JANUSZ SZPYTKO*, PAWEŁ HYLA
AGH University of Science and Technology
Faculty of Mechanical Engineering and Robotics
Mickiewicza Ave. 30, PL 30-059 Cracow, Poland
**Corresponding author*. E-mail: szpytko@agh.edu.pl

THE METHOD OF USING A GPS DEVICE FOR DISTANCE ASSIGNING

Summary. The paper is focusing on a method of using a GPS device for assigning distance with the NMEA standard. Experiment carried out showed the usefulness of the GPS/GSM module to use in mobile applications. Further works are required to increase the accuracy of positioning.

SPOSÓB UŻYCIA URZĄDZENIA TYPU GPS DO WYZNACZENIA ODLEGŁOŚCI

Streszczenie. Referat przedstawia sposób użycia urządzenia typu GPS do wyznaczania odległości z użyciem standardu NMEA. Przeprowadzony eksperyment wykazał użyteczność modułu GPS/GSM do zastosowań w mobilnych aplikacjach. Otrzymana dokładność pozycjonowania ogranicza obszar zastosowania wykonanego rozwiązania. Wymagane są dalsze prace w kierunku zwiększenia dokładności pozycjonowania urządzenia.

1. INTRODUCTION

Admission on the market of devices of positioning of the spatial type GPS (*Global Positioning System*) of navigations with the use of the system of satellite GPS-NAVSTAR (*NAVigation Signal Timing And Ranging*) [3,12] devices enhancing their operating possibilities are available. Linking devices of achieving the technology of the GSM type are an example (*Global System for Communications Mobiles*) for sending to the established position from the receiver GPS to the computer with the help of popular SMS (*Short Message Service / Simple Message System*). The sent information concerning the position and different parameters of the located object is implemented through the standard of the NMEA (*National Marine Electronics Association*) [10].

The NAVSTAR GPS is leaned against the group of satellites, circling in orbits at 20200 km above the Earth (two-time going around the Earth in the sequence of twenty-four hours). At present the system is being managed by the command of TheAir Force of the United States of America.

Using and organizing the type is an object of the statement GPS for appointing the distance with the use of NMEA standard (*National Marine Electronics Association*).

2. NMEA STANDARD

NMEA standard (*National Marine Electronics Association*) is an explicit specification of the interface which enables the communication between devices of different kind in the opened arrangement (*open source*) for a charge. GPS allows integration of the module of the type with different devices. The initial standard had the NMEA-0183 label, and being in effect in may of 2007 there was a 3.01 version. Every receiver operating the newer standard GPS must be also in accordance with the NMEA-0183 standard (it is so-called compatibility into the back).

By using the standard, sending independent fall-ropes is possible with NMEA (of line) of text data (of information), in which every time they are starting with the determined headline (of appropriate fall-rope of signs determining the type of the information) - Fig. 1. A possibility of establishing the position even is an advantage of such a format of data in case of loss of the previous record, because every individual line is independent from the previous. For needs of verification of the information sent by the receiver it is most often supplemented by the test sum which lets one check whether while sending they didn't surrender to the GPS for distortion. The standard of the NMEA type also enables to interpret newer standards, but headlines not interpreted by the existing application are being omitted without negative effects in the positioning.

```
$GPRMC,183729,A,3907.356,N,12102.482,W,000.0,360.0,080301,015.5,E*6F
$GPRMB,A,,,,,,,,,,,,V*71
$GPGGA,183730,3907.356,N,12102.482,W,1,05,1.6,646.4,M,-24.1,M,,*75
$GPGSA,A,3,02,,,07,,09,24,26,,,,,1.6,1.6,1.0*3D
$GPGSV,2,1,08,02,43,088,38,04,42,145,00,05,11,291,00,07,60,043,35*71
$GPGSV,2,2,08,08,02,145,00,09,46,303,47,24,16,178,32,26,18,231,43*77
$PGRME,22.0,M,52.9,M,51.0,M*14
$GPGLL,3907.360,N,12102.481,W,183730,A*33
$PGRMZ,2062,f,3*2D
$PGRMM,WGS 84*06
$GPBOD,,T,,M,,*47
$GPRTE,1,1,c,0*07
$GPRMC,183731,A,3907.482,N,12102.436,W,000.0,360.0,080301,015.5,E*67
$GPRMB,A,,,,,,,,,,,,V*71
```

Fig. 1. Example of data saved in the NMEA standard
Rys. 1. Przykład danych zapisanych w standarcie NMEA

In the NMEA standard every line of text must meet the following requirements:

- the line is starting from the sign $ and is ending with the sign of the new line (\ r),
- every line has the headline (from the sign $ to the first sign of the comma),
- the length of the line cannot cross 80 signs (plus the sign of the beginning of the line and the sign of the new line),
- data sent by the receiver in the given line is divided by the GPS in with signs of the comma (,),
- numerical data can have fractional places (after the dot),
- doesn't have the above established number of signs after the dot (different devices are characteristic of a GPS itself with different precision of the measurement),
- at the end of the line a test sum can be in the form (the star plus 2 HEX signs). The presence of the test sum at the end of the line is optional. Two numbers written in the hexadecimal system which is preceded are making the sum up with a star sign. The presence of the star sign always shows the beginning of the result of the test sum.

