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Effect of Measurement Duration on the Accuracy of Position Determination in GPS and GPS/EGNOS Systems

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ABSTRACT: The authors have analyzed the effect of measurement duration on the accuracy of ship's horizontal (2D) position obtained by GPS and GPS/EGNOS receivers. Also, the influence of measurement duration on the mean position determination error in relation to a reference (geodetic) position has been examined.

1 MEASUREMENTS

In order to assess how measurement time affects the accuracy of horizontal position determination in GPS and GPS/EGNOS systems, more than thirty measurement sessions were performed. Observations during each session lasted at least 24 hours. The tests were carried out with two identical MiniMAX receivers made by CSI. The use of two receivers of the same type (with the same software) was aimed at eliminating possible errors that otherwise result from measuring instruments of various types. The GPS antennas were mounted on the antenna platform of the Maritime University of Szczecin. The antennas' positions were determined by geodetic methods.

The receivers were operated by using PocketMax_PC_Ver.2.2. software, which makes it possible to record data from MiniMAX receivers by PC computers. The data were recorded at 1 Hz frequency in NMEA-0183: $GPGGA, $GPGGL, $GPGSA, $GPGST, $GPGSV and $GPZDA formats. Observations lasted from November 2007 to November 2008.

2 MEASUREMENT RESULTS ANALYSIS

The assessment of measurement duration effect on the accuracy of horizontal position obtained by GPS and GPS/EGNOS systems based on registered data required current calculations, i.e. after each measurement, of the following quantities:

- mean latitude,
- mean longitude,
- circular error of position M (for P = 0.95),
- latitude shift of mean position relative to geodetic position (Δφ [m]),
- longitude shift of mean position relative to geodetic position (Δλ [m]),
- distance between mean position and geodetic position (R [m]).

Table 1 presents calculation results for selected ten 24-hour measurement sessions.

Table 1. Ten 24-hour measurement sessions by GPS and GPS/EGNOS receivers.

	Measurement type	Elevation	Measurement date	M(95%) [m]	Δφ [m]	Δλ [m]	R [m]
1	GPS	20°	18.06.08	2.11	-0.73	-0.64	0.972
2	GPS/ EGNOS	25°	19.06.08	29.17	-1.12	-0.58	1.262
3	GPS	20°	18.08.08	20.21	-0.58	-0.13	0.605
4	GPS	5°	19.11.08	1.88	-0.55	-0.80	0.973
5	GPS/ EGNOS	5°	20.11.08	2.02	-0.66	-0.56	0.868
6	GPS/ EGNOS	5°	21.11.08	2.54	-0.54	-0.61	0.733
7	GPS/ EGNOS	5°	22.11.07	2.90	-0.48	-0.62	0.795
8	GPS	5°	25.11.08	2.94	-0.41	-0.60	0.725
9	GPS	5°	26.11.08	3.49	-0.33	-0.55	0.639
10	GPS	5°	27.11.08	3.09	-0.67	-0.63	0.913

Figures 1, 2 and 3, show the data from three sessions:

- changes of the circular error in time M (95%),
- changes of latitude shift of mean position in time relative to geodetic position (Δφ [m]),
- changes of longitude shift of mean position in time relative to geodetic position (Δλ [m]),
- changes in time of mean position distance to geodetic position (R [m]).

