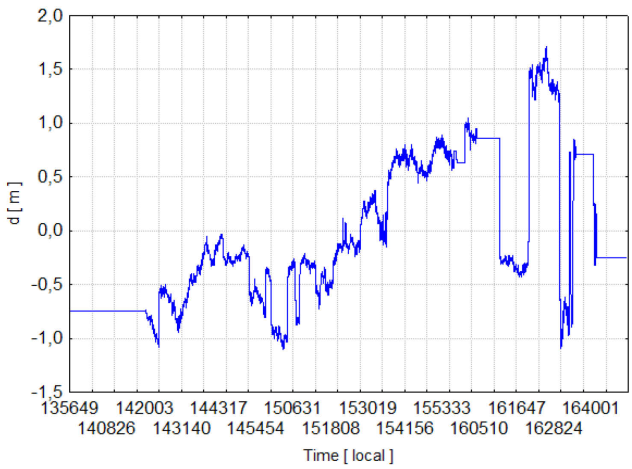


Fig. 2. Dispersion for average position in measuring points: a) Glinki, b) ul. Bolesława Śmiałego c) AM Szczecin
(date: 2006-10-26)

a)



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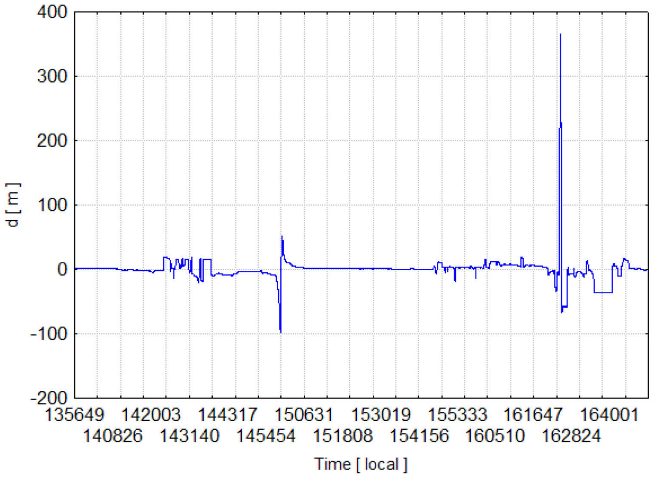

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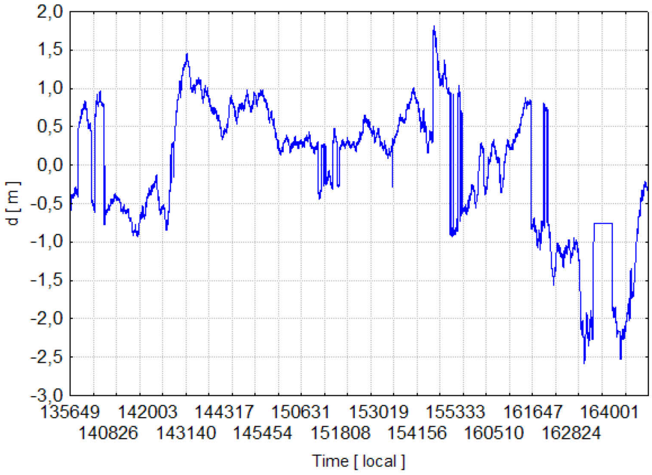
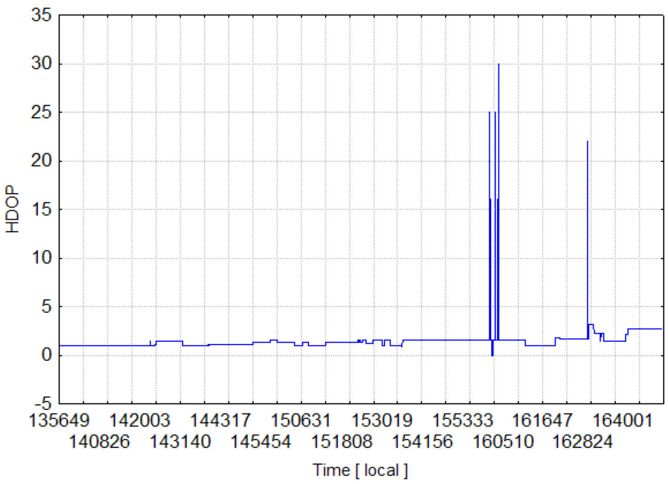


Fig. 3. Deviation for average position in measuring points: Glinki, b) ul. Bolesława Śmiałego, c) AM Szczecin (date: 2006-10-26)

a)



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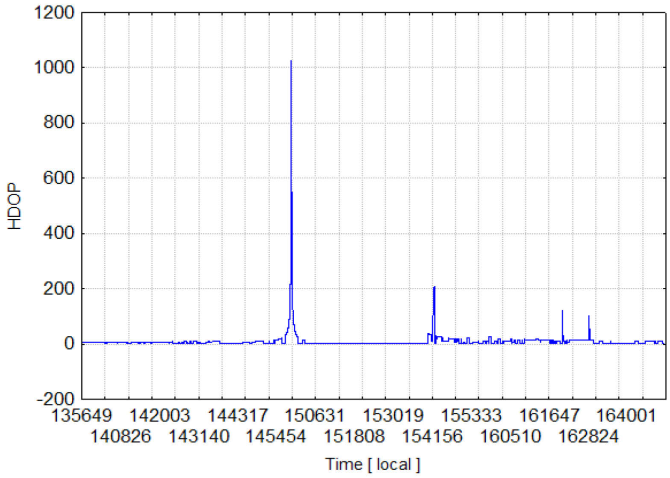

