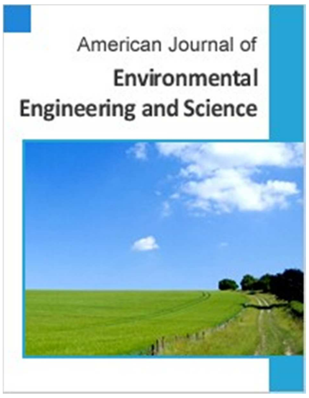
American Journal of Environmental Engineering and Science
2017; 4(5): 42-47
http://www.aascit.org/journal/ajees
ISSN: 2381-1153 (Print); ISSN: 2381-1161 (Online)

American Association for Science and Technology



Keywords
RINEX Data,
Absolute Data,
Post-Processing,
Handheld GPS

Received: May 30, 2017
Accepted: July 31, 2017
Published: September 20, 2017

Assessing the Accuracy of GPS Control Point, Using Post-Processed and Absolute Positioning Data

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Citation
Tata Herbert. Assessing the Accuracy of GPS Control Point, Using Post-Processed and Absolute Positioning Data. *American Journal of Environmental Engineering and Science.*
Vol. 4, No. 5, 2017, pp. 42-47.

Abstract
Hand held GPS have become the most useful instrument used by Surveyor and many professional bodies in obtaining data for several purposes. The need to determine an approach in using hand held GPS is required as the accuracy is not reliable. Assessing the accuracy of control point using post-processed and absolute positioning data was carried out using five (5) GPS control points, established by the federal surveys of Nigeria in Adamawa state. Two type of data were used, Receiver Independence Exchange (RINEX) and Absolute positioning data. The raw RINEX GPS data obtained from the field were downloaded into the computer using GRIGO software and were later post processed using P4 software; while that of absolute positioning data, there mean were calculated. The results were tested statistical to determine which method meets the requirement for surveying. For the computed standard errors, the geodetic GPS receiver with post processed data was 0.0001m for Northings and 0.0128m for Easthings, while that of geodetic GPS receiver with absolute positioning was 0.0015m for Northings and 0.0141m for Easthings. Base on the analysis, the post processed data was more precise to that of the absolute positioning. Hence data Obtained using a hand held GPS when post-processed can now be recommended for surveying jobs and other professional bodies.

1. Introduction

The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of Defense. Military actions was the original intent for GPS, however in the 1980s, the U.S. government decided to allow the GPS program to be used by civilians. Weather conditions do not affect the ability for GPS to work. The system works 24/7 anywhere in the world [1].

GPS technology has demonstrated stellar performance ever since its inception. The uses and applications have grown at an incredibly rapid rate. From navigation to recreational uses, from mapping to precision surveying and GIS, the ubiquitous nature of GPS is impacting our lives in a positive manner [9], [1].

The usefulness of a GPS is now well recognized and interest is increasing all the time. As a result, there are those who do not know how to use a compass and map but, who after buying a GPS feel that they now have the ultimate tool for ease of travel in backcountry [1].

The GPS satellites are owned and controlled by the US Department of Defense and this agency has the prerogative to degrade the accuracy for purposes of national defense.

This is done by what is called "Selective Availability" or what is commonly known "SA." SA is now turned "off" and the accuracy of GPS readings is now much better. Preliminary reports suggest 95% time, 10 metre accuracy and 50% of the time 5 metre accuracy [13], [14], [7].

The gain in accuracy without SA is still not sufficient to do any surveying or professional jobs, to mark a hidden treasure or to find a bow-hunting tree-stand in the middle of a cedar swamp at 4am in the morning [2].

GPS Overview

The global positioning system is the integration of three main components: space or the satellite orbiting the earth; control, the infrastructure monitoring and operating the satellites; and the users as shown in Figure 1 below.