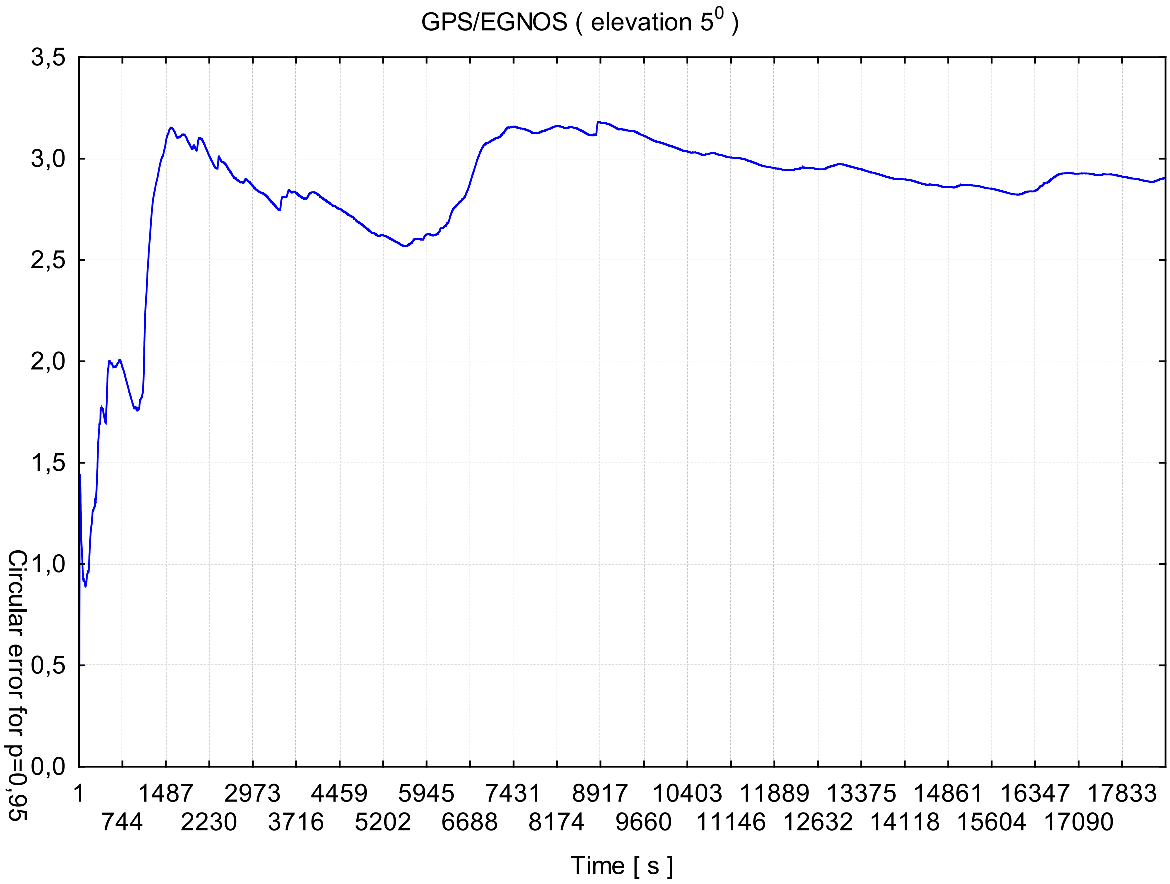

Figure 1. Changes of circular error after n seconds. Time scale x 5. Measurements of 22.11.2008