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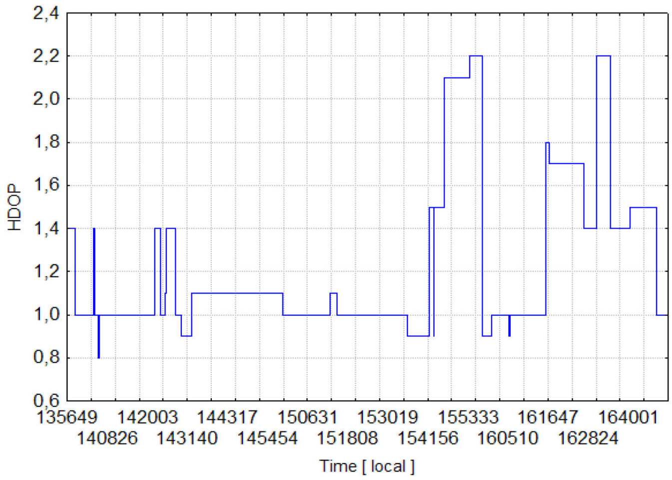

Fig. 4. HDOP factor in measuring points:
a) Glinki, b) ul. Bolesława Śmiałego c) AM Szczecin
(date: 2006-10-26)

3 RESEARCH METHODS

In order to find out the position determination accuracy obtained by the GPS/EGNOS system, and the relation of the accuracy with measurement location, parallel measurements were performed using three identical CSI-made MiniMAX receivers. The use of the same type receivers (with the same software) for investigations was supposed to eliminate possible errors resulting from the use of various type receivers for measurements. The receivers were handled using PocketMax PC_Ver.2.0 software, enabling the choice of recorded data from MiniMAX receivers by PC computers. Three measurement sessions were executed on 10 October, 18 October and 26 October 2006.

The following parameters were measured and logged at 1 Hz frequency:

GPGGA – moment, latitude and longitude, height, HDOP, number of satellites tracked, correction age;

GPGGL – latitude and longitude, moment, status;

GPGSA – position mode (2D/3D), (M/A), PDOP, VDOP.

4 THE RESULTS

The calculations for each session shown in Table 1 were made on the basis of recorded data from three field locations:

- mean latitude (φ),
- mean longitude (λ),
- mean height (H),
- radius of error circle (M) (p=0.95),
- parameters of error ellipsoid (a, b, α) (p=0.95).

The measurement data, shown in Table 1, are additionally presented graphically:

- dispersion for average position in each measuring point (Fig.2),
- deviation for average position in each measuring point (Fig.3),
- values of the HDOP coefficient (Fig.4).

An analysis of data in Figures 2 and 3 shows that at the locations with similar reception conditions (*Glinki*, *AM Szczecin*) deviations from the mean position are small and do not exceed 2.5 metres. On the other hand, in a densely built up area (location *ul.Bolesława Śmiałego*) values of maximum deviations reach as much as 380 m.

An assessment of the HDOP (Fig.4) has shown that at *ul.Bolesława Śmiałego* this coefficient at short time intervals has very large values reaching 1000, which considerably decreased position accuracy.

5 CONCLUSIONS

The research has clearly proved that the accuracy of position obtained from a GPS/EGNOS system depends on the antenna location, as this strictly relates to the number of observed satellites. If the receiver antenna observed the whole celestial sphere (*Glinki*, *AM Szczecin*), position determination accuracy was M = 0.72-2.57 m. When the receiver worked in a densely built up area (*ul.Bolesława Śmiałego*), then the accuracy was visibly lower (M=33.26-58.72 m). The data recordings featured very short but significant oscillations of the HDOP coefficient that could not be explained by satellite constellation. Besides, signals from EGNOS satellites were disappearing for significant periods of time during the measurements.

Table 1. Measurement results

	ul. B. Śmiałego	AM	Glinki
		10.10.2006	
φ [N]	53° 25' 59.74"	53° 25' 44,93"	53° 30' 16,66"
λ [E]	014° 32' 13,51"	014° 33' 49,19"	014° 36' 14,86"
H [m]	44,29	44,95	81,86
M(95%) [m]	33,26	1,12	2,57
a [m]	18,89	0,53	1,47
b [m]	3,51	0,36	0,13
α [°]	31,3	16,7	22,2
		18.10.2006	
φ [N]	53° 26' 00,18"	53° 25' 44,93"	53° 30' 16,60"
λ [E]	014° 32' 13,97"	014° 33' 49,15"	014° 36' 14,81"
H [m]	8,32	44,88	82,54
M (95%) [m]	58,72	0,72	1,16
a [m]	33,84	0,37	0,61
b [m]	2,39	0,18	0,27
α [°]	19,7	60,3	11,6
		26.10.2006	
φ [N]	53° 25' 59,86"	53° 25' 44,87"	53° 30' 16,60"
λ [E]	014° 32' 13,76"	014° 33' 49,15"	014° 36' 14,81"
H [m]	24,91	44,87	82,30
M (95%) [m]	33,37	1,45	1,16
a [m]	18,88	0,76	0,59
b [m]	3,91	0,35	0,34
α [°]	20,5	33,4	4,3

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