Education & Science Journal of
Policy Review and Curriculum Development
Hard Print: 2315-8425 Online: 2354-1660

November, 2016

Vol. 6, No. 1

Towards Improving the Accuracy of Positioning Data Obtained using Handheld Global Positioning System (GPS)

[1]**Ahmed Babayo,**
[2]**Mohammed Jawaluddeen Sani, &**
[3]**Shuaibu Umar**
[12&3]*Department of Surveying and Geoinformatics,*
Federal Polytechnic Bauchi

Abstract

Hand held GPS receiver is a popular instrument among practicing Surveyors due to its portability, and low cost. It is designed for reconnaissance, low accurate positioning and navigation. However, it was observed that handheld global positioning system (GPS) is now being use indiscriminately for survey jobs that require higher accuracy such as Cadastral boundary surveys. This paper is about development of window based user friendly software that can be used to post-process the position data acquire by handheld global positioning system (GPS) with a view of improving the accuracy of the processed data. The software was designed to refine and improve the accuracy of handheld global positioning system (GPS) data acquired simultaneously over a known (control) point and unknown point(s).The output result of a set of refined coordinates of the observed points in a text file which can be an input to most of the common Cartographic/GIS software such as AutoCAD, Civil CAD, ArcGIS, QGIS and suffer. The flexibility and efficacy of the software was validated using field observation over known points with an improvement in the region of about ±0.2m.

Keywords:
Handheld GPS, ATBUGPS Software, GPS coordinates, Control Point, and Post-processing

Corresponding Author:
Ahmed Babayo

Background to the Study

Global Positioning System (GPS) is essentially designed for global navigation and guidance. These systems brought about a new and unique approach to surveying, positioning and mapping. It provides precise timing and positioning information anywhere on the Earth at a low cost. The systems can be operate in the day or in the night and do not require cleared lines of sight between survey stations (Khalil, Mohammed, & LAmmaldean, 2014).

GPS positioning is based on the method of trilateration, signals from a minimum of four GPS satellites is required by the GPS receiver for the determination of its position as well as time (Gunter, 2003). Due to a number of error sources such as satellite orbit, clock errors, ionospheric and trophospheric delays as well as multipath effect, the usually claim of positional accuracy of about 3-5meters are seldom achieved. This brought about the emergence of different techniques and procedures of observations to minimize the effects of the errors.

The portability and affordability makes Handheld GPS receivers popular among Nigerian Surveyors, consequently it is now being use indiscriminately for survey jobs that require higher accuracy. Therefore, there is the need to device means of minimizing the error to improve the accuracy of data acquired using Handheld GPS. This paper aimed at presenting an improved techniques for data collection and processing using a window based user friendly software package design for the post-processing of positioning data acquire using handheld GPS receiver. The primary aim is to enhance the reliability and positional accuracy of the Handheld GPS receiver position data.

Theoretical and Conceptual Framework

The GPS is a satellite-based navigation system designed by US Department of Defense DoD that uses the constellation of 24 operational satellites orbiting the earth and continually broadcast a unique signal on the two carriers, which are transmitted in the L band of microwave radio frequencies, identified as L1 and L2 signals with frequencies of 1575.42 MHz and 1227.60 MHz respectively (Moca, 1999).

The system consists of three Segments, namely the space, the control, and the user segments.

GPS Composition

1. **The space segment** consists nominally of 24 satellites operating in six orbital planes spaced at 60° intervals around the equator. The orbital planes are inclined to the equator at 55°.
2. **The control segment** consists of 5 monitoring stations, one meter control station at the Consolidated Space Operations Center (CSOC) located at Schriever Air Force base in Colorado Springs USA.
3. **The user segment** consists essentially of a portable receiver/processor and an Omni-directional antenna.

The GPS Signal
Each GPS satellite transmits two different PRN codes. The L1 signal is modulated with the precise code, or P code, and also with the course/acquisition code, or C/A code. The L2 signal was modulated only with the P code. Each satellite broadcasts a unique set of codes known as GOLD codes that allow receivers to identify the origins of received signals. This identification is important when tracking several different satellites simultaneously.