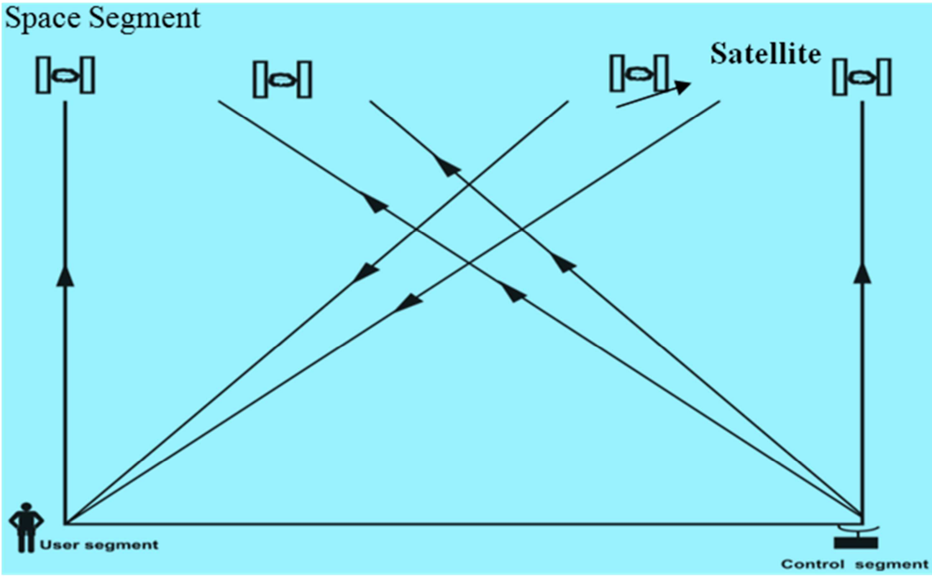

Figure 1. *The above diagram shows the GPS segment.*

1.1. The Space Segment

The space segments comprise of satellites in the system called "constellation" and the individual satellite themselves. The constellation of the orbit in the figure above was designed so that at least four satellites are visible anywhere on earth at any time [7] each satellite broadcasts radio signals that receivers can calculate apposition each satellite continuously transmits a message or signal, which allows the user to determine the spatial position of the satellite for arbitrary instants, given their position by resection [7].

1.2. The Control Segment

The control segment referred to as operational control system (OCS), it composed of all the ground-based facilities that are used to monitor and control the satellites. The segment is not usually seen by the user, but is a vital part of the system [2].

The main operational tasks of the control segment are tracking of the satellite for orbit and clock determination and prediction modelling. The control segment is also responsible for operating the GPS system. The monitor stations track all satellites in view and continue to accumulate ranging data. This information is processed at the MCS to determine satellite orbits and to update each of the satellite navigation information's. Updated information is transmitted to each stage, the GPS coordinate were referred to the WGS-72 reference system but since 1987, they have been referred to WGS 84 datum [5], [10].

1.3. The User Segment

The user segment refers to the user and a GPS receiver, which is a specialized radio receiver. It is designed to listen to the radio signals being transmitted from satellites and calculates a position based on those signals.

Of course, the third segment is made up of the users of the GPS segments. In the aviation industry, transportation, agriculture, consumers, public service sector, and many others rely on the system. All users of GPS take the ephemeris and almanacs transmitted by the satellites and use it to derive new information; time position and /or velocity. This derived information allows users to answer basic questions such as "where am I?" And "what time is it?" With the level of accuracy that was unthinkable prior to GPS [11], [10].

Considering the lack of trust in the use of hand held GPS for surveying, the hand-held GPS could provide a better result if raw GPS RINEX data are collected and processed. This research is to see, if the handheld GPS will actually provide a better result when the raw data obtained in RINEX format from a handheld GPS are processed [12].

2. Methodology

GPS surveying differs essentially from classical surveying because it is weather independent and there is no need for inter-visibility between sites [6]. Some terms associated with GPS point positioning include real time observation and post-processing observation. In real time GPS position result are obtained in the field immediately while still at the station. In Post – processing data are collected in the field and processed later [4].

