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Etrex Garmin GPS Receiver Accuracy Testing

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Abstract- Global Positioning System (GPS) is a system that helps users to determine their geographical position with sufficient accuracy. Accuracy of the obtained coordinates depends on number of parameters such as the type of GPS receiver used, and observation technique adopted. Since hand held GPS receivers are mainly manufactured for navigation purposes, sometimes users utilize these receivers for mapping purposes without knowing the accuracy of observed coordinates and suitability of collected data for particular mapping scale.

Here, in this research work, EtrexGarmin hand held navigation GPS receiver was tested to evaluate its accuracy and justify suitability of its collected coordinates mapping purposes. Results showed that Etrex Garmin GPS receiver produces planimetric accuracy of 3.16m. On the other hand, the vertical accuracy above ellipsoid was found to be 7.68m.

If topographic maps are intended to be produced, thenit has to take into account that linear accuracy that can be obtained with EtrexGarminGPS receiver is 8.30m.

Index Terms**–** *Global Positioning System (GPS), Mapping, Navigation,Planmetric Accuracy, VerticalAccuracy.*

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I. INTRODUCTION

Positioning or coordinate determination is the process by which location of point can be figured out relative to a known coordinate system. This coordinate system can be local, geographical, geodetical or others.These coordinates can bedetermined using conventional or modern land surveying techniques. Recently GPS receivers become the most important tool of obtaining such coordinates. But, these receivers can be precise such as those used for geodetic purposes or non-precise, such as those used for common purposes. Hand held GPS Receivers are manufactured for navigation purposes and not for precise work. For precise work, especialGPS instrument are manufactured.

Although photogrammetric and remote sensing are the practically used techniques for mapping large areas, land survey methods are applicable for mapping small areas by coordinating large number of points. In this case GPS can be viewed as time saving and cost reducing technique.

II. OVERVIEW OF GLOBAL POSITIONING SYSTEM

GPS devices determine their position by receiving radio signals broadcast from the GPS satellites orbiting above the earth. Using three-dimensional trilateration, the device figures out its distance from four different satellites in the constellation. Then calculates its own position using this information.

The system has been divided into three sections; satellite, administrative and user units.

Satellites unit, also known as space segment,concerned with satellites operating system.Consists of 24 satellites operating in 6 orbital planes spaced at 60˚ interval around the equator. Four additional satellites are held in reserve as spares. The satellites travel in near-circular orbits inclined 55 degrees to equator and have a mean altitude of 20,000km above the earth and an orbital period of 12 sidereal hours.

Precise atomic clocks are used in the GPS satellites to control the timing of the signal they transmit.

The satellite sends the message into two different waves, which are known as, Long Band$_1$ (L_1) with 10.23×154 MHz and Long Band$_2$ (L_2) with10.23×120 MHz.The waves carrier band L_1 and L_2, carry two types of information. One is L_1 carrier frequency signal, consists of the amount of 1575.42 *MHz*, and precise code known as P-Code, with 19 mm as wavelength (λ), or another carrier frequency signal known as Course Acquisition (C/A-Code). In addition to navigational information message known as (N.M) with 50 *MHz*, only exist in L_1 carrier frequency; this is what differentiates between L_1 from L_2, note that L_2 does not have (C/A-Code) and its wavelength (λ) is 244mm.

The signals usually in the random or pseudo form known as Pseudo Random Noise (PRN), which is used to distinguish between satellites. To interpreting PRN it needs to use special devices receivers.

Administrative unit or control unit containing five monitoring stationsat which the signals from the satellites are monitored and their orbits tracked. The tracking information is relayed to the master control station in Colorado Springs. The master control station uses this data to make precise near futurepredictionsof the satellite orbits, and their clock correction parameters.

GPS user unites or receivers rang in precision and capabilities. Geodetic or survey receivers provide high accuracy and have numerous capabilities of mapping. Navigation and geographic information system (GIS) receivers produce lower accuracy and have limited capabilities.