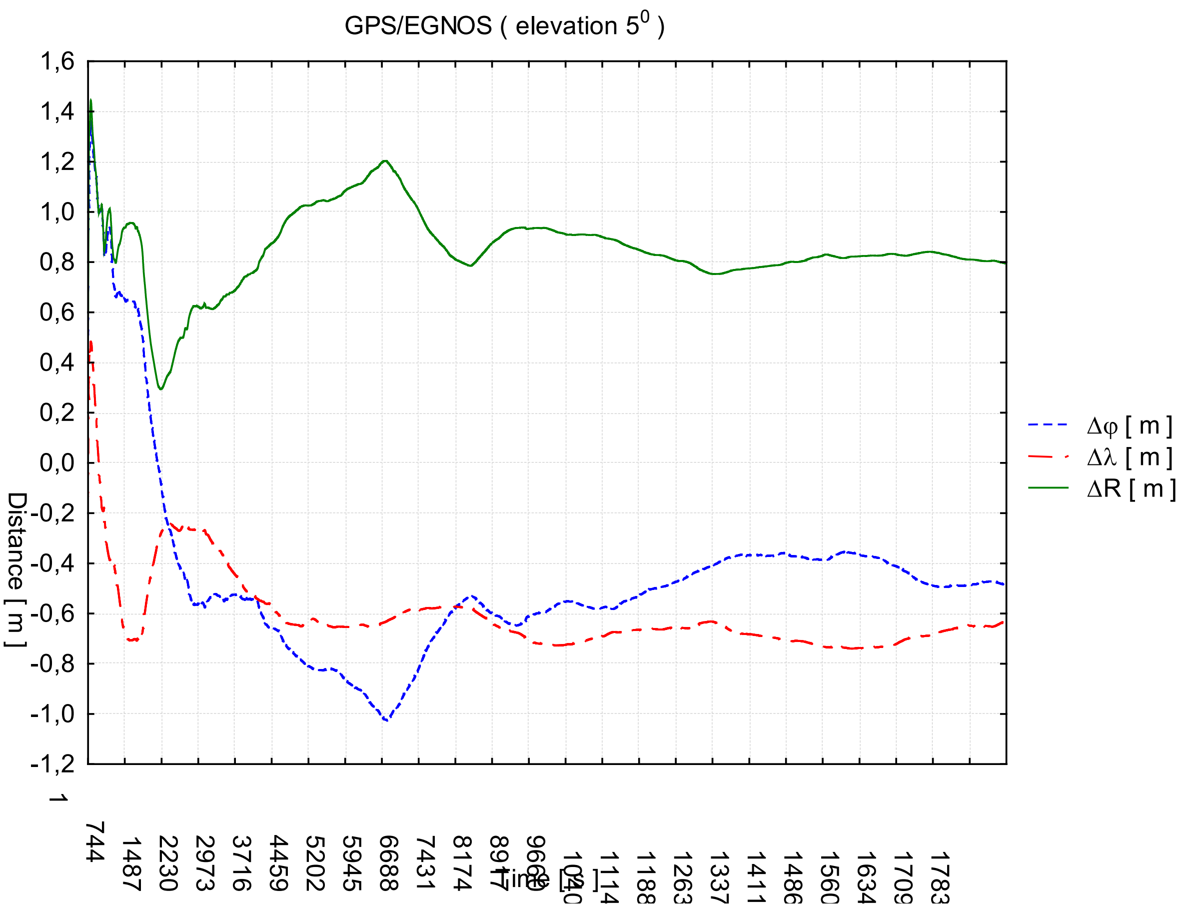

Figure 2. Changes of mean position shift after n seconds relative to geodetic position. Time scale x 5. Measurements of 22.11.2008