Different method or mode of observation exists. Static and kinematics methods

2.1. Static Method

Static implies a stationary observation. In static positioning (also known as absolute point positioning) coordinates of a single point are determined using a single receiver with measures pseudo ranges to (normally four or more) satellites. Static point positioning is used if points are needed with moderate accuracy, say 5-10m. The static technique was primarily used for early GPS surveys [7].

2.2. Kinematics Method

The kinematics method denotes mobile observation. Kinematics surveying (relative positioning) is a method where two receivers are used and measurements to the same satellites are simultaneously made at two sites. This produces better accuracy than in the case of point positioning as a consequences of processing data from two sites. Normally the coordinates of other side is determined, relative to the known site i.e. the vector between the two sites is determine to a high degree of accuracy. In general, kinematics method involves one stationary receiver placed on a known site and one moving [3], [7].

For the purpose of this research, the static method was adopted.

3. Field Work

A Recce survey was carried out, within Jimeta and Yola metropolis. This was done in order to identify the GPS control points. About five (5) of those GPS control point established by the federal survey of Nigeria were identified.

The following are the GPS control points which were identify

I) XSM 31
II) YSM 41
III) YSM 80
IV) YSM 65
V) XSM 30

The above points which were identified were used for the field work.

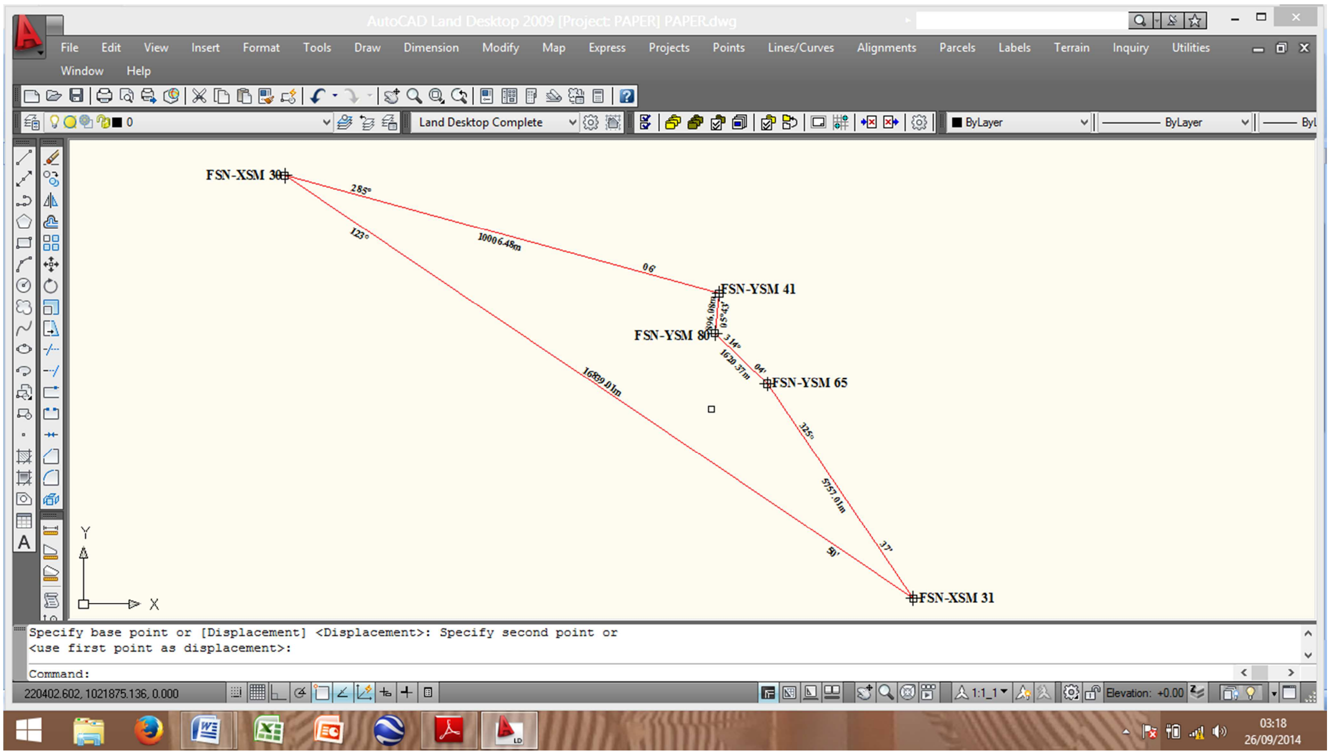

Figure 2. Showing traverse of control point.