The headline of the line is being with the sign and always consists of a few letters. The first letters determine the code of the device (interpretation of the type and the different product is possible than GP, e.g.: company Magellan - PMGN, the GARMIN company - PGRM), however next determine applying the given headline and the presented information. Standard sequences of 26 starting headlines from GP signs described in the NMEA-0183 standard [9] ordered alphabetically have the form:

[$GP] AAM	- Waypoint Arrival Alarm
[$GP] ALM	- GPS Almanac Data
[$GP] APB	- Autopilot format "B"
[$GP] BOD	- Bearing, origin to destination
[$GP] BWC	- Bearing and distance to waypoint, great circle
[$GP] GGA	- Global Positioning System Fix Data
[$GP] GLL	- Geographic position, latitude / longitude
[$GP] GRS	- GPS Range Residuals
[$GP] GSA	- GPS DOP and active satellites
[$GP] GST	- GPS Pseudorange Noise Statistics
[$GP] GSV	- GPS Satellites in view
[$GP] HDT	- Heading, True
[$GP] MSK	- Control of a Beacon Receiver
[$GP] MSS	- Beacon Receiver Status
[$GP] R00	- List of waypoints in currently active route
[$GP] RMA	- Recommended minimum specific Loran-C data
[$GP] RMB	- Recommended minimum navigation info
[$GP] RMC	- Recommended minimum specific GPS/Transit data
[$GP] TRF	- Transit Fix Data
[$GP] STN	- Multiple Data ID
[$GP] VBW	- Dual Ground / Water Speed
[$GP] VTG	- Track made good and ground speed
[$GP] WPL	- Waypoint location
[$GP] ZDA	- UTC Date / Time and Local Time Zone Offset

The headline has its GGA ID badge. Every measurement (independently of organizing the class and the model) is being shown in one line (Fig.2). Distinguished in the line the sequence of signs has the following interpretation:

```
$GPGGA,123519,4807.038,N,01131.000,E,1,08,0.9,545.4,M,46.9,M,,*47
```

Fig. 2. The example code line written in the NMEA standard
Rys. 2. Przykładowa linia kodu napisana w standarcie NMEA

GGA	– ID badge of the headline,
123519	– actuality of data - 12:35:19 UTC,
4807.038,N	– latitude - 48 deg 07,038 'N,
01131.000,E	– longitude - 11 deg 31,000',
1	– quality of the measurement,
08	– amount of tracked satellites,
0.9	– horizontal accuracy of the HDOP (*Horizontal Dilution of Precision*) position, 545.4,M – height in undergrounds above sea level,
46.9,M	– height geoids above the WGS84 ellipsoid,
(empty field)	– timed from last updating DGPS (*Differential GPS*),
(empty field)	– number ID of the DGPS station,
*47	– test sum.

Horizontal accuracy of the HDOP (*Horizontal Dilution of Precision*) position is a rate assessing the accuracy of the measurement carried out. The description of the HDOP rate was presented in the study [5]. In standard measurements it is entertaining one another, that value of the HDOP rate is less than six (HDOP < 6).

A WGS-84 frame of reference was accepted in 1984. On the outlined ellipsoid every point has the determined situation (x, y, around) which are being counted to the geodetic arrangement being in effect in data of the covering country: the latitude, the height of the point above the surface area of the ellipsoid, geodetic length L [2].

DGPS (*Differential GPS*) are updating differences sent by earth stations, which are increasing the accuracy of measurements (not all devices are supporting this signals). The quality of the measurement each time is assessed by the receiver of the GPS and determined with the help of one of the given value [13]L below)

0 – is lacking the position, or a very big mistake exists (results should not be a subject of interpretation),
1 – located on the base GPS (*Global Positioning System*) or SPS (*eng. Positioning Service Standard*),
2 – located at the DGPS participation (*Differential GPS*),
3 – PPS position (*Precise Positioning Service*),
4 – cinematic mode with the so-called accuracy *geodetic* RTK (*Real Time Kinematics*),
5 – *float* cinematic mode with the so-called accuracy *geodetic* FRTK (*Float Real Time Kinematics*),
6 – approximate measurement,
7 – measurement in manual mode,
8 – measurement in the simulation mode.