The C/A code has a frequency of 1.023 MHz and a wavelength of about 300 m and it is accessible to all users. The P code, with a frequency of 10.23 MHz and a wavelength of about 30m, is 10 times more accurate for positioning than the C/A code. To meet military requirements, the P code is encrypted with a W code to derive the Y code. This Y code can only be read with receivers that have the proper cryptographic keys. This encryption process is known as anti-spoofing (A-S). Its purpose is to deny access to the signal by potential enemies who could deliberately modify and retransmit it with the intention of "spoofing" the unwary friendly users (Khalil, Mohammed, & LAmmaldean, 2014).

Principles of GPS Positioning
Conceptually, GPS observable ranges from receivers located on ground stations of unknown locations orbiting GPS satellites whose positions are known precisely. These ranges are deduced from measured time or phase differences based on a comparison between received signals and receiver generated signals. Algebraically, (Schwieger, 2003) the system of equations used to solve for the Position of the receiver and clock bias are:

$$R_A^i = \rho_A^i(t) + c\left(\delta^i(t) - \delta_A(t)\right)$$

Where
A is the observed range from receiver to satellites.
t is the epoch (time)
c is the speed of light in a vacuum.

The receiver clock bias, and the satellite clock bias, can be modeled using the coefficients supplied in the broadcast message.

$$R_A^i = \sqrt{(x^i - x_A)^2 + (y^i - y_A)^2 + (z^i - z_A)^2}$$

Factors affecting position accuracy
The accuracy of the position determined using a single receiver essentially is affected by the following factors:

a. Accuracy of each satellite position,
b. Accuracy of pseudo range measurement,
c. Geometry of the observed satellites. (Abdulkadir Funtua, 2010)

Development of Differential Global Positioning System (DGPS)
The degradation of the point positioning accuracy by SA has led to the development of Differential GPS (DGPS). This technique is based on the use of two (or more) receivers, where one (stationary) reference or based receiver is located at a known point and the position of the rover receiver is to be determined. At least four common satellites must be tracked simultaneously at both sites. The known position reference receiver is used to calculate corrections to the GPS derived position or to the observed pseudo range. These corrections are then transmitted via telemetry (i.e., controlled radio link) to the roving receiver and allow the computation of the rover position with far more accuracy than the single-point positioning mode (in RTK mode), otherwise the rover and base station data are collected and processed without linkage in real time (Static mode).

The fundamental assumption in Differential GPS (DGPS) is that the errors within the area of survey would be identical. This assumption is acceptable within a limited distance between the Rover and the Base station, where the areas involved are small compared with the distance to the satellites (Hofmann-Wallenhof, 2014).

Material and Method
ATBU GPS Software Overview
ATBU GPS software for handheld data processing is made up of four modules namely; data import and blunder detection module, Shift computation and application module, data adjustment and result compilation module and display and export module.