3.1. GPS Set up

The Laptop, GPS and a generator were set up. The low cost external antenna was connected to the GPs, with the antenna set up over each of the control point, allowing for a clear view of satellite. An interface cable was connected from the GPS to the Laptop for proper logging and transfer of the raw RINEX data from the satellite. The Laptop was powered by the generator to enable the laptop carry out long time observation. The configuration of the setup is shown below.

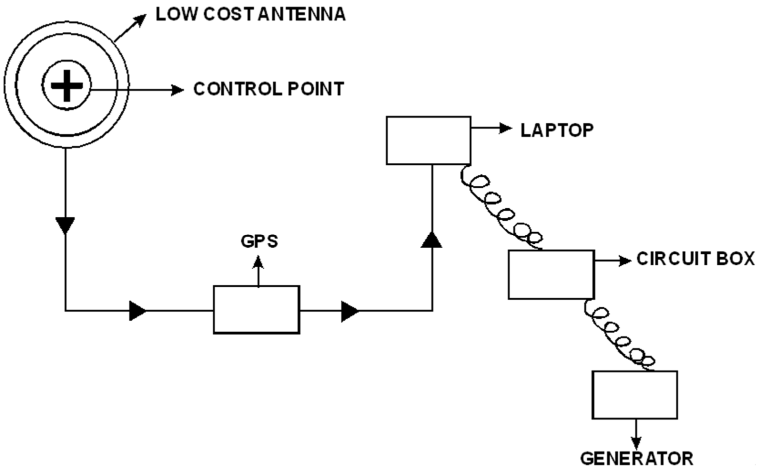

Figure 3. *Showing Configuration of setup.*

Below are the photographs of the setup, which include:-

a) Station with GPS antenna on top. Plate 1.

b) Researcher. Plate 2

Figure 4. *Showing Station with GPS antenna on top.*

Figure 5. *Showing Researcher carrying out observation.*

3.2. RINEX Data Logging

GPS RINEX generator software called GRINGO was used in logging of RINEX data, using static mode. Before logging of RINEX data, the following operations were performed on the instrument.

i. GPS

1. The Garmin GPS MAP76s Receiver was turn on.
2. The Garmin GPS MAP76s receiver was allowed to receive signals from at least four satellites.
3. The Garmin GPS MAP 76s communication protocol was set to Garmin.

ii. Laptop

a) The laptop was powered (booted)

b) The GRINGO software was launched or opened. The necessary parameters for logging RINEX data were set. They include:-

1. Name of the observer
2. Name of the company
3. Logging interval (epoch) at one (1) second
4. The GPS MAP76s serial number
5. The antenna serial number
6. The coordinate of the known points in Easting and Northings
7. An input file created to store the RINEX data.

Data were logged at 1 Hz for a period of 1hr on every station. The above procedure was carried out at every location.

3.3. Absolute Positioning

The Hand held GPS was placed on top of the stations; the GPS was set to read on UTM on WGS 84 datum. Data were logged and recorded at 5 minutes interval for a period of 1 hour on each station.

Below is the picture of a GRINGO screen.

Figure 6. *Showing GRINGO screen.*

3.4. Summary of Post Processing Procedure

The following are the steps involved in processing using P4 software.