3. THE NMEA STANDARD USING TO APPOINTING GPS DEVICE

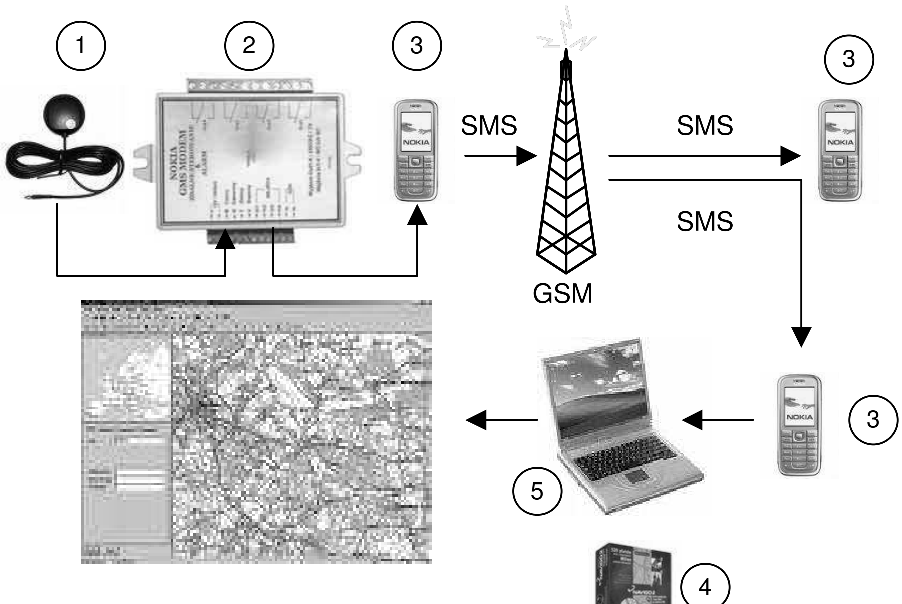

Fig. 3. Measuring path for appointing the distance with the geographical coordinate use: 1 – GPS aerial, 2 – GPS module, 3 – GSM phone, 4 – specialist software, 5 – PC class computer

Rys. 3. Ścieżka pomiarowa dla wyznaczenia odległości z użyciem koordynat geograficznych: 1 - antena GPS, 2 - moduł GPS, 3 - telefon GPS, 4 - dedykowane oprogramowanie, 5 - komputer klasy PC

They assumed that distances between devices were being calculated (appointed) on the basis of geographic coordinates. In order to calculate the distance on the attitude of two geographic coordinates they are using the so-called ortodroma (*gr. orto - accurate, correct / droma – the line, the road*) length. Ortodroma is the shortest way between two points on the surface (Fig. 4.) and constituting the fragment of the great circle. Ortodroma line through cutting in two the bullet with the plain AB going through points and its middle are received. Ortodroma length is appointing using the following relations (1) and (2).

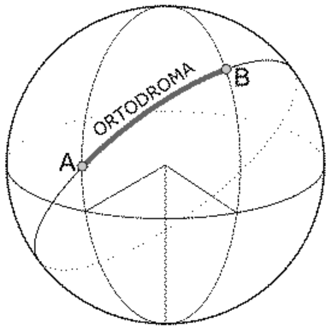

Fig. 4. Ortodroma between points A and B [6]
Rys. 4. Ortodroma pomiędzy punktami A i B [6]

$$d = arc\cos\left(\sin\left(\varphi_1\right)\sin\left(\varphi_2\right) + \cos(\varphi_1)\cos\left(\varphi_2\right)\cos\left(\lambda_1 - \lambda_2\right)\right) \tag{1}$$

$$d = 2arc\sin\left(\sqrt{\left(\left(\sin\left(\frac{(\varphi_1 - \varphi_2)}{2}\right)\right)^2 + \cos\left(\varphi_1\right)\cos\left(\varphi_2\right)\left(\sin\left(\frac{(\lambda_1 - \lambda_2)}{2}\right)\right)^2\right)}\right) \tag{2}$$

where:
φ_1 – latitude of the A point,
φ_2 – latitude of the B point,
λ_1 – longitude of the A point,
λ_2 – longitude of the B point.

The calculated distance with comparison to real distance value is burden with the possible position errors of the GPS device. For the possible position errors of the GPS the influence have the following factors [7]:

- ionospheric delay; 20-30 meters into the day and up to 3-6 meters into the night,
- troposferic delay; about 3 meters (it is dependent on the pressure, the temperature and the air humidity,
- ephemeras mistake; (effect of the gravity of the Sun, the Moon and the solar wind),
- satellite clock error; (difference between the perfect time of satellite clock and GPS receiver clock),
- receipt of signals reflected,
- receiver errors.

Possible errors have been presented in Table 1.