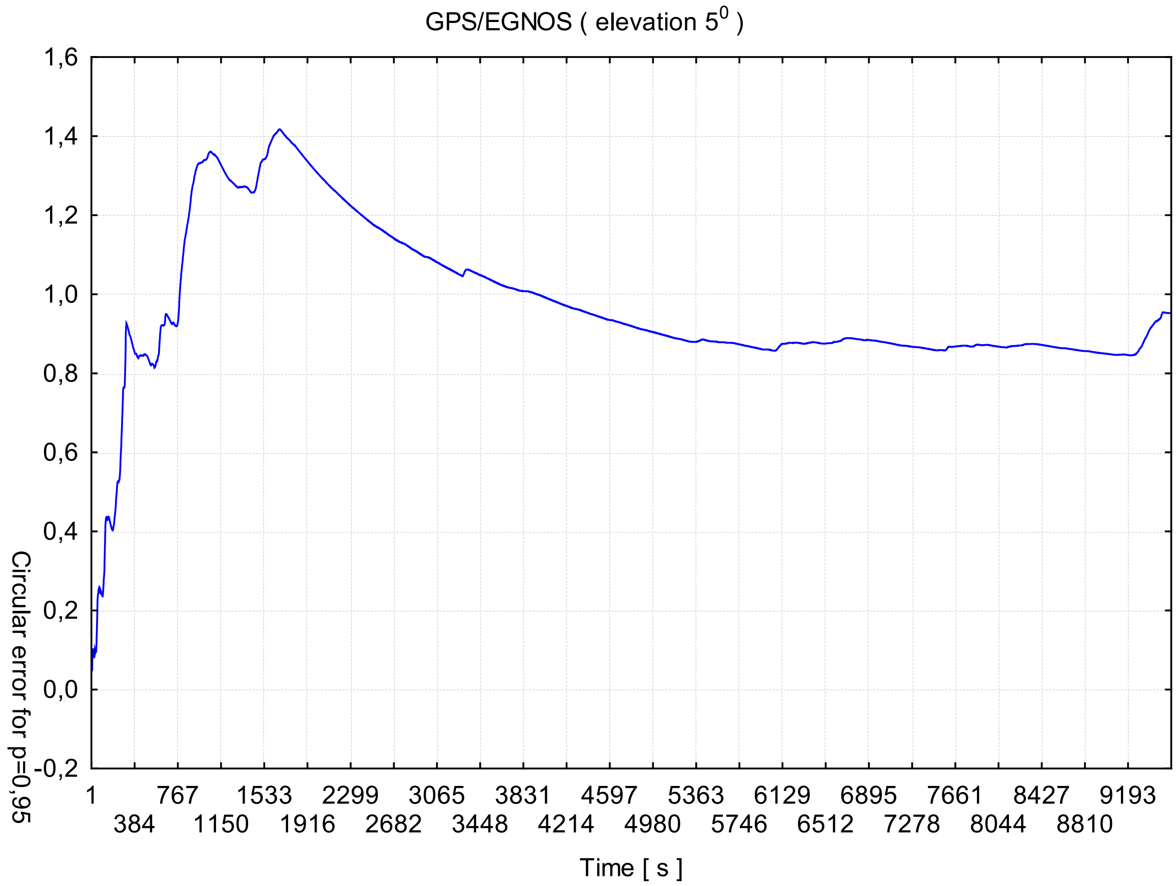

Figure 3. Changes of circular error after n seconds. Time scale x 5. Measurements of 23.11.2008