1. Choose A RINEX File For The 'Roving' Reciever.
2. Choose A RINEX File for the 'Reference' Receiver
3. Choose a Satellite 'Ephemeris' File
4. Defining the Session Times and Satellite Constellation
5. Select the Pseudorange Processing and Output Options and Process the Pseudorange Data
6. Processing Interval
7. DGPS Or Stand – Alone
8. Ephemeris
9. Satellite Elevation
10. Phase Smoothing
11. Signal – To – Noise Ratio Thresholds
12. Output Options

4. Presentation of Data

4.1. Mean of Post Processed Data

Table 1. *Showing mean of post processed data.*

Station	Northings	Easthings
FSN – XSM 31	224892.953	1017686.571
FSN – YSM 65	221641.592	1022436.331
FSN – YSM 80	220481.881	1023569.718
FSN – YSM 41	220573.593	1024452.142
FSN – XSM 30	210912.193	1027056.770

4.2. Mean of Absolute Positioning

Table 2. *Showing mean of absolute positioning.*

Station	Northings	Easthings
FSN – XSM 31	224898.385	1017683.769
FSN – YSM 65	221647.167	1022434.846
FSN – YSM 80	220483.000	1023561.923
FSN – YSM 41	220572.308	1024453.538
FSN – XSM 30	210911.222	1027059.889

5. Statistical Analysis Method

Test of hypothesis was used for the statistical analysis. A test of hypothesis is the partitioning of the sample space into two parts called the rejection region (critical region) denoted as H0 and the acceptance region denoted as H1.

Using the formula below for the statistical analysis

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{\partial \bar{x}_1 + \partial \bar{x}_2}{n\bar{x}_1 + n\bar{x}_2}}}$$

Where,

$\bar{x}_1$ = mean of the known coordinate (Geodetic GPS Receiver Data)

$\bar{x}_2$ = mean of the observed coordinate (post-process and Absolute Data)

n = number of observed stations

t = test of hypothesis

Test of Hypothesis

H_0: there is no significant difference between the Post Processed and Geodetic GPS Receiver

H_1: there is a significance difference between the Post Processed and Geodetic GPS Receiver

6. Analysis of Result

The analysis of the result was based on absolute data and post processed data to that of a Geodetic GPS data which was made in terms of their precision (reliability). Precision is the degree of closeness or conformity of repeated measurements of the same quantity to each other while a standard deviation is a measure of precision. Therefore, lower the standard deviation the higher the precision. Based on the standard deviation computed for both the absolute and post processed data which were being compared to that of Geodetic GPS receiver when compared, the standard deviation of the post processed data was 3443.574m for Northings and 5228.207m for Easthings while that of the absolute data was 3445.483m for Northings and 5230.470m for Easthings. Hence the post processed data is more reliable to that of absolute positioning which confirm with [12] (See table 3 below).

Table 3. *Showing result of standard deviation.*

	Northings	Easthings
Post Processed	3443.574	5228.207
Absolute positioning	3445.483	5230.470
Geodetic	3443.850	5224.462

For the computed standard errors, the standard error of the geodetic GPS receiver with post processed data was 0.0001m for Northings and 0.0128m for Easthings, while that of geodetic GPS receiver with absolute positioning was 0.0015m for Northings and 0.0141m for Easthings. Hence the value of Geodetic GPS receiver with post processed data was reliable, to that of the Geodetic GPS receiver with absolute positioning. The reason is that the values of the Geodetic GPS receiver with post processed data tend more close to zero (see Table 4 below).

Table 4. *Showing result of standard error.*

	Northings	Easthings
Post Processed with Geodetic	0.0001	0.0128
Absolute positioning with Geodetic	0.0015	0.0141

7. Conclusion

In this research, based on the results of the statistical analysis obtained, the data which were being logged in RINEX format using a handheld GPS and post-processed were more reliable than that of the absolute positioning, when compared to that of Geodetic GPS receiver. From the results analysed for both the post-processed RINEX data and absolute positioning data, it can therefore be recommend that the post-processed RINEX data can be used for any meaningful surveying jobs.

Hence do accept that;

H_0: there is no significant difference between the Post Processed and Geodetic GPS Receiver

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