Table 1

The influence of environmental factors on measurement error (the *Selective Ability* is disable [4]

Possible error source	Possible error [m]
Ephemeras error	2,1
Clock error	2,1
Ionospheric delay	4,0
Troposferic delay	0,7
Receipt	1,4
Receiver errors	0,5
in total	**10,8**

4. EXPERIMENT DESCRIPTION

Pilot examinations were carried out on the length of 1500 [m] that was divided in 15 stretches for lengths 100 [m] every (Fig. 5), 16 points. Taken by the receiver GPS in appointed points geographic coordinates (Fig. 6) enabled next by using mathematical ortodoma's model (equations no no 1 and 2) appointing by the distance between these points. Data was sent in NMEA format by the GSM phone accepting text messages (SMS) sent on the phone to GSM by GPS connected to the module.

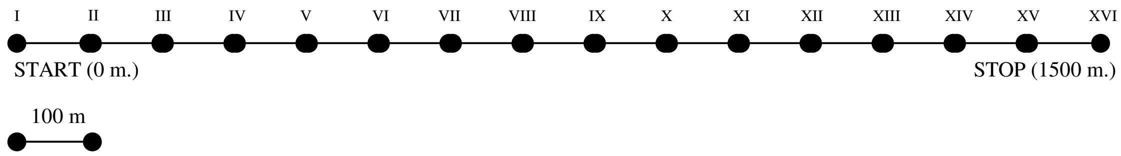

Fig. 5. The situation sketch of the subject of experiment
Rys. 5. Rysunek sytuacyjny przedmiotu eksperymentu

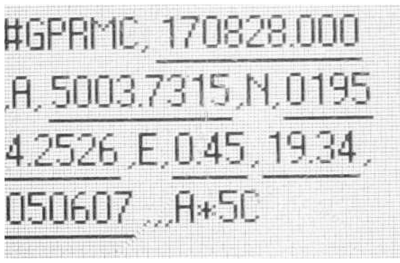

Fig. 6. The SMS screen with the information about the location with the use of the NMEA standard (for the point of measuring no II - Fig. 5)
Rys. 6. Ekran SMS z informacją o lokalizacji z użyciem standardu NMEA (dla punktu pomiaru nr II - Rys. 5)

Data with the correct test sum with geographic coordinates were cut from individual sequences of the line of the NMEA standard (Table 2). Data was receive from 16 arranged points to the lengths of 1500 flat.

Table 2

Geographical coordinates of individual points - Fig.5

No of measurement point	Geographical coordinate		Calculated distance [km]
	Latitude [φ]	Longitude [λ]	
I	5003.5714 N	01954.1686 E	
II	5003.7315 N	01954.2526 E	
III	5003.7183 N	01954.3343 E	0,100 (II-III)
IV	5003.7062 N	01954.4195 E	0,104 (II-IV)
V	5003.7014 N	01954.4910 E	0,085 (IV-V)
VI	5003.6849 N	01954.5756 E	0,105 (V-VI)
VII	5003.6676 N	01954.6596 E	0,105 (VI-VII)
VIII	5003.6599 N	01954.7355 E	0,091 (VII-VIII)
IX	5003.6467 N	01954.8172 E	0,100 (VIII-IX)
X	5003.6334 N	01954.8999 E	0,100 (IX-X)
XI	5003.6194 N	01954.9836 E	0,104 (X-XI)
XII	5003.6045 N	01955.0674 E	0,103 (XI-XII)
XIII	5003.5966 N	01955.1421 E	0,090 (XII-XIII)
XIV	5003.5859 N	01955.2221 E	0,097 (XIII-XIV)
XV	5003.5709 N	01955.3029 E	0,100 (XIV-XV)
XVI	5003.5571 N	01955.3849 E	0,101 (XV-XVI)

1,446 (I-XVI)

With the Gauss distribution it was calculated: medium x_m value (equation 3), standard S_x deviation (equation 4) and confidence interval of the Δ measurement (equation 5) [14]:

$$x_m = \sum_i \frac{x_i}{n} \tag{3}$$

$$S_x = \sqrt{\frac{\sum_i (x_i - x_m)^2}{n-1}} \tag{4}$$

$$\Delta = t_{(n-1)\alpha} \frac{S_x}{\sqrt{n}} \tag{5}$$

In the result of calculations: x_m = 98.9285 [m], S_x = 6.1452 [m], Δ = 3.5475 [m]. The enumerated approximate accuracy of the isolated measurement is taking out: x = 98.9285 ± 3.5475 [m]. Compared data with possible random walk of GPS introduced in Table 1is a subject of satisfaction.

5. CONCLUSION

Experiment carried out showed the usefulness of the GPS/GSM module to use in mobile applications. Further works is required to increase the accuracy of positioning.

Presented solution can send automatically 90 SMS in one hour what is giving the maximum resolution: 1 SMS for 40 seconds. To eliminate dead points of the object locations further works should be undertaken to increase this resolution.

Acknowledgement

The research project is financed from the Polish Science budget for the years 2005-08.

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