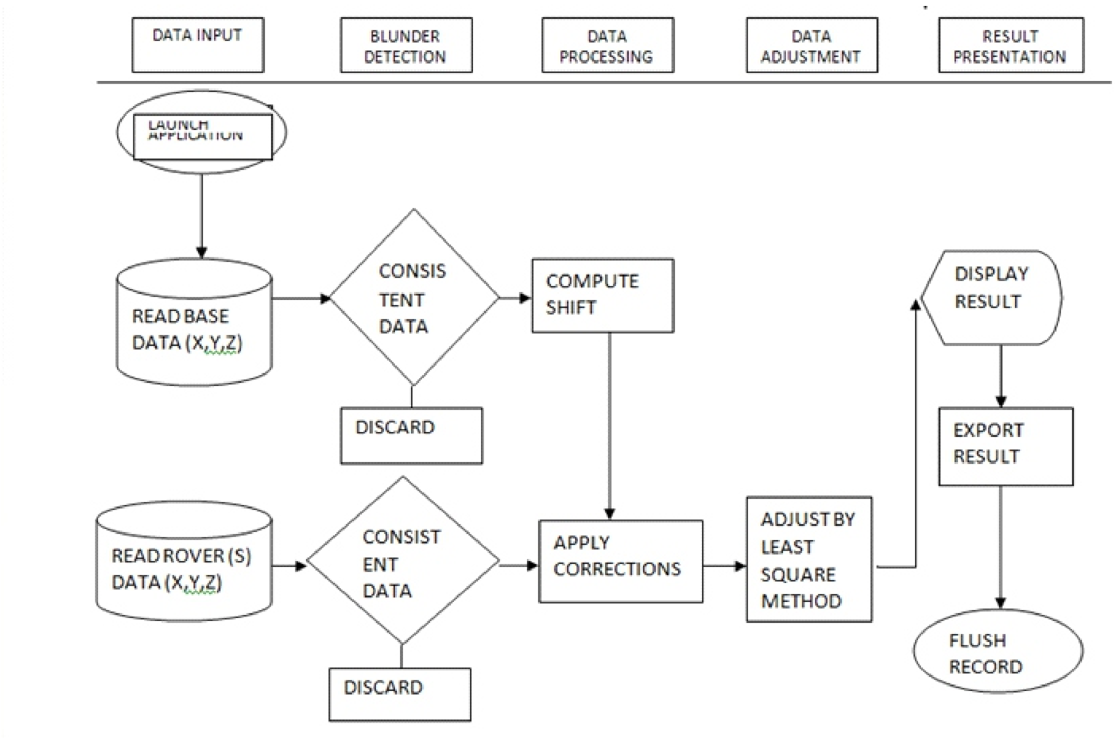


Fig. 1 Flow chart describing the software structure

Software Models
The following mathematical model where used in the development of the software (ATBU GPS).

Coordinate Computation Procedure
The mathematical relationships employed for the computation of the coordinates are based on the following algorithm.
$X_B = X_A + \Delta X$
$Y_B = Y_A + \Delta Y$
$Z_B = Z_A + \Delta Z$

Where
*($X_{A,}$ $Y_{A,}$ Z_A) are the coordinates at the base station A,
* ($X_{B,}$ $Y_{B,}$ Z_B) are the coordinates at the unknown station B, and
*($\Delta X_,$ $\Delta Y_,$ ΔZ) are the computed baseline vector components.

Shift Computations
The difference between the known and the observed coordinates of the Control station can be calculated using the following mathematical expressions.
$\partial N = No - Nc$
$\partial E = Eo - Ec$
$\partial h = ho - hc$

Where
1. ∂N, ∂E, ∂h are the shift in Northing, Easting, and Heights coordinates at the base station.
2. No, Eo, ho, are observed Northing, Easting, and Heights coordinates at the base station and.
3. Nc, Ec, hc, are Northing, Easting, and Heights coordinates of the control station.

Application of Shift Corrections
From the fundamental assumption in Differential GPS (DGPS), that the same errors occur in the GPS observation receiving signal from the same satellite configuration at the same time. The shift computed from the Base station can be applied as correction to the rover observation on synchronous to the time of observation. This can be expressed mathematically as follows: $R^p_{ijk}(t) = R^o_{ijk}(t) + (B^o_{ijk}(t) - B^c_{ijk}(t))$

Where
*$B^o_{ijk}(t) - B^c_{ijk}(t)$ are the shift in Northing, Easting, and Heights coordinates at the base station at the time (t).
* $R^o_{ijk}(t)$ are observed Northing, Easting, and Heights coordinates at the Rover station at the time (t),
* $R^p_{ijk}(t)$ are the processed Northing, Easting, and Heights coordinates of the Rover station.
$R^p_{ijk}(t) = R^o_{ijk}(t) + \partial_{ijk}(t)$

Least Square Adjustment

To obtain a single, unique coordinate of the point being observed, the Least Square Adjustment model in the software is used to enable us to compute the MPV of the set of the observation. This is achieved by minimizing the sum of squares of the residuals. Mathematically expressed as:

$\sum_{i=1}^{n} vi^2$ = minimum. (Wolf & Ghilani, 1997)

The residuals are the differences between mean and each of the respective set of the observation.

Software Limitations

All the modules in the software (ATBUGPS) were design using Wave-based Php Programming Language. The ATBUGPS software presented in this paper is limited to producing a result that is a set of coordinates in txt scripts or acii which can be recognize, read and plot directly in AutoCAD or ArcGIS software packages.

Field Validation

Four controls stations namely DSUG01, DSUG02, DSUG07, DSUG08, were used to validate the software. The DSUG01 station was used as a base station while the remaining three were used for rover stations. The positions were sequentially changed, this enable a set of four observations were each control station was made the master station until all the four were occupied respectively.