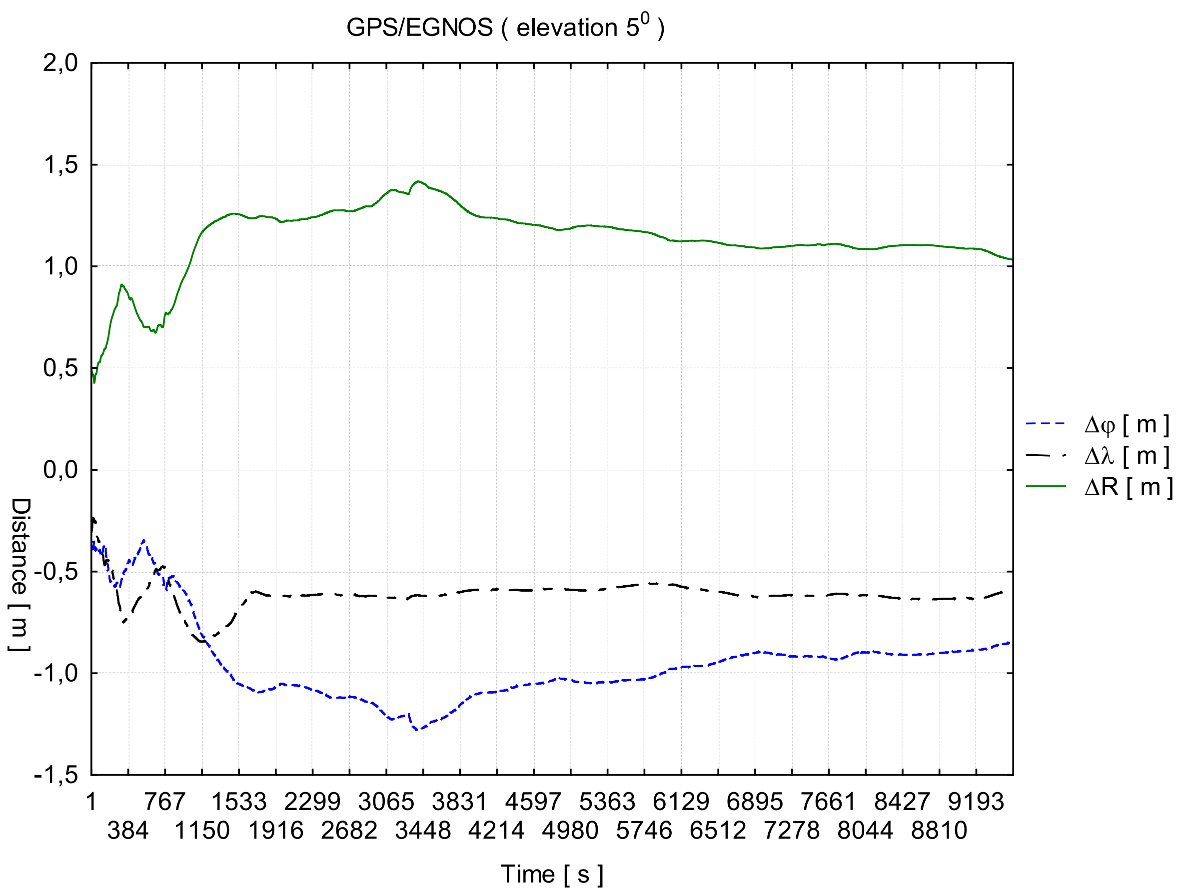

Figure 4. Changes in mean position shifts after n seconds relative to geodetic position. Time scale x 5. Measurements of 23.11.2008