The major differences in the receivers are the number of channels available and whether or not the receiver can observe both L1 and L2 frequencies; code phase and carrier phase may also be measured. Generally speaking, dual frequency receivers require much shorter observation times for positioning measurements than do the single- frequency receivers and can be used for real-time positioning. Some low-end, general-purpose GPS receivers track only one channel at a time (sequencing from satellite to satellite as tracking progresses); an improved low-end, general- purpose receiver tracks on two channels but still must sequence the

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tracking to other satellites to achieve positioning. Some low-end surveying receivers can continually observe on five channels, whereas some-end surveying receivers can observe on twenty channels. Some receivers can log data every 15 second-controlling photogrammetric camera operation- while other geodetic-quality receivers can log data every second.

III. APPLICATION OF GPS

Now a days, GPS become applicable in different field. This is so because, by using GPS the positions can be located anywhere on the earth and at any time, that's because the GPS satellites cover the whole world 24 hours. Also, GPS allows the user to know position information with remarkable accuracy. Moreover, anyone who can read coordinates and find the corresponding position on a map can use a GPS receiver.

The GPS system was developed to meet military needs, but new ways to use its capabilities in everyday life are continually being found. The system has been used in aircraft and ships, helps to save lives and property (mining and medical units in the case of emergency), identification of areas of the fires in the forests, mapping and construction, track vehicles (public transport and postal services)., manufacturers and car rental (give instructions to the driver on the screens through recorded voice instructions) and balloons monitor the ozone layer over the holes in the Polar Regions (these are some of which).

IV. RELATED WORKS

In previous work author in [10] evaluate planimetricaccuracy that can be obtained using the hand held GPS receiver. Results obtained, showed that the hand held GPS receiver can practically provide horizontalaccuracy of about 4m and proved its suitability of using its collected data to produce planimetric maps at scale 1:7,500 and smaller.Hand held GPS receivers can successfully be used for collecting data for mapping in different fieldsincluding national, and town maps.Moreover, Ground control points for adjusting satellite images of 5m resolution and less, can be established using hand held GPS receivers.

In this research work EtrexGarminhand held GPS receivers is used and number of tested points were increased. More over study area wasextended to cover larger area of Khartoum capital.

V. MEASURMENTS AND RESULTS

The study area of this research work was extended to cover about 15×15 km of Khartoum capital area (Sudan).

The approach of estimating the accuracy of EtrexGarminGPS receiver is using it for observing coordinates of precisely known points. Then comparing results. Differences between actual coordinates and EtrexGarminobserved coordinates are then analyzed.

Number of 25 points were selected to cover the study area. These points were precisely observed in the field using Deferential Global Positioning System (DGPS) model R8-GNN from Trimble Company. Static mode system are used every 45 minutes for observe each point. Unexpected amount accuracy was equal to 0.5 cm ±1ppm. Table (2) below is the result of Eastings (E), Northings (N) and Heights (H) of observed coordinates of the points.

Table (1) Precisecoordinates

Point	E(m)	N(m)	H(m)
1	449101.669	1725509.714	383.113
2	448340.140	1725365.933	383.415
3	448412.645	1724739.837	383.519
4	448367.877	1724260.062	381.851
5	448470.900	1723645.658	382.161
6	448400.810	1723172.145	383.810
7	449144.144	1724130.761	381.782
8	449152.327	1723066.223	384.543
9	450199.025	1725462.274	381.784
10	450159.446	1724744.166	383.997
11	450067.027	1724230.469	385.429
12	450198.86	1723497.647	385.493
13	450078.078	1722963.961	383.832
14	450921.739	1725231.631	386.380
15	450718.066	1724957.814	383.806
16	450877.109	1724054.616	383.764
17	450775.234	1723581.077	383.200
18	451003.688	1723088.568	385.259
19	462452.600	1711316.563	384.013
20	463230.526	1711107.382	383.482
21	462465.290	1710147.500	385.072
22	462700.003	1710913.440	383.900
23	463209.022	1710914.899	382.461
24	463416.010	1710678.511	381.387
25	463430.331	1710306.879	383.140

EtrexGarminGPS receiver was then used to find out the coordinates of the 25 points. Table (2) below demonstrates the results.

Table (2) EtrexGarminNavigator coordinates

Point	E(m)	N(m)	H(m)
1	449103.000	1725511.000	387.000
2	448340.000	1725363.000	389.000
3	448411.000	1724743.000	388.000
4	448370.000	1724259.000	391.000
5	448471.000	1723643.000	391.000
6	448398.000	1723173.000	388.000
7	449147.000	1724131.000	385.000
8	449153.000	1723068.000	397.000
9	450198.000	1725461.000	394.000
10	450161.000	1724743.000	387.000
11	450066.000	1724234.000	400.000
12	450195.000	1723500.000	394.000
13	450080.000	1722966.000	390.000
14	450923.000	1725233.000	403.000
15	450714.000	1724956.000	395.000
16	450876.000	1724051.000	389.000
17	450776.000	1723579.000	391.000
18	451003.000	1723092.000	390.000
19	462456.000	1711318.000	387.000
20	463233.000	1711105.000	386.000
21	462467.000	1710147.000	388.000
22	462699.000	1710910.000	387.000

23	463213.000	1710916.000	385.000
24	463418.000	1710678.000	384.000
25	463414.000	1710304.000	388.000

Differences in coordinates (Δ) between precise and EtrexGarmincoordinateswere computed and listed as shows below in table (3)

Table (3) Differences

Point	ΔE(m)	ΔN(m)	ΔH(m)
1	1.331	1.286	3.887
2	0.140	2.933	5.585
3	1.645	3.163	4.481
4	2.123	1.062	9.149
5	0.100	2.658	8.839
6	2.810	0.855	4.190
7	2.856	0.239	3.218
8	0.673	1.777	12.457
9	1.025	1.274	12.216
10	1.554	1.166	3.003
11	1.027	3.531	14.571
12	3.860	2.353	8.507
13	1.922	2.039	6.168
14	2.261	1.369	16.620
15	4.066	1.814	11.194
16	1.109	3.616	5.230
17	0.766	2.077	7.800
18	0.688	3.432	4.741
19	3.400	1.437	2.987
20	2.474	2.382	2.518
21	1.710	0.500	2.928
22	1.003	3.440	3.100
23	3.978	1.101	2.539
24	1.990	0.511	2.613
25	3.669	2.879	4.860

Referring to resultsin table (3) above it can be found that EtrexGarminGPS receiver can provide anaverage accuracy of approximately 2m in easting and also 2m in northing with about4m rang in both.

The Root Mean Square Error (RMSE)of easting, northing and height were found to be 2.258, 2.204 and 7.681m respectively. This results produces planimetric accuracy of 3.155 and linear accuracy of 8.304m. Table (4) below summarizes these results.

Table (4) Result analysis

Δ	E(m)	N(m)	H(m)
RMSE	2.258	2.204	7.681
Rang	4	4	17
Planmetric Accuracy	3.155		
Linear Accuracy	8.304		

VI. CONCLUSION

Referring to tests carried out and results obtained it can be said that EtrexGarminGPS receiver can be used to find out coordinates of single points with accuracy of about 2.2m in both, easting and northing. Thus, it can be used successfully to produce planimetric accuracy of about 3.12m. Although GPS heights measured relative to ellipsoid, they can be determined up to 7.68m accuracy with EtrexGarminGPSreciever.

Linear accuracy that can be obtained with EtrexGarminGPS receiver is 8.30m.

Compared with previous work it can be said that hand held GPS receiver producedslightly betteraccuracy.

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