Instrument Used

1. Two set of computer system (Laptop).
2. Two Interface cable.
3. Two Handheld GPS receivers.

Data Acquisition Procedure

1. The **dnr Garmin** software was downloaded and installed on the two computers PC, and both were connected to a Garmin GPS 74H using data transfer cable as shown in Plate 1. Below
2. One of the systems was set on an established control station (DSUG 01), where the middle of Handheld GPS antenna phase was placed on the beacon center nail and starts to acquire data continuously at 15seconds epoch.
3. While the other set was set up on another point (DSUG 02) and allow to acquire data at the same epoch of 15seconds for a duration of 5minute. The data was saved to a computer as txt format.
4. Same procedure was carried out on two more stations (DSUG 07 and DSUG 08).
5. The data collected on all the four stations were saved in a folder on a computer. Plate 1. Shows the data acquisition set up.

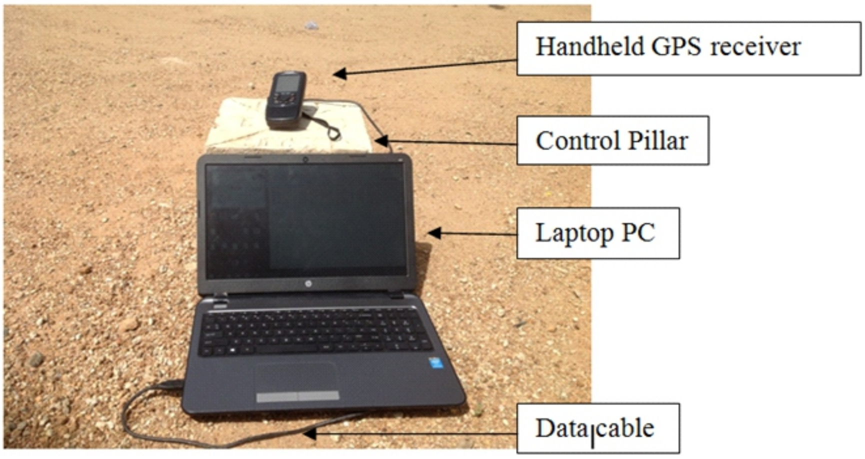


Plate1. Data acquisition set up.

Data Processing
The processing of acquired field data was as follows.

Data Import and Blunder Detection.
ATBUGPS software was installed on the computer and launch. The startup page is shown below Fig 2. Only authorized user using his username and password to access the software.

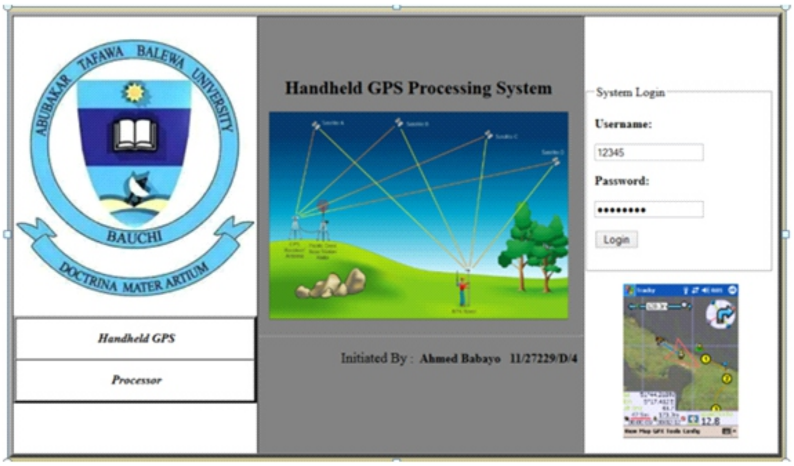


Fig.2. Screen view of Application start up page

After logging the base data was loaded by clicking "Load Base Data" from the main menu bar through window explorer from the home page. As shown in Fig 3. below

Fig.3. Screen view of Application Home Page

"Filter Data" was then click from the menu bar, this removed the outliers from the set of observation and show the result as shown in Fig 4. Then the coordinates of the control point were imputed at the bottom Under "Register Control coordinates" command and "Compute Shift" button was clicked. Result shown in Fig 5