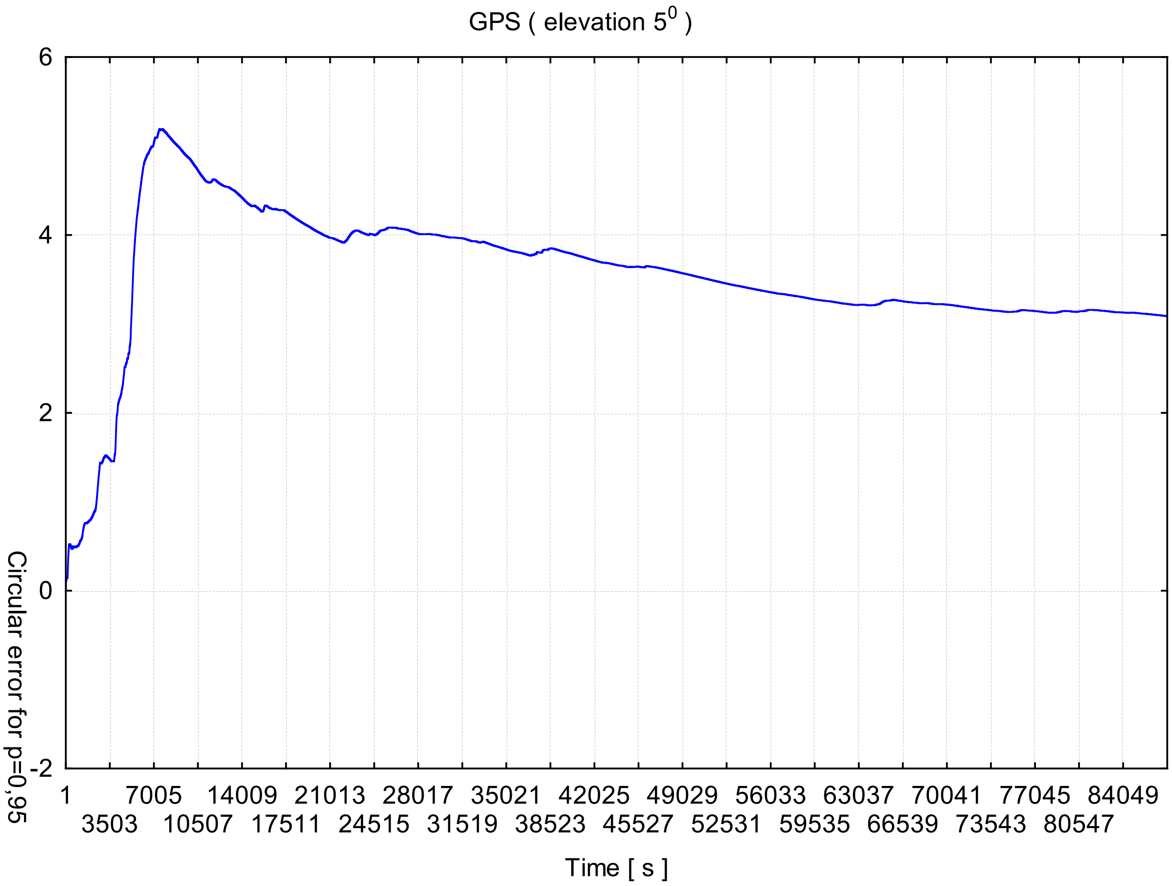

Figure 5. Changes of circular error after n seconds. Measurements of 27.11.2008

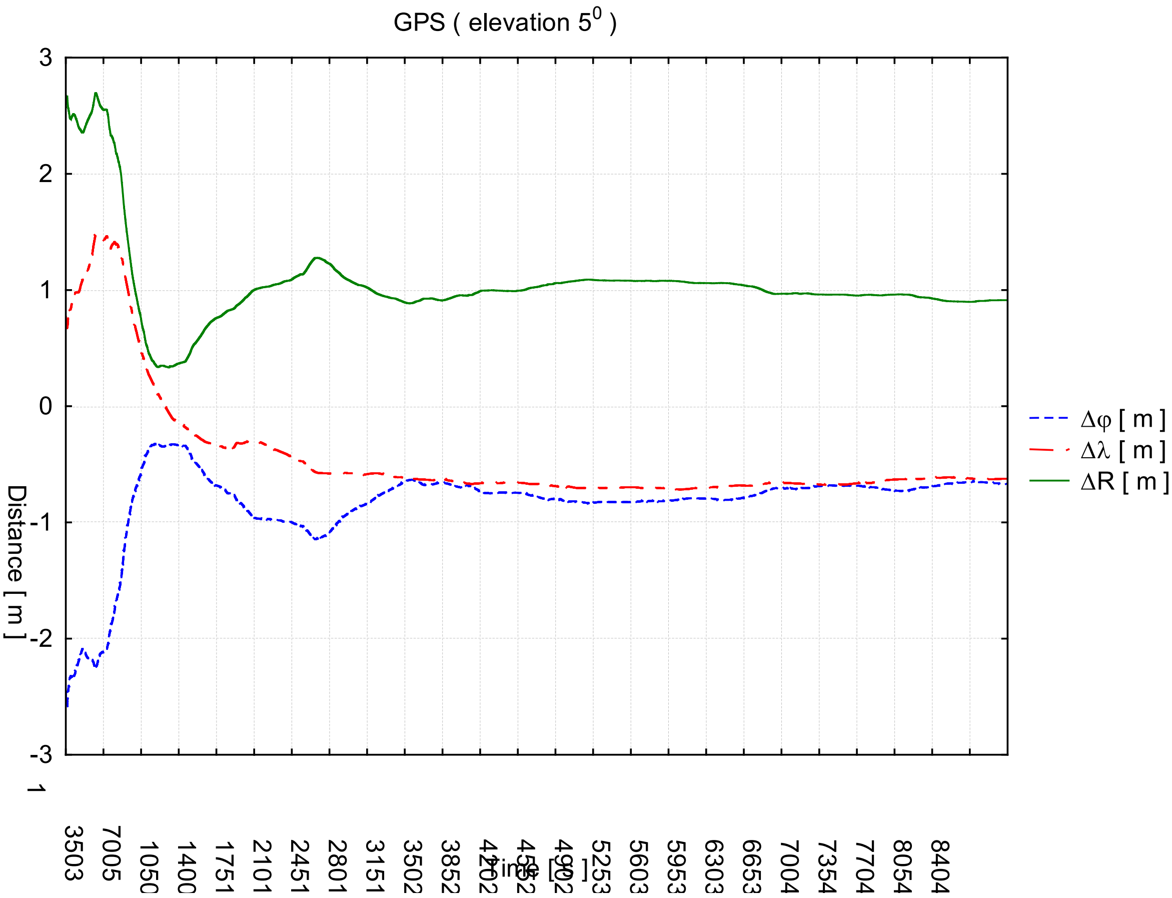

Figure 6. Changes of mean position shifts after n seconds relative to geodetic position. Measurements of 27.11.2008

3 CONCLUSIONS

1 In the first stage of measurements (one hour) both the position error determined from current readouts of the receiver and the mean position shift relative to the geodetic position show significant fluctuations. The position shift exceeds two meters.
2 After about 12 hours the mean position relative to the geodetic one seems to be stable. After that time the distances between the mean position and the geodetic position do not change more than 19 centimetres.
3 Even if there occur major disturbances during the measurements (2nd and 3rd measurement series) the mean position for a long period of measurements does not differ significantly from the mean position obtained from undisturbed measurements. This refers to both GPS and GPS/EGNOS measurements.
4 The accuracy of positions determined for long measurement series is similar for GPS and GPS/EGNOS systems.

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