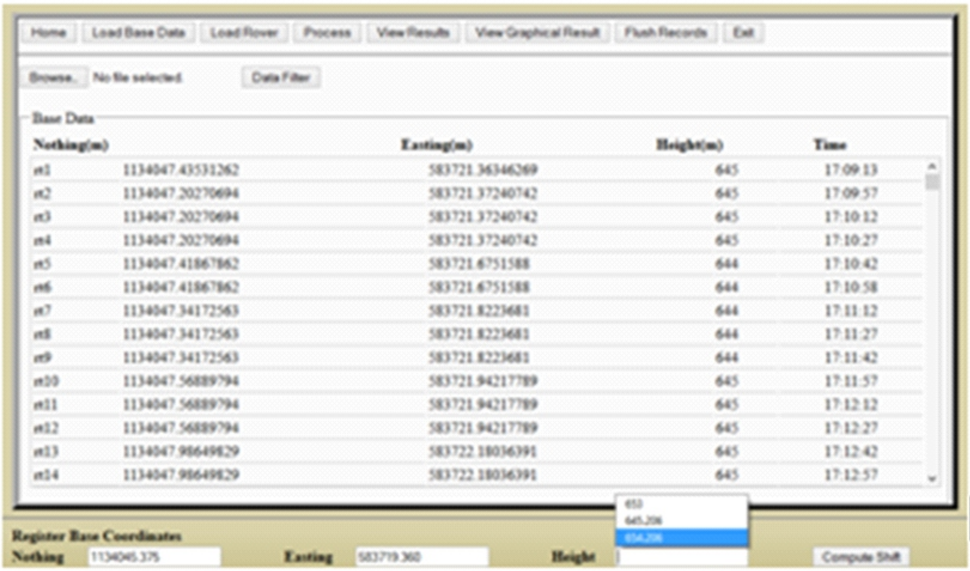


Fig. 4. Screen view of imported control (Base Data) observed data

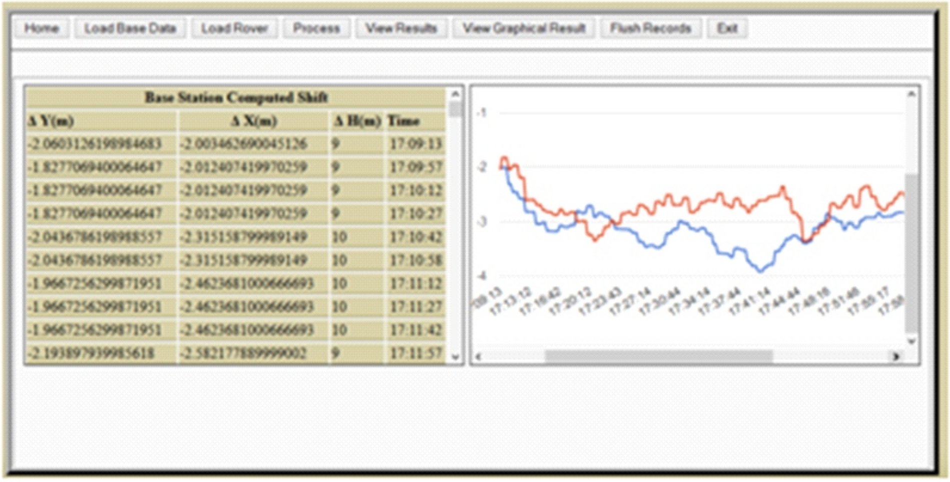


Fig. 5. Screen view of Computed shift

Rover(s) data were then imported by clicking on "Load Rover" from the main menu bar as shown in Fig. 6. Then "Adjust XYZ" button was clicked to adjust the corrected coordinates of the Rover data, then "Save Result" was clicked to save the adjusted result as shown in Fig.7.

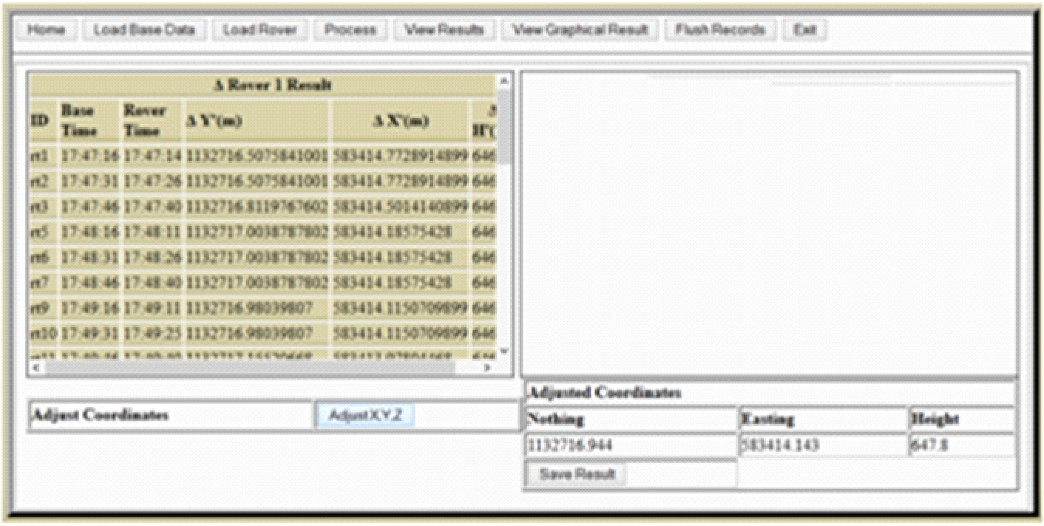
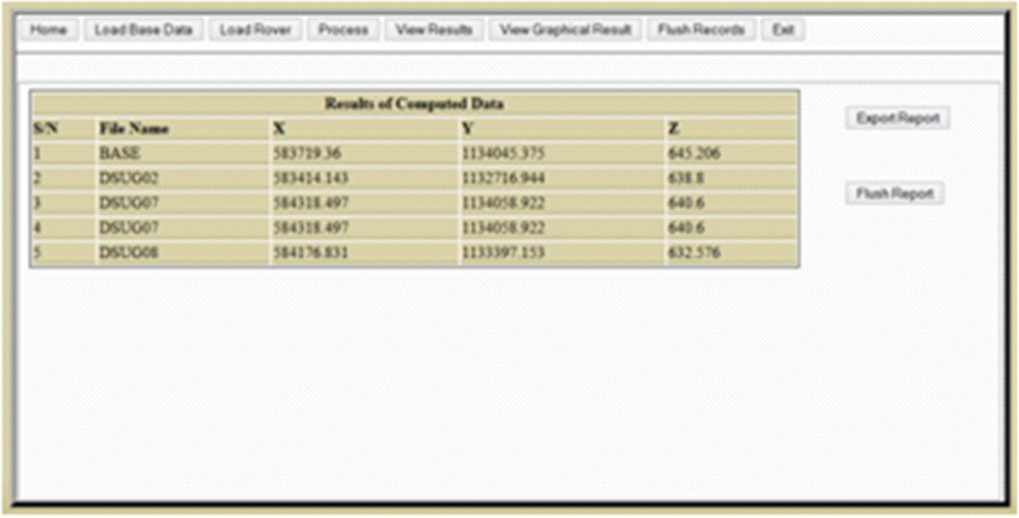


Fig. 6. Screen view of Adjusted Rover (s) data



Results of Computed Data

S/N	File Name	X	Y	Z
1	BASE	583719.36	1134045.375	645.206
2	DSUG02	583414.143	1132716.944	638.8
3	DSUG07	584318.497	1134058.922	640.6
4	DSUG07	584318.497	1134058.922	640.6
5	DSUG08	584176.831	1133397.153	632.576

Fig. 7. Screen view of Result table

"View Graphical Result" was clicked from the main menu, which displays the view of result as in Fig 7. Then the result was exported for plotting by clicking on "Export Results" button. Fig.8.

Fig.8. Screen view of Graphical representation of sample result.

Data Presentation and Discussion of Results

Table 1below is the result analysis. It shows the range of attainable consistencies of the results in both the unprocessed northing and easting coordinates (column 3 and 4) and the processed coordinates (column 5) of the respective points of observation (column 1).

Column 6 is the differences between coordinates obtain from DGPS and that of handheld GPS (unprocessed). The Column 7 is the differences between coordinates obtain from DGPS and that of handheld GPS (processed). Column 6 indicates that the highest difference in the Easting is 2.650m (at DSUG08) and Northing is 1.97m (at DSUG01). While the lowest difference in the easting was 1.107 at DSUG07 while in the northing is 1.260.

Column 7 shows that the highest difference in the easting is -0.512 at DSUG08 and in the northing is 0.085m at DSUG07 while the lowest difference in the both easting and northing is 0.000m at DSUG01.

Fig.9. is the graphical representation of the comparison of the results on point DSUG01 (Fig. 9a), DSUG07 (Fig.9b), DSUG08 (Fig.9c), and DSUG09 (Fig.9d).

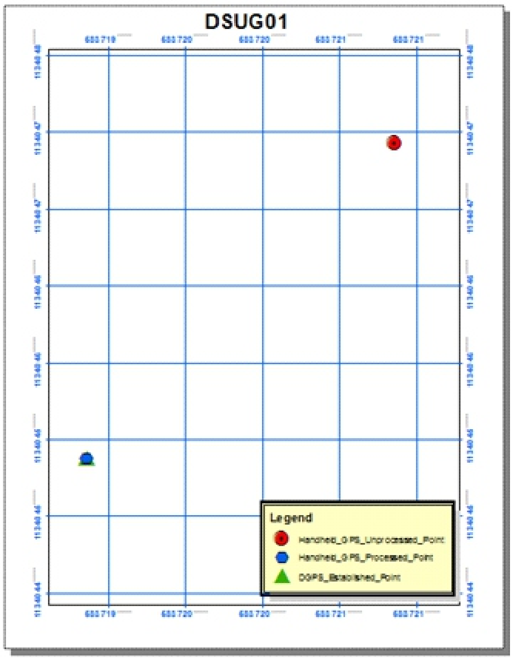
It shows that in

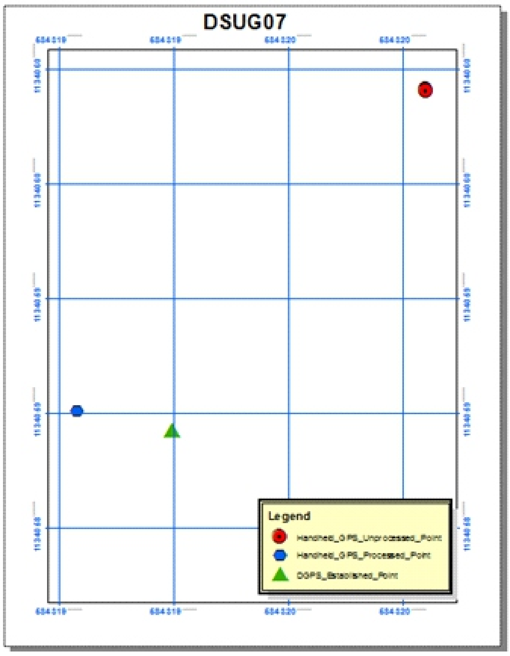
Table 1: Result analysis table coordinates (XYZ) obtained.

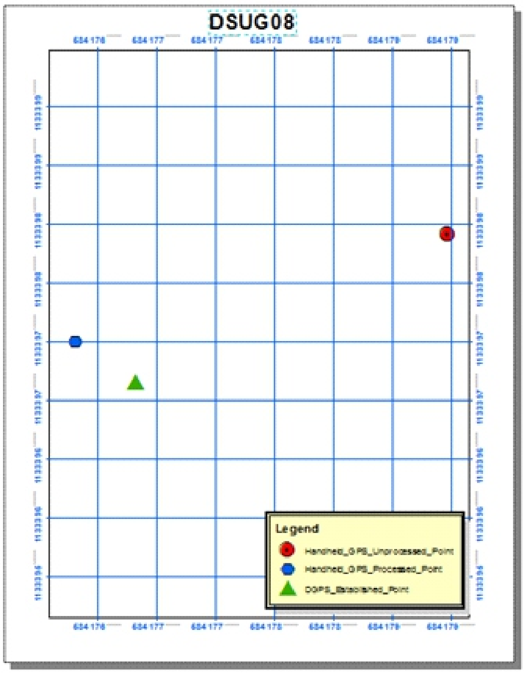
1	2	3	4	5	6	7
DSUG 01s (CONTROL)	EASTING X	583719.360	583721.363	583719.360	2.003	0.000
	NORTHING Y	1134045.375	1134047.435	1134045.375	1.97	0.000
	HEIGHT Z	645.206	645.000	645.206	-0.206	0.000
DSUG 09s	EASTING X	583414.401	583416.776	583414.143	2.633	0.258
	NORTHING Y	1132716.857	1132718.567	1132716.944	1.623	-0.870
	HEIGHT Z	638.820	637.000	638.800	-1.800	0.020
DSUG 07s	EASTING X	584319.085	584320.604	584319.497	1.107	-0.412
	NORTHING Y	1134059.007	1134060.409	1134058.922	1.487	0.085
	HEIGHT Z	640.706	641.000	640.600	0.400	0.106
DSUG 08s	EASTING X	584176.319	584179.481	584176.831	2.650	-0.512
	NORTHING Y	1133397.498	1133398.413	1133397.153	1.260	0.345
	HEIGHT Z	632.721	632.000	632.576	-0.576	0.145

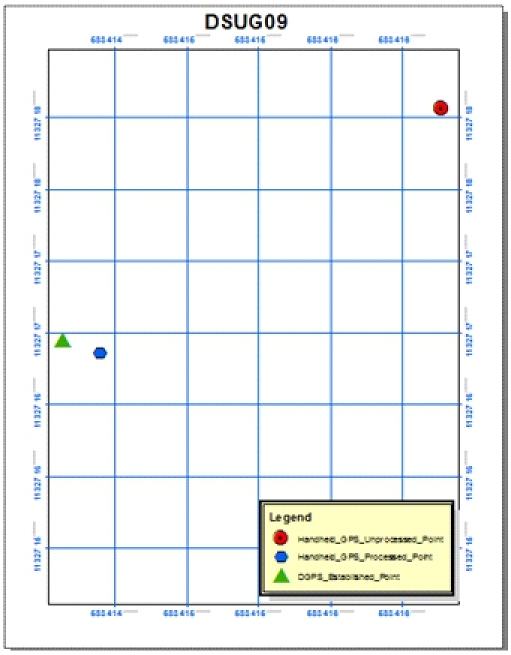
Legend

1- Point ID
2- Coordinates
3- Handheld GPS Processed Data in Meters
4- Handheld GPS Unprocessed Data in Meters
5- GNSS Receiver Processed Data in Meters
6- Difference between GNSS and Handheld GPS Unprocessed Data
7- Difference between GNSS and Hand Held GPS Processed Data


DSUG01
Legend
Handheld_GPS_Unprocessed_Point
Handheld_GPS_Processed_Point
DGPS_Established_Point


DSUG07
Legend
Handheld_GPS_Unprocessed_Point
Handheld_GPS_Processed_Point
DGPS_Established_Point


DSUG08
Legend
Handheld_GPS_Unprocessed_Point
Handheld_GPS_Processed_Point
DGPS_Established_Point


DSUG09
Legend
Handheld_GPS_Unprocessed_Point
Handheld_GPS_Processed_Point
DGPS_Established_Point

Conclusion

Base on the conclusion ATBUGPS software has shown that it is possible to enhance the accuracy and consistency of the data obtain using Handheld GPS receiver. The basic requirement is the observation procedure and data processing techniques. In this presentation, the field validation of the software has shown that the inherent positional inaccuracy of Handheld GPS has been minimized from about 3 - 5m to ±0.3meter accuracy.

Recommendation

It is therefore recommended that Handheld GPS can be use for low accuracy survey works such as third order cadastral surveys and Route surveying and for navigation purpose. However, the data obtained from such works should be process using ATBUGPS or similar post-processing software for improved position accuracy. Further research in this respect is also recommended for improvements.

References

Abdulkadir, F. I. (2010). An overview of the fundamental concepts and Uses of GPS for effective institutionalization of school mapping in Katsina State. *3-Day Capacity Development of Ministry of Education, State Universal Education Board and Local Govt. Education Authority Staff on the Institutionalization of School Mapping in Katsina State*, (p. 6). Katsina.

Gunter, S. (2003). *Satellite Geodesy-Foundations, Methods, and Applications*. Berlin: Walter de Gruyter GmbH & co.

Hofmann-Wallenhof, P. D. (2014). Basics of Satellite Navigation-An elementary Introduction. *ESA Conference* (pp. 3-4). Austria: Graz, University of Technology Press.

Khalil, R. A., Mohammed, M. A., & Lammaldean, M. M. (2014).*On the establishment of a precise gps network in khartoum state*. khartoum.

Moca, E. (1999). GPS in the oil industry. *The graduate Surveyor* , 13-17.

Schwieger, V. (2003). Using Handheld GPS for Precise Positioning. *2nd FIG Regional Conference Marrakech*. Marrakech,Morocco.

Wolf, P., & Ghilani, C. D. (1997). *Adjustment computations Statistics and Least square in Surveying and GIS*. New York: John Wiley and sons